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Graduate Catalog, 1999-2002, New Jersey Institute of Technology

New Jersey Institute of Technology

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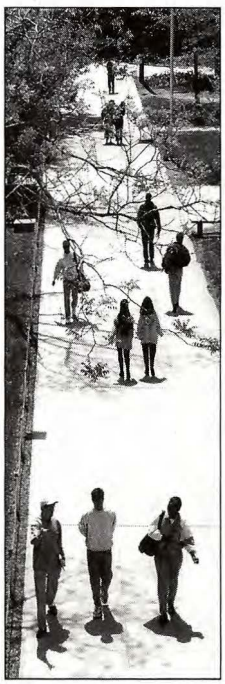

graduate catalog

1999–2002

NJIT

Contents

This printed edition of the catalog contains the programs, courses and requirements of graduate study at New Jersey Institute of Technology. **The official version of the NJIT Graduate Catalog is located on NJIT's Web site, www.njit.edu. Consult the on-line version of the graduate catalog for the most current programs, courses and requirements.**

Neither the provisions of this catalog nor the publication thereof constitute an offer for a contract which may be accepted by students through registration and enrollment in the university. The university reserves the right to change any provision, offering or requirement at any time during the student's period of study at NJIT.

ABBREVIATIONS

The following abbreviations are used in this catalog:
GRE (Graduate Record Examinations)
GMAT (Graduate Management Admission Test)
GPA (Grade Point Average)
LSAT (Law School Admission Test)
MCAT (Medical College Admission Test)
Rutgers-Newark (Rutgers University, Newark campus)
Rutgers-New Brunswick (Rutgers University, New Brunswick campus)
TOEFL (Test of English as a Foreign Language)
UMDNJ (University of Medicine and Dentistry of New Jersey)

Fall 1999

PROGRAMS

COURSES

About the University

New Jersey Institute of Technology

NJIT's history spans from the Industrial Revolution to the Information Age. Newark was a factory town when the tuition-free evening school was founded in 1881 to support local industries. The first 90 students — including machinists, draftsmen, carpenters, printers, electricians and clerks — studied algebra, geometry, trigonometry, chemistry, physics and drawing. The range of courses offered is testimony to the fact that, from the beginning, NJIT's programs have provided a broad-based foundation to prepare students for success in the workplace. From those early days, science and technology have been the engines fueling the university's development.

Over time, the university both anticipated and responded to change by expanding its curriculum and mission. Most notably, in 1919 the university established baccalaureate programs in three engineering fields. By 1975, NJIT offered a broad range of undergraduate and graduate degrees including architecture, engineering, computer science, management and other science-oriented programs. All of these programs included significant research and public service components with the goal of providing an academic environment that fostered intellectual depth and breath, as well as social responsibility.

Today, continuing a fourfold mission of instruction, research, economic development and public service, NJIT is among the leading comprehensive technological universities in the nation. With more than 8,200 students, NJIT is the largest technological university in the New York metropolitan region. The university has state-of-the-art facilities with more than 2,000,000 sq. ft. of space located on a 45-acre campus in Newark, a Technology and Engineering Center at our 125-acre campus in Mount Laurel shared with Burlington County College, and a solar observatory in Big Bear, California. With robust Extension and Distance Education programs, NJIT's degree and non-degree programs are available throughout the state and world.

NJIT's Five Colleges

While there has been tremendous growth and diversification at NJIT, NJIT's roots are in engineering education. For more than eight decades, Newark College of Engineering (NCE) has been preparing engineering students to use science, mathematics, technology and problem-solving skills to design, construct, test and maintain products, services and information systems. NCE alumni lead major corporations, hold senior public positions, own their own businesses and teach at universities.

NJIT's School of Architecture, established in 1974, is the eighth largest architecture school in the nation and is nationally recognized for the innovative integration of computer technology into the design curriculum.

The College of Science and Liberal Arts (CSLA), established in 1982, is moving into the forefront of many national research activities from solar astronomy to computational and mathematical modeling. CSLA provides students with the skill sets for the professional marketplace including literacy in the computer, mathematical, physical and biological sciences, as well as the traditional liberal arts disciplines.

The School of Management, established in 1988, combines the best of the traditional business disciplines (e.g., finance, marketing, accounting) with the power of information and technology management to develop professionals who can manage and communicate effectively.

The Albert Dorman Honors College, established in 1993, offers one of the nation's leading technological oriented honors programs for students who are prepared to undertake a rigorous and individualized course of study.

America's Most Wired Public University *(Yahoo! Internet Life)*

As *America's Most Wired Public University,* NJIT is nationally recognized as a pioneer in the use of computing and information technologies from developing algorithms to reduce simulation times on large scale parallel computers, to advancing the frontiers of visualization technology, to patenting optics-based sensors, to developing computer-based infrastructure management systems, to developing advanced computer mediated communication systems.

As a technological university, NJIT is educating leaders for a technology-driven economy. The university is rethinking educational programs to emphasize marketplace skills, and redesigning our methods of delivering education. Indeed, computing and information technology underpin every facet of the NJIT mission.

NJIT received Carnegie Foundation designation as a Doctoral II university in 1994 and has ranked among the "best national universities" by U.S. News and World Report every year since. NJIT expends over $43 million in a panoply of research and development partnerships with industry, government and other universities and has earned a national reputation for excellence in research areas such as environmental science, information technology, manufacturing, microelectronics, transportation, solar and device physics and building science.

For more than a century, NJIT has been a splendid change agent, transforming the competencies of individuals, creating jobs and supporting the competitiveness of business enterprise. NJIT sees itself as the embodiment of the "university of the future," playing an essential role in the economic and social life of the state and nation. All of NJIT's programs support the professional success of individuals and the competitive success of business. As NJIT looks ahead, the goal is quite simple: to do more and get better at everything the university does, so that it can serve students, business and government better than ever.

NJIT Mission Statement

NJIT is a ***public, urban, research university,*** committed to the ***pursuit of excellence*** in:

- undergraduate, graduate, and continuing professional ***education,*** preparing students for productive careers and amplifying their potential for lifelong personal and professional growth;
- the conduct of ***research*** in such multi-disciplinary areas as environmental engineering, materials science, manufacturing, productivity enhancement, infrastructure systems, communications technologies, and an array of bio-related sciences and technologies;
- contributing to the state's ***economic development*** through partnerships and joint ventures with the business community and through the development of intellectual property;
- ***service*** to both its local communities and the broader society of the state and nation by conducting public policy studies, making educational opportunities widely available, and initiating community-building projects.

NJIT ***prepares its graduates*** for positions of leadership as professionals and as citizens; ***provides educational opportunities*** for a broadly diverse student body; ***responds to needs*** of large and small businesses, state and local governmental agencies, and civic organizations; and ***advances the uses of technology*** as a means of improving the quality of life.

NJIT offers a ***comprehensive array of programs*** in engineering and engineering technology, computer science, architecture, applied sciences, mathematics, management, policy studies, and related disciplines throughout New Jersey and the nation.

Graduate Studies

NJIT offers advanced studies in numerous disciplines leading to master's degrees, doctoral degrees and graduate certificates. Programs are available to full-time students and to working professionals who are interested in part-time study. Some programs are offered in cooperation with Rutgers-Newark and with UMDNJ as part of continuing collaborations within The Graduate Center at Newark.

Full-time students are involved in the university's extensive research activities through association with renowned faculty and research centers. Financial support is available through a variety of programs that permit students to become part of the teaching, administrative and research functions of the university. Other non-service-based support is also available.

Graduate courses and programs are also offered at off-campus sites and through Distance Learning. Current undergraduates have opportunities for early entry into graduate study through the B.S./M.S. program and accelerated dual degree programs.

Graduate Programs Available

Graduate Degrees

The doctoral and master's degree programs offered at NJIT are listed below. All doctoral programs lead to the doctor of philosophy; master's programs lead to the master of science with the exception of the Master of Architecture, the Master of Arts in History, the Master of Business Administration in Management of Technology, the Master in Infrastructure Planning, and the Master of Public Health. Dual degree offerings are available for M.Arch./M.S. in Civil Engineering, M.Arch./Master in Infrastructure Planning, and M.Arch./M.S. in Management. Other degree options include the B.S./M.S., the M.S./M.S., the M.S. in Management Executive Program, and the Collaborative Doctorate. The degree program descriptions are specified in the Academic Programs section of this catalog.

Applied Chemistry (M.S.)
Applied Mathematics (M.S.)
Applied Physics (M.S., Ph.D.) *joint with Rutgers-Newark*
Applied Science (M.S.)
Applied Statistics (M.S.)
Architecture (M.Arch.)
Architectural Studies (M.S.)
Biology (M.S., Ph.D.) *joint with Rutgers-Newark*
Biomedical Engineering (M.S.)
Biomedical Informatics (M.S., Ph.D.) *joint with UMDNJ*
Business Administration in Management of Technology (M.B.A.)
Chemical Engineering (M.S., Ph.D.)
Civil Engineering (M.S., Ph.D.)
Computer Engineering (M.S., Ph.D.)
Computer and Information Science (Ph.D.)
Computer Science (M.S.)
Electrical Engineering (M.S., Ph.D.)
Engineering Management (M.S.)
Engineering Science (M.S.)
Environmental Engineering (M.S., Ph.D.)
Environmental Policy Studies (M.S.)
Environmental Science (M.S., Ph.D.) *joint with Rutgers-Newark*
History (M.A.) *joint with Rutgers-Newark*
Industrial Engineering (M.S., Ph.D.)
Information Systems (M.S.)
Infrastructure Planning (M.I.P.)
Interdisciplinary Studies (M.S.)
Management (M.S., Ph.D.)*
Manufacturing Systems Engineering (M.S.)
Materials Science and Engineering (M.S., Ph.D.)
Mathematical Sciences (Ph.D.) *joint with Rutgers-Newark*
Mechanical Engineering (M.S., Ph.D.)
Occupational Safety and Health Engineering (M.S.)
Occupational Safety and Industrial Hygiene (M.S.)
Power Engineering (M.S.)
Professional and Technical Communication (M.S.)
Public Health (M.P.H.) *joint with Rutgers-Newark and UMDNJ*
Telecommunications (M.S.)
Transportation (M.S., Ph.D.)

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* The Ph.D. in Management is conferred by Rutgers-Newark.

Graduate Certificates

Graduate certificates are offered in "fast track" professional fields externally validated with expanding employment opportunities. Therefore, annual adjustments are made in the subject areas. Those listed here are available through June 2000.

Computer Networking (relates to M.S. in Computer Engineering)

Electronic Media Design (relates to M.S. in Information Systems; M.S. in Professional and Technical Communication)

Environmental Infrastructure and Management (relates to M.S. in Environmental Policy Studies; in part to M.S. in Management)

Health Care Information Systems (relates to M.S. in Management; M.S. in Biomedical Informatics)

Information Systems Design and Development (relates to M.S. in Information Systems)

Internet Applications Development (relates to M.S. in Information Systems)

Managing Human Resources (relates to M.S. in Management)

Object-Oriented Design (relates to M.S. in Information Systems; M.S. in Computer Science)

Practice of Technical Communications (relates to M.S. in Professional and Technical Communication)

Programming Environment Tools (relates to M.S in Information Systems; M.S. in Computer Science)

Project Management (relates to M.S. in Engineering Management)

Telecommunications Networking (relates to M.S. in Computer Science; M.S. in Electrical Engineering; M.S. in Telecommunications)

Major Research and Public Service Centers

Engineering and Applied Science

Associated Institutions for Material Sciences (AIMS)[1]
AIMS is a consortium with Princeton, Rutgers, David Sarnoff Research Center and UMDNJ. Associated centers include the New Jersey Center for Biomaterials and Medical Devices[1], which works to initiate major research programs and transfer technologies to New Jersey companies regarding implant design improvement and a better understanding of the relationship between living tissue and artificial implants. (732) 445-0488

Center for Applied Mathematics and Statistics (CAMS)
Fosters and supports the application of advanced mathematical and statistical methods to scientific, engineering, and management problems. The statistical consulting facility assists internal and external clients with problems in data analysis, time series, design of experiments, and estimation and reliability theory. (973) 596-8545

Center for Computational Biology and Bioengineering
The center assists in developing interdepartmental research programs in cardiovascular dynamics, computational neuroscience, technology for rehabilitation, biomaterials, medical imaging and computational biochemistry. Collaborating institutions include: UMDNJ, Rutgers University, the Kessler Institute and the Public Health Research Institute. (973) 596-6597

Center for Membrane Technologies[1]
The center focuses on research in new membrane structures, materials and devices, novel membrane-based processes and techniques and applications development of membrane technologies for separations and other applications. NJIT leads an academic consortium whose other members include Rowan, Rutgers-New Brunswick and Stevens. Training of professionals, graduate and undergraduate students, developing new membrane technologies and their applications and transferring them to corporate partners are prime objectives of the center. (973) 596-8479

Center for Solar Research
The center focuses on observational and theoretical astrophysics and operates the Big Bear Solar Observatory, at Big Bear Lake, California, and a dedicated array of solar radio telescopes at Owens Valley Radio Observatory, in Owens Valley, California. The facilities at both locations have the unique capacity to study the sun and its extended magnetic atmosphere simultaneously. (973) 596-3565

Multi-lifecycle Engineering Research Center (MERC)[1]
The center is dedicated to the research and development of innovative engineering methodologies and technologies incorporating re-use as a primary consideration in the design of new products and recovering and re-engineering of components and materials for next-generation feedstocks; and to the education of new engineers and professionals with a broad knowledge of these systems. It targets cross-disciplinary thrust areas in multi-lifecycle product and process design, re-engineered materials from the waste stream, manufacturing and materials processing, demanufacturing systems technology, application, demonstration and integration. (973) 642-7198

Particle Processing Research Center[1]
The center focuses on fundamental and applied research in particle technology for industry and promotes technology development and transfer to industrial partners. The research thrust areas include particle storage and transport, particle and surface property modification (engineered particulate materials), particle segregation, mixing and separations, simulations and modeling. Undergraduate and graduate education and professional training complement the research. (973) 596-8479

Environmental Engineering and Science

Otto H. York Center for Environmental Engineering and Science (CEES)
CEES is the home for many of NJIT's environmental centers, programs and initiatives. The $11 million center, containing $2.4 million in state-of-the-art laboratory equipment, is the first building in the nation especially constructed for cooperative public and private research in hazardous waste management. (973) 596-3233

Hazardous Substance Management Research Center (HSMRC)[1,2]
This internationally recognized center is the nation's largest industry/university cooperative research program dedicated to hazardous substance management. NJIT is the lead institution of the center's academic consortium whose other members include Princeton, Rutgers, Stevens, Tufts and UMDNJ. (973) 596-3233

Northeast Hazardous Substance Research Center (NHSRC)[3]
The center conducts research training and technology transfer related to the management of hazardous substances. Its research efforts focus on technology development and demonstration, with emphasis on site remediation and effluent treatment. NJIT is the lead institution in an academic consortium whose other members include MIT, Princeton, Rutgers, Tufts, Stevens, and UMDNJ. (973) 596-5883

Center for Airborne Organics[3]
NJIT is joined by MIT and Caltech in this U.S. Environmental Protection Agency (EPA) center. The center provides tools to the EPA, industry and the states — improved methodologies and predictive and interpretive models — to connect reliably the identities and concentrations of airborne organic compounds with major anthropogenic pollutant emission sources. (973) 596-5883

Sustainable Green Manufacturing (SGM)
SGM is a partnership of NJIT's Gallo Center, New Mexico State University, the Army Industrial Ecology Center, and the National Defense Center for Environmental Excellence. The Sustainable Green Manufacturing Initiative develops advanced, environmentally responsible manufacturing processes for weapon systems that address corrosion prevention and control; weapon system maintenance, repair, and upgrade operations; the use and repair of advanced materials such as composites; lifecycle modeling and simulation; coating technologies; and new technologies for remanufacturing.

Manufacturing

Center for Manufacturing Systems (CMS)[1]
CMS is NJIT's focal point for industrial interaction in research, technology extension, education and training pertinent to manufacturing. Project work spans aspects of materials production, component part fabrication and automated assembly. (973) 596-3616

AlliedSignal Advanced Manufacturing Laboratory
The manufacturing laboratory houses a full complement of advanced machine tools, CAD/CAM/CAE systems, and rapid prototyping equipment. (973) 596-2874

Polymer Engineering Center (PEC)
PEC seeks to advance the foundations of design and control of polymer production and part fabrication technologies with facilities including a production scale, multi-layer co-extrusion line with thermoforming unit, and extruders, injection molding machines, and test and characterization equipment. (973) 642-4582

Polymer Processing Institute (PPI)
PPI is a not-for-profit institute with special areas of expertise in the development of high performance products and processes for advanced compounding; property characterization; and computer modeling. PPI includes the professionally managed Characterization Lab, Computer Center, and Process Lab, which contains a number of single and twin screw extruders and several injection machines along with downstream equipment. (973) 642-4582

Transportation

Institute for Transportation
The institute conducts interdisciplinary research on the transportation needs of the public and private sectors. Affiliated centers include the National Center for Transportation and Industrial Productivity[4], which investigates methods for increasing productivity through transportation improvements and provides technical, administrative and fiscal management necessary to conduct research projects in the field of transportation, (973) 596-3355; and the New Jersey Center for Transportation Information and Decision Engineering (TIDE) Center[1], a partnership of NJIT, Princeton and Rutgers that develops and markets technologies that will help individuals and commercial enterprises make better transportation-related decisions. (973) 596-8493

Electronics and Communications

Center for Communications and Signal Processing Research
The center promotes research on the theoretical and practical aspects of communications and signal processing in collaboration with government organizations and local industry with emphasis on wireless and personal communications. (973) 596-3520

Electronic Imaging Center
The center's research emphasizes novel diffractive methods in spectral filtering, which are combined with visible and infrared imaging systems. Of particular interest are applications of infrared imaging and radiometry with industrial and commercial partners. (973) 596-3538

Microelectronics Research Center
Research focuses on advanced semiconductor and micromachined device design, simulation and fabrication. Features a complete Class 10 cleanroom with 6-inch silicon wafer processing capability, one of only a few such university cleanrooms in the nation. Recent state-of-the-art equipment additions include wafer bonding and deep reactive etching tools. The center provides industry and university clients with technical support and prototype development in MEMS and/or CMOS technologies. (973) 596-5736

New Jersey Center for Multimedia Research (NJCMR)[1,2]
NJCMR is a partnership of NJIT, Princeton and Rutgers that works to understand the best ways to present educational material using state-of-the-art technology and to enhance technology transfer to New Jersey's and the region's multimedia technology businesses. Research focuses on multimedia technology, hypermedia and presentation, and cognition in multimedia. (973) 596-5650

New Jersey Center for Wireless Telecommunications
NJIT is the lead institution in a research partnership with Princeton, Stevens and Rutgers that focuses on enabling technologies for digital wireless communication systems to enhance the competitive position of those companies and institutions in New Jersey in the wireless arena. (973) 596-3516

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[1] Supported by the N.J. Commission on Science and Technology
[2] A National Science Foundation Industry/University Cooperative Research Center
[3] Supported by the U.S. Environmental Protection Agency
[4] Supported by the U.S. Department of Transportation
[5] Supported by the N.J. Department of Environmental Protection

■ Architecture

Center for Architecture and Building Science Research
This applied research group investigates the built environment within a social and economic context. Major areas of study include housing, learning environments, healthcare and aging, disabilities, preservation technologies and the utilization of waste materials for construction and infrastructure. (973) 596-3097

■ Public Policy

Center for Policy Studies
This interdisciplinary center conducts basic and applied research that serves as the basis for public policy development and assessment. Public policy areas include transportation, environmental/economic; health economics and health; coastal; and college and secondary education. (973) 596-8467

■ Small Business Assistance

Center for Information Age Technology (CIAT)
CIAT provides impartial, professional computer-related assistance to government, education, non-profit, and business organizations. The center assists with a wide range of projects such as assessment of current hardware and software, identification of systems requirements, vendor and package evaluation, implementation, training, and Web site development. (973) 596-3035

Defense Procurement Technical Assistance Center
The center provides individualized marketing, contractual and technical assistance to businesses currently selling or seeking to sell goods/services to the federal, state or local government, and prime contractors. (973) 596-5807

Enterprise Development Centers I and II (EDC I and II)[1]
EDC I and II operate two technology-oriented small business incubators committed to the long-term economic vitality and growth of entrepreneurial ventures in New Jersey. EDC addresses problems inherent to these businesses and helps to commercialize companies' new products, processes and services. (973) 596-5864

New Jersey Manufacturing Extension Program, Inc. (MEP)
MEP is a not-for-profit organization headquartered at NJIT that serves as a gateway for small to medium-sized manufacturers to access statewide services in the public and private sectors that address business, financial and technical issues essential to forming high performance firms. (973) 642-7900

New Jersey Technical Assistance Program for Industrial Pollution Prevention (NJTAP)[5]
NJTAP assists New Jersey small and medium-sized businesses with guidance, advice and information regarding environmental issues and pollution prevention (P2) opportunities. NJTAP partners with New Jersey manufacturers, Publicly Owned Treatment Works, the Environmental Defense Fund, trade associations, counties and municipalities, manufacturing extension programs, and various governmental agencies to provide environmental assistance, education and training. NJTAP is supported by the N.J. Department of Environmental Protection. (973) 596-5864

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[1] Supported by the N.J. Commission on Science and Technology
[2] A National Science Foundation Industry/University Cooperative Research Center
[3] Supported by the U.S. Environmental Protection Agency
[4] Supported by the U.S. Department of Transportation
[5] Supported by the N.J. Department of Environmental Protection

NJIT Faculty Research

NJIT faculty conduct extensive research in the university's research centers and laboratories, and in partnership with other universities, industry and government laboratories. Highlights of major research areas are presented here. Additional information about NJIT research centers mentioned is available on page 4 and a listing of center directors is located on page 151 of this catalog.

ARCHITECTURE

In addition to independent research, architecture faculty are involved in a wide array of interdisciplinary research mainly the:

- Center for Architecture and Building Materials Research
- Multi-lifecycle Engineering Research Center

Areas of Research

Building Technologies and Sciences — Moisture in buildings, building materials, energy transfer through building envelopes, conservation and passive solar heating, building systems integration, and building economics.

Computer-Aided Architecture — Use of computers in architectural practice, modeling and simulation, computer application in architectural design, and data structures and graphic representation.

History and Theory of Architecture — Architectural theory and criticism, history of architecture since 1750, urban history and cultural geography, literary themes in architecture, and contemporary art and architectural criticism.

Housing Studies and Urban Design — Housing for new household types, public policies in design arts, technology and architectural design, social meaning of building form, housing environments, community revitalization, and economic development.

Urban Infrastructure Planning — Interdisciplinary project planning and design, infrastructure technology and design principles, public space infrastructure, history and theory of urban infrastructure, and financing and implementation of infrastructure projects.

BIOMEDICAL ENGINEERING

NJIT's interdisciplinary biomedical engineering faculty are involved in research and development in collaboration with the following institutions:

- Columbia College of Physicians and Surgeons
- Hershey Medical Center
- Kessler Institute for Rehabilitation
- Saint Barnabas Medical Center
- UMDNJ-New Jersey Medical School
- UMDNJ-New Jersey Dental School
- Veterans Administration Medical Center in East Orange

Areas of Research

Mechanical Engineering — In the area of biomechanics, research is ongoing in knee joints, heart valves, spinal disks, spinal fixation devices, and a quantification device for lower back pain. Biomaterials research focuses on artificial ligaments and resorbable fracture fixation materials.

Electrical Engineering — Researchers in biomedical signal processing are developing electrocardiogram analysis as a tool for diagnosing and treating stroke disorders and neuromuscular disorders. Other signal processing research involves electroencephalogram analysis in treating epilepsy and electromyogram analysis in fatigue studies.

Chemical Engineering/Chemistry — Studies involve use membranes for controlled-release of pharmaceuticals; protein separation using affinity chromatography; molecular modeling of drug-receptor interactions; mixing and mass transfer phenomena in bioreactors; and reactor analysis and solvent minimization.

CHEMICAL ENGINEERING, CHEMISTRY AND ENVIRONMENTAL SCIENCE

The chemical engineering, chemistry and environmental science research programs are closely associated with the:

- Center for Membrane Technologies
- Hazardous Substance Management Research Center
- Multi-lifecycle Engineering Research Center
- Northeast Hazardous Substance Research Center
- Polymer Engineering Center

Areas of Research

Hazardous Waste Treatment and Waste Minimization — Dynamic modeling of biological reactors, anaerobic/aerobic biotreatment processes, in-situ bioremediation, biofiltration of VOCs, kinetic and thermodynamic analysis of combustion and pyrolysis processes, catalytic combustion, acid gas treatment, sampling and analysis of organic and inorganic pollutants, supercritical extraction, treatment of gaseous pollutants by corona discharge, novel routes for solvent-less chemical synthesis, ultrasonic enhancement of in-situ remediation, and process design for waste minimization.

Biochemical Processing — Reactor analysis, mixing phenomena, chromatographic separations, molecular modeling of enzyme mimics and drug-receptor interactions.

Materials Processing — Polymer characterization and process engineering, plastics recycling, and particle flow systems.

Membrane Separations — Excellent facilities exist for conducting research on membrane separation processes, particularly hollow-fiber membranes. Applications include gas-gas, gas-liquid, and solute-liquid separations, as well as combined reaction/separation processes. Support for these activities comes from industrial and federal research grants, the environmental research centers at NJIT, and NJIT's Sponsored Chair in Membrane Separations and Biotechnology.

CIVIL AND ENVIRONMENTAL ENGINEERING

Research in civil and environmental engineering is conducted within the department and in these NJIT centers:

- Center for Manufacturing Systems
- Hazardous Substance Management Research Center
- Institute for Transportation
- Multi-lifecycle Engineering Research Center
- Northeast Hazardous Substance Research Center

Areas of Research

Geoenvironmental Engineering Laboratory — This state-of-the-art facility was established with support from a $1 million National Science Foundation (NSF) grant, which was matched with more than $2 million from NJIT. The laboratory provides research support for geoenvironmental projects such as soil decontamination using biological, chemical and/or physical means; modeling of contaminant transformation and transport; and the testing of waste treatment, solidification, and stabilization and containment systems. The equipment includes an environmental scanning electron microscope (ESEM), X-ray fluorescence and X-ray diffraction spectrometers (XRF/XRD), GC/MS and SFE, capillary electrophoresis (CE), UV-VIS, FT/IR, respirometers, particle size analyzer (PSA), and hydraulic conductivity apparatus.

High Performance Concrete Laboratory — Equipped with funds from NSF, this laboratory is capable of testing very high strength concretes under uniaxial as well as triaxial states of stress. The primary testing system is capable of applying up to 1 million pounds of axial load on a specimen in a computer-controlled closed-loop environment. The materials processing component includes two computer-controlled micro-sizers, and fractionators for particle size analysis and categorization of industrial by-product additives to concrete, such as fly-ash, microsilica and blast furnace slags.

Smart Sensors and Nondestructive Testing Laboratory — This laboratory provides means for studying self-sensing systems built into structures to monitor excessive strains, deflections, load distributions, temperature variations and corrosion.

Recycled Plastics Laboratory — This research facility concentrates on developing innovative uses for recycled plastics. In addition to material tests, the lab develops constitutive models and analysis techniques required by the nonlinear characteristics of the material and its variation through the cross section. Computer simulations are used to analyze the barriers during a crash by modifying current programs to include recycled plastic models. Experimental studies include wind and acoustic tests of noise barriers and in-situ implementation of the proposed designs.

COMPUTER AND INFORMATION SCIENCE

Computer and information science research is conducted in the following laboratories: Advanced Computer Architecture and Parallel Processing; Artificial Intelligence; Computer Communications and Networking; Data and Knowledge Engineering; Knowledge Representation and Artificial Intelligence; Dependable Real-Time Systems; Collaborative Systems; Computer Vision; Computing Education, Cognition and Learning; Hypermedia Information Systems; Neurological Computation and Robotics; Simulation and Modeling; and Software Engineering.

Areas of Research

The department provides research laboratories with infrastructure and coordination for conducting multidisciplinary research and development. Some key areas that the department focuses on are the technology, health care and financial industries, which require research in software engineering, telecommunications, computing systems, artificial intelligence, database, algorithms, and biomedical and information systems. In addition, the department sustains an interdisciplinary research support environment for biomedical and neuroscience applications, computer engineering, computer-mediated communication, enterprise engineering, health care information systems, manufacturing systems, medical imaging and information systems, microelectronics, as well as other disciplines.

ELECTRICAL AND COMPUTER ENGINEERING

In addition to independent research, Department of Electrical and Computer Engineering faculty participate in research at the:

- Center for Communications and Signal Processing Research
- Electronic Imaging Center
- Microelectronics Research Center
- Multi-lifecycle Engineering Research Center
- New Jersey Center for Multimedia Research
- New Jersey Center for Wireless Telecommunications

Areas of Research

Ion Beam and Thin Film Laboratory — Studies focus on processing and properties of materials and structures in the form of thin films. The laboratory has a number of thin film deposition systems, including a state-of-the-art ultrahigh vacuum chamber that permits deposition on atomically clean surfaces. Thin film structures, basic elements of modern microelectronic and optoelectronic devices, are increasingly important in almost all areas of technology. Current research includes metal epitaxy on silicon, modification of surfaces with atomic and cluster ions, and development of novel dielectrics with properties controlled by light beams.

Microwave and Lightwave Engineering Laboratory — Research is ongoing in the areas of microwave device modeling and measurement, computer-aided design (CAD) of microwave components and systems, characterization of RF/microwave/optical systems, monolithic microwave integrated circuit design and testing, numerical electomagnetic codes, analysis design and wire antenna multiscattering in vegetation, experimental and theoretical study of linear and semiconductor surfaces, integrated optics, fabrication and characterization.

Multimedia — Research projects are in the areas of multimedia signal processing and compression, multimedia communications, digital content security and data hiding, Internet delivery of multimedia, and many others. The multimedia production and Internet delivery studio, with its state-of-the-art webcasting and DVD authoring platforms, facilitates the use of emerging Internet multimedia technologies for education and learning purposes. More than 30 faculty members and about 40 doctoral students are involved in multimedia research.

Communications and Signal Processing — Recent emphasis on wireless and personal communication systems includes multi-user detection and interference cancellation algorithms, smart antennas, and space-time processing. Other areas include adaptive systems and arrays, blind signal separation and equalization, synthetic aperture, radar processing and calibration, source encoding and synchronization, detection and estimation, and ATM networking. Signal processing research covers wide areas of nonlinear and adaptive signal processing and algorithms, one- and multidimensional signal processing, image-video coding, subband and wavelet transforms, QMF-wavelet filters, and advanced DCT algorithms.

Computer Engineering — Computer engineering faculty members are conducting research in these areas: test generation; fault simulation; design for testability; built-in self-test; data compression; CAD; computer architecture; design verification; computer reliability; fault tolerance; interconnection in high speed digital circuits; microprocessing;

Internet-based computer-aided instruction; interconnection networks; multiprocessor systems; nonlinear optimization techniques; genetic algorithms; neural networks; infrared imaging; computer networks; routing in ATM networks; LANs; CEBus; BACnet; parallel computing systems; parallel algorithms; computer vision; Petri nets; discrete event systems; embedded control; computer integrated manufacturing and networking intelligent automation; information display; robotics; ATM switches; and VLSI.

Electronic Imaging — Special filters are widely used in the characterization of chemical or biological systems. Much information on these systems can be deduced from spectral analysis of transmission and reflection of the samples, especially in the infrared (IR) spectral region. Researchers examine tunable filter systems, such as wavefront division interferometers (WDI), together with a two-dimensional IR imager. Such systems are based on multiplexing procedure, which minimizes optical loss. The resolution and the extent of the filtering process is determined by novel electronic processing methods. The goal is to develop a handheld instrument to monitor harmful molecules in a remote or a nearby environment.

Nonlinear Nanostructures Laboratory — Nanotechnology is a fast-growing interdisciplinary area. While many thin film and granular technologies are within the nano scale, nanotechnology is related to the "added value," i.e., the functionality, of nanostructures. The basic "building block," the nanocluster, is an ultrafine-grained solid with a high percentage of atoms at the grain boundaries. The non-linear optical properties of nanoclusters are of intense interest for use in optical switching and IR sensing. The confinement of the electronic wave function to small dimensions results in an enormous refractive index change. Experiments are under way on Si nanoclusters grown by either laser ablation or ion implantation.

Wireless Telecommunications — Research activities are distributed among four focus areas: wave propagation models for delivery of advanced broadband services and R.F. engineering of novel devices and systems for wireless digital communications technologies; wideband multiple access systems, and multi-user technologies including adaptive equalization and space-time adaptive processing; wireless networking including architectures, wireless ATM, geolocation, teletraffic modeling, resources allocation; and services, applications, and wireless technology transfer.

HISTORY

The Federated History Department of NJIT and Rutgers-Newark conducts research in a wide variety of historical fields, regions and periods. Faculty in the department have obtained many grants from government and private foundations such as the National Endowment for the Humanities; the National Science Foundation; the John Simon Guggenheim Memorial Foundation; Fulbright Fellowships; and the Spencer Foundation. The department produces two periodicals:

- Eighteenth-Century Scotland
- Horn of Africa

Areas of Research

History of Technology, Environment and Medicine — American environmental history; urban environmental history; the social and cultural history of medicine and technology (including gender issues); military medicine; history of mental health; history of print culture; film, television and history; and technology and warfare.

American History — Social, cultural and diplomatic history; the history of women and the family; African-American history; legal history; public history.

World History — Comparative history; economic history; intellectual, cultural, and political history; modern Africa; modern China; Latin America and the Caribbean; Russia and eastern Europe; medieval Europe and Eurasia; modern France, Spain and Britain.

HUMANITIES AND SOCIAL SCIENCES

The department integrates the humanities and social sciences for the purpose of understanding the cultural, social and scientific contexts informing contemporary culture. Special emphasis is given to research in the study of science, technology, and society; the study of communication; the study of environmental and health policy; professional ethics; the study of environmental and health economics; and the study of multicultural and international literature. The department is committed to using the humanities and the social sciences as a coherent model for examining human society. Research is conducted in these centers:

- Center for Architecture and Building Science Research
- Center for Policy Studies
- Institute for Transportation
- Multi-lifecycle Engineering Research Center

Areas of Research

Environmental Studies — Research is ongoing in policy studies, health, coastal geomorphology, economics, ethics, history, communications and education. The department hosts the nationally acclaimed environmental publication, Terra Nova.

Professional and Technical Writing — Multimedia design, distance learning, writing assessment, and environmental communications are areas that faculty currently pursue. The department hosts a new journal, Newark Review.

Contemporary Literature — This research area includes modern poetry, multicultural and international studies, and the relationship between literature and the natural world.

INDUSTRIAL AND MANUFACTURING ENGINEERING

The Department of Industrial and Manufacturing Engineering has a significant and diverse research program that includes areas such as industrial and operations research, design for manufacturing, quality, assembly and concurrent engineering, robotics, global networking, logistics and simulation issues of small and medium-sized companies, multimedia, environmental and health/safety and medical engineering. Research also is affiliated with these major NJIT research centers:

- Center for Manufacturing Systems
- Multi-lifecycle Engineering Research Center

Areas of Research

Industrial Engineering, Systems and Operations — Research includes the development of control and scheduling algorithms for the optimization of container terminal operations, global networking and logistics operations for small, medium and large corporations, the impact of telecommuting strategies on traffic flow, engineering system modeling and design tools, distributed virtual laboratory networks between research groups, the R&D of quality systems, quality control and management systems.

Manufacturing Systems and Mechatronics Engineering — Focus is on robotics, robot cell design, flexible computer integrated manufacturing, system integration of automation systems, flexible assembly system modeling, integration, implementation, non-contact sensing and inspection, CAD/CAM integration, servo pneumatic positioning, and sensor technology.

Concurrent/Simultaneous and Total Lifecycle Engineering — This new research field includes the development of new methods and toolsets for small batch luxury automobile manufacturers (such as Rolls-Royce Motor Cars), and general methods, tools and technologies for design for manufacturing, design for quality manufacturing, and assembly and maintenance systems.

Medical, Environmental, Health and Safety Engineering — Activity in this area is increasing. Main areas include the assessment of the realistic impact of environmental factors on productivity, devices and methods for the prevention of repetitive motion injuries, micro-robotic manipulators for human artery cleaning, and new medical devices coupled with simulators and expert systems that can be used for interacting with the human body and other medical applications.

Multimedia, Simulation and Virtual Reality Modeling — Research activities are spread between discrete event and continuous system modeling and simulation and areas such as graphical modeling of workcells, object-oriented simulation coupled with AI, engineering multimedia developments for the study of servopneumatic positioning, multimedia for total quality management and the ISO9001 standard, flexible automation, concurrent engineering and the virtual reality simulation (and rapid prototyping) of complex electromechanical products and their manufacturing/assembly processes.

MANAGEMENT

In addition to independent research, School of Management faculty are pursuing research conducted in affiliation with the:

- Center for Manufacturing Systems
- Center for Policy Studies
- Institute for Transportation
- Multi-lifecycle Engineering Research Center

Areas of Research

Entrepreneurship and Small Business — Assessment of emerging technologies, economics, employment growth, theories and practice in relation to entrepreneurship and private enterprise.

Building Production and Management — Building efficiencies, organization of international construction, environmental technology management, and industrial ecology systems.

Behavioral Science and Organizational Theory — Organizational design and development, organizational behavior, occupational and organizational socialization, legal and ethical issues, public administration, social perception, leadership, attachment and commitment processes in organizations, and transportation behavior.

Economics and Finance — Mathematical programming and multi-criteria decision making in financial management, portfolio analysis, emerging international capital markets, applied corporate finance, financial economics, public finance, international competitiveness of U.S. economy, and international economic/financial relationships.

Human Resources Management — Managing new technology, labor management relations, public policy and technological change, and tasks and unit level technologies.

Information Systems Management — Policy analysis, computer auditing, control and security, interface design, systems evaluation, technological forecasting and assessment, management information systems, management and social impacts of computer and information systems, group decision support systems, and database analysis.

Information Systems Auditing — Operational auditing, internal auditing.

Marketing Management — Marketing research, new product management, consumer behavior, international marketing, marketing technological innovation, mathematical programming and multi-criteria decision making, strategic management, sales management, enhancing global competitiveness, and technology transfer.

Operations Management — Project management, industrial quality control, production planning, management of manufacturing systems, and mathematical programming and multi-criteria decision making.

Corporate Law and Ethics — Employment law, legal and ethical issues in business, international legal environment of business, job security, and unlawful discharge/unjust dismissal.

MATHEMATICAL SCIENCES

The research interests of the faculty focus on the development and use of mathematical and computational tools for solving scientific, technological and industrial problems. The Center for Applied Mathematics and Statistics promotes and represents the research interests of all NJIT mathematical sciences faculty.

Areas of Research

Acoustics and Signal Processing — Faculty involved in acoustics study both the forward and inverse problem of sound propagation in the ocean. Work on the forward problem aims for accurate and computationally efficient solutions of the wave equation for complex oceanic environments. Research on the inverse problem addresses the development of algorithms for source localization and geoacoustic inversion, combining array and statistical signal processing concepts and waveguide physics.

Electromagnetics — The electromagnetics group is concerned with the scattering of electromagnetic waves by complex structures and materials. Methods used include modeling, asymptotics and numerical analysis. Applications to material processing are an important aspect of this work. Current and recent projects include the analysis of microwave sintering of ceramics including thermal runaway and hot-spot dynamics, electron beam welding of ceramics, nonlinear pulses in optical fibers and the development of numerical methods for Maxwell's equations in free-space and in complex, dispersive media.

Fluid Dynamics and Materials Science — Several faculty are involved in the development of analytical and computational methods and their application to problems arising in fluid dynamics and materials science. A particular area of emphasis is the study of the dynamics of interfaces between two fluids or a fluid and a solid. Research in this area includes liquid jet breakup, bubble dynamics, crystal growth, and flame front propagation as well as related problems in combustion and detonation. Other research areas include stability theory, particulate flows, viscoplastic flows, thin films, and physiological fluid mechanics (e.g., blood flow in arteries).

Mathematical Biology — This group is involved in two major research projects. First, the development of strategies to promote improved medical and therapeutic techniques, including use of coupled-oscillator theory for optimal walking strategies, use of elasticity theory for wound suturing and use of virtual reality in studies of epilepsy. Second, the development of testable mathematical models of neuronal networks including modeling the bistability of vertebrate motoneurons, modeling motor patterns in crustacea and modeling of hippocampal place cell dynamics in connection to memory recollection.

Statistics — Faculty research areas and interests include applied probability modeling, statistical inference, statistical reliability theory and applications, survival analysis and applications in biostatistics, time series analysis and forecasting, signal processing, design and analysis of industrial experiments.

MECHANICAL ENGINEERING

The scope of research in the Department of Mechanical Engineering is broad. Projects are carried out within the department's laboratories as well as in collaboration with the:

- Center for Manufacturing Systems
- Hazardous Substance Management Research Center
- Multi-lifecycle Engineering Research Center
- Particle Processing Research Center
- Polymer Engineering Center

Areas of Research

Bearings and Bearing Lubrication — Research areas include design of hydrodynamic, hydrostatic, rolling element bearings and novel designs of unique bearings, such as composite bearings. Also, the role of bearings in rotor dynamics is investigated. Students are engaged in the design and development of testing machines, which include computer data acquisition, for friction and wear, and for testing bearing materials and lubricant additives. Research is conducted in modeling and compensation of friction in control systems for precise motion control, stick-slip friction, friction-induced vibrations and anti-lock brakes. Work is conducted in modeling and measurement of dynamic friction in bearings, clutches, vehicle breaks and tires. Other research interests are rheology of lubricants, including viscoelastic and synthetic lubricants.

Computational Fluid Dynamics — The laboratory for computational fluid dynamics is equipped with state-of-the art computer equipment consisting of an SGI compute server (Origin 2000), four SGI 02 workstations and PCs. The purpose of the laboratory is the understanding, prediction and control of many fluid flows in the laminar, transitional and turbulent regimes. High performance computing, advanced data analysis, hydrodynamic stability theory and control theory are used for this purpose. Research includes boundary layer and channel flows, wake flows, film flows, ocean water waves, and propagating flames. Another thrust area is the numerical simulation of multiphase flows such as particulate and bubbly flows.

Electro-Hydrodynamics Research — The research aims at developing a fundamental theory of the synergism of electric- and shear-induced phenomena in suspensions and to examine the accuracy of predictions regarding the effects of high-gradient strong fields on the particle motions and aggregation. Understanding of these phenomena is used towards the control and manipulation of suspension flows. Applications include the development of a novel filtering technology for on-line cleaning of in-service fluids in shipboard equipment.

Granular Flow — The goal of this research is to develop predictive models of flowing granular materials critical to the design of efficient and reliable solids handling systems prevalent in the industrial sector (chemicals, food, agriculture, pharmaceuticals, minerals, energy, materials, munitions, and electronics), as particulates are universally found in most products either as raw materials or as the final product.

Investigations aimed at understanding observable bulk behavior are carried out as part of the Particle Technology Center and made through realistic dynamic computer simulations, analytical modeling and physical experiments. Paramount is the connection between microstructure evolution and transport properties. Phenomena of interest include hopper flows, vibrated beds, shearing, percolation in packed beds, and segregation.

Multiphase Flow Research — Research objectives are to develop a fundamental knowledge of hydrodynamic and interfacial interactions of phases in multiphase flows as well as develop advanced technologies related to particulate multiphase flows. Projects include drag forces and collisions of interacting particles in viscous flows, fibrous filtration of particulate-laden flows, membrane separation, wet scrubbing, liquid jet evaporation in gas-solid suspension flows, and filtration applications using rotating fluidized beds.

Non-Newtonian Fluid Dynamics — A knowledge of non-Newtonian fluid dynamics is essential in many industries, including those involving plastics, paints, suspensions, oils, lubricants, rubber, and detergents. Projects include theoretical and computational analyses of the popular constitutive equations for a range of flow problems, e.g. injection molding, porous media flows, viscoelastic particulate flows, free-surface flows, etc., as well as the modeling of non-Newtonian fluids. Both finite element and finite difference methods are used to solve the governing equations in two and three dimensions.

Particle Technology Research — Research includes fundamental and applied projects including modeling and development of novel techniques for dry particle coating and manufacturing of engineered particles; ultrafine particle mixing using dry methods, discrete element modeling (DEM) and numerical simulations of particle flows and processes; granulation with minimal use of liquids; particle transport; and handling/flow and delivery from hoppers. Some past projects were development of non-intrusive particle tracing technique for granular flow experiments; development of motion analysis algorithms for high-speed optical imaging of three-dimensional particle collisions; and pattern recognition and cluster analysis techniques to detect microstructure in granular flows.

Pattern Recognition/Cluster Analysis/Image Processing Research — This research focuses on the use of "soft computing" methods for various applications: fuzzy clustering algorithms, robust clustering, clustering of relational data, application of robust statistical techniques in cluster analysis, shape detection in noisy data, generalization of fuzzy clustering algorithms for multi-characteristic shape detection, such as hyper-spherical/ellipsoidal shells as cluster prototypes, or adaptive clustering, and cluster validity issues. Clustering methods and evidence collection techniques are used for lines, curves and arc detection in digital images. These algorithms are also used in reverse engineering through development of CAD models from image sensor data. Machine vision applications are also studied.

Plastics Engineering — The New Jersey Bell Plastics Laboratory is well equipped with a wide range of state-of-the-art plastics processing and forming equipment, supported by analytical testing capabilities. The laboratory is used for a wide range of research and development activities. Activities include re-engineering of commingled waste plastics, studies on self-reinforced composites, and combined parametric and experimental studies to develop models to explain the interrelationships between product properties and process parameters for injection molding processes. As part of the research activities, students use CAD and computer-aided engineering (CAE) tools in the design, analysis and manufacture of plastics products.

Rapid Intelligent Manufacturing and Prototyping — The research aims to generate fundamental knowledge and develop advanced technologies to enable the design and manufacture of products to be done more quickly and cost-effectively. Research projects include next-generation CAD/CAM system with virtual reality, rapid tooling and manufacturing, rapid freezing prototyping, and environmental performance analysis of solid freeform fabrication processes.

System Integration and Robotic — The research applies theoretical analyses, simulations and experiments to the design and control of mechanical and electromechanical systems (mechatronics). Kinematic and dynamic modeling, system calibration and optimization techniques are used to enhance system performance. Projects include development of design, planning, and control methodologies for effective use of parallel kinematics machines and development of ultrafine motion technologies to enable fast, flexible automated assembly of optoelectronics systems.

Waterjet Technology Research — The Waterjet Research facility develops technologies for the use of high- and super high-speed fluid jets for manufacturing complex components from hard-to-machine materials, cleaning and grinding of sensitive surfaces, and bio-medical applications. Projects include numerical modeling of fluid jets, developing expert systems for jet-based processing, precision cleaning of complex surfaces, using ice for machining applications, and using impact and explosion to form jets.

PHYSICS

Interdisciplinary applied physics research is conducted in collaboration with faculties of NJIT, Rutgers-Newark, Rutgers-New Brunswick, and UMDNJ in areas such as electrical engineering, chemistry and chemical engineering, materials science, industrial and manufacturing engineering, biological sciences and geological sciences. Cooperative research efforts are under way with the National Solar Observatory, Bell Labs-Lucent Technologies, U.S. Army Research Lab, and other industrial and federal research laboratories. Research also is conducted at these major NJIT centers and NJIT-maintained facilities:

- Microelectronics Research Center
- Center for Solar Research
- Big Bear Solar Observatory
- Owens Valley Radio Observatory

Areas of Research

Device Physics — Research at NJIT is under way in silicon microfabrication, micromachining and fusion bonding for conventional and novel microelectromechanical (MEMS) device applications, metal-insulator-semiconductor device structures and rapid thermal processes in silicon integrated circuits. Studies at Rutgers-Newark involve sensors for biophysics applications. Facilities for this work include state-of-the-art metrology electrical characterization equipment, cryostats for very low temperature measurements and access to NJIT's Class 10 cleanroom with full process capabilities for 6-inch silicon wafers.

Materials Research — Molecular beam epitaxy (MBE) of III-V semiconductors is used to fabricate various photonic devices, digital integrated circuits, and optoelectronic integrated circuits. Research on the synthesis and characterization of chemical vapor deposited (CVD) and physical vapor deposited (PVD) silicon-based dielectric films is ongoing. Optical characterization of materials includes visible and far-infrared spectroscopy, photoconductivity, photoluminescence, spectral emissometry and thermal modulation spectroscopy. Materials studies include photoinduced superconductivity in High-Tc materials (i.e., YBCO) and optical properties of SiC, GaN and porous silicon.

Ultrafast Optical and Optoelectronic Phenomena — Terahertz spectroscopy is used to study ultrafast carrier dynamics in semiconductors. Other areas include ultrafast photodetectors, ultrashort nonlinear pulse propagation in optical fibers and planar waveguides, ultrafast photophysics of semiconductor and quantum well devices, and ultrafast optical switching in novel nonlinear materials. The Ultrafast Optics and Optoelectronics Laboratory is capable of producing ultrashort laser pulses of 100 femtosecond duration over a tuning range of 230-nm (ultraviolet) to 2300-nm (infrared).

Optical Science and Engineering Education — The National Science Foundation (NSF) is supporting the development of an optical science and engineering curriculum with optics research collaboration among NJIT's physics, electrical and computer engineering, and chemical engineering, chemistry and environmental science departments.

Solar Physics — The Center for Solar Research operates two world-class observation facilities: Big Bear Solar Observatory (BBSO) and a dedicated array of solar radio telescopes at Owens Valley Radio Observatory (OVRO), both in California and both formerly managed by Caltech. Research focuses on the development of state-of-the-art instruments for solar observations; the study of solar magnetic fields and extended atmosphere; and the study of solar activities and their terrestrial effects. Solar physics interacts closely with other research areas at NJIT including device physics, image processing and atmospheric chemistry. With the acquisition of BBSO and OVRO, the NJIT physics department has one of the best-known university-based research efforts in solar physics in the world.

Imaging Technology — A developing initiative builds upon NJIT's nationally recognized work in infrared imaging technology, applying it to the promising area of infrared solar physics. State-of-the-art infrared imaging devices are being developed and tested as part of an IR telescope system to be installed at Big Bear Solar Observatory.

Free Electron Laser Physics — The free electron laser (FEL) on the Rutgers-Newark campus generates short tunable far infrared (FIR) pulses allowing a new class of experiments to be carried out at wavelengths of 150-400 microns. The unique time dependence of the Rutgers' FEL will be used to develop an important class of transient FIR experiments with 50 picosecond resolution. Photon echo techniques using the Rutgers' FEL will be applied to obtain significantly improved resolution for the FIR spectra of DNA. Similar techniques will be used to study quantum wells in semiconductors.

Surface Physics — This area focuses on research on laser-induced physical processes on surfaces. One area of current interest is laser-stimulated hydrogen ion desorption from a hydrogenated Si (100) surface. Another area is the interaction of spin polarized atoms with surfaces.

Discharge Physics — Research on glow discharges for plasma processing of semiconductors and other materials is being carried out under an NSF-sponsored program. Related studies on VUV (vacuum ultraviolet) light sources and unique laser pumping schemes are also under way.

Applied Laser Physics — With industry funding, research is being carried out at Rutgers-Newark on laser processing of materials with low thermal conductivity. The physics involves heat transport, laser properties and material properties. New instrumentation to resolve variations in temperature in time and space is being developed. This work is in collaboration with the Department of Ceramics and Engineering in the Rutgers College of Engineering in New Brunswick.

Biophysics — An NSF-funded research training group program in collaboration with the Rutgers-Newark's chemistry department, the federated biological sciences department and Rutgers-Newark's Center for Molecular and Behavioral Neuroscience provides training and research opportunities in frontier interdisciplinary biophysics areas including spectroscopy, signal processing and biomedical instrumentation. One area of great current interest involves the use of stable isotope tracers for medical diagnostics. Another is the development of microsensors to probe nonlinear auditory response in mammals.

TRANSPORTATION

The interdisciplinary program in transportation through its Institute for Transportation involves about 30 NJIT faculty and 25 NJIT graduate students in its research and program activities. Congressional legislation requires that TELUS (Transportation Economic and Land Use System) be customized and deployed for use throughout the United States. TELUS is a computerized system for tracking the progress of transportation projects and assessing their economic and land use impacts and interrelationships. Institute research activities are associated with the following centers at NJIT:

- National Center for Transportation and Industrial Productivity (NCTIP)
- New Jersey Center for Transportation Information and Decision Engineering (TIDE)

Areas of Research

Mitigation of Increased Highway Congestion — resulting in reduced productivity, increased gridlock, pollution and fuel consumption.

Advanced Traffic Control and Engineering — are requiring new systems for traffic management and new engineering and management techniques to expand the capacity of the transportation infrastructure.

Intelligent Transportation Systems — resulting in more efficient use and increased safety for the existing transportation infrastructure.

Increased Competition — for railroad, truck and air carriers because of deregulation. Carriers must further reduce costs while providing high quality service and consider that a smaller number of large companies may dominate the market.

Globalization — of markets requiring the ability to efficiently move goods over long distances often using multiple carriers. Several large transportation consortia are likely to establish themselves in world markets in the next decade.

Reduction in Public Assistance to Transportation — and the high social and political costs of building new transportation systems placing a tremendous emphasis on improved management of existing facilities, thereby requiring the introduction of innovative financing practices and larger participation from the private sector.

Increase in Social Awareness — demonstrated by society's concern with the energy consumption of scarce fossil fuels and the negative by-products of transportation such as noise, air and water pollution.

Streamlining the Logistics Process — to reduce transportation and inventory costs through the expedition of raw materials from origins to production plants, semi-finished products between plants, and finished products to consumers.

Intermodalism — to combine the best of two or more modes of transportation for the coordinated movement of people or freight. The economy of line haul with the flexibility of another mode for local collection and distribution is an example.

Aircraft Routing — to reduce aircraft noise and to improve air traffic operation.

Library Services

The university's Robert W. Van Houten Library is located in the heart of campus in a new facility for study, research and browsing. The library has a collection of more than 150,000 books, and subscribes to more than 1,000 printed periodicals and about 1,500 electronic journals. The library's home page provides access to NJNEER, the library's electronic catalog, and links to a wide array of information services.

The library's Information Commons, located on the first floor, is designed to provide a unique variety of services to satisfy student information needs. Commons workstations have computers for searching World Wide Web sites, computers for searching the NJNEER on-line catalog, access to CD-ROM based databases, and access to a variety of on-line journal databases, many providing full-text articles. VCRs for viewing videocassettes reserved for courses are also available, as are computers with word processing and other services. A student user manual describing library services is available at the library's circulation and reference desks.

Journal and conference literature in engineering, science, management, architecture and other subject areas is accessible through a variety of indexing and abstracting publications, in both print and electronic format. Among the databases available on line are CompendexWeb (Engineering Index), Proquest Direct (articles on business, management and industry), Applied Science and Technology Index, Avery Index to Architectural Periodicals, and UnCover, a document delivery service that faxes articles within 48 hours.

The librarians provide individualized reference services, literature searches, and instruction in the use of information resources. There are ten professional librarians providing such services, each holding a master's degree in library science and, among the group, degrees in chemistry, industrial engineering, information science, art, mathematics and liberal arts. They also act as liaisons to NJIT academic departments in materials selection and assistance.

The Architecture Library, a branch of the Van Houten Library, is located on the fourth floor of Weston Hall, part of the Architecture and Building Sciences Complex. The collection includes more than 13,500 volumes of books and journals, nearly 80,000 slides, and more than 1,000 maps in addition to product catalogs, videotapes, CD-ROMs, models, portfolios and theses. The makeup of the collection is primarily architecture — including history, theory, design and practice — and secondarily art, design, structures and planning. Access to the architecture journal articles is provided by the Avery Index to Architectural Periodicals on the Web and the Art Index on CD-ROM.

In addition to NJIT's libraries, students have full access to nearby Rutgers-Newark's Dana Library, UMDNJ's Smith Library and Newark Public Library. Students may also borrow from the libraries of New Jersey City University, Kean University, Ramapo College, Rowan University, Stockton State College, William Paterson University, College of New Jersey, and Montclair State University.

More information about the library can be found at www.njit.edu/Library/Welcome.html or by calling (973) 596-3210 (reference desk), (973) 596-6371 (circulation desk).

Information Services and Technology Resources

NJIT's information services and technology resources provide members of the university community with universal access to a wealth of resources and services available over the NJIT network and the advantages of a highly computing intensive environment. In 1998 and again in 1999, Yahoo! Internet Life magazine has ranked NJIT America's "most wired" public university in the nation for the use of technology as measured by a set of indicators that include academics, student services, communications, and technology infrastructure. Students have the opportunity to experience many aspects of a "virtual university." The latest advances in telecommunications and multimedia technology enhance the delivery of courses and overall educational experience for all students. As a member of the Internet2 research consortium, students have the opportunity to work closely with faculty and researchers as new families of advanced networking applications are developed for the new millennium. NJIT has issued a PC to all incoming freshman students as a part of tuition since 1985. NJIT also operates an on-campus PC store where all students, faculty and staff may purchase PC hardware and software and a PC maintenance facility for service and support.

Computers and information technology play an important role in virtually every task performed on campus, from cutting-edge research to parking-space reservations. Computers assist in teaching and independent study, campus communications, library research, engineering and architectural designs. Computers allow students to register for classes and choose course schedules and ask questions of academic advisors. Students can access the tools they need to design new buildings, develop complex solutions to engineering problems or compile detailed management analyses — all by logging on to the NJIT network.

The Newark campus' ATM network backbone connects more than 3,900 nodes in classrooms, laboratories, residence halls, faculty and staff offices, the library, student organization offices, and others. The network provides access to a wealth of shared information services. Some of these include high-performance compute servers providing CPU cycles for simulation and computational research, disk arrays for storage of large data sets, communication servers for electronic mail and document exchange, databases, digital journal subscriptions, and a virtual "Help Desk." A virtual private network combined with Internet access, plus a large ISDN modem bank extend access to campus information resources to faculty, staff and students anywhere working at home, work, any of the university's many extension sites, or throughout the world.

Primary academic computing is provided via a distributed computing environment using the Andrew File System (AFS). Students receive a single log-on account that provides access to hundreds of UNIX and NT-based workstations on the campus network for programming, computation, Internet access, graphics and visualization facilities, and many other applications. Powerful statistical analysis software is provided on a separate VMS computing system. The Academic Computing lab in the Student Mall has several hundred PCs for student use. Additional PC clusters are available in the Honors Center, the Robert W. Van Houten Library, the University Learning Center, and many departmental facilities.

NJIT is home to the EIES/VC Virtual Classroom® conferencing system, one of the first computerized conferencing systems to be used for distance education. Each semester more than 2,000 students use the Virtual Classroom® system as a meeting place for class group discussion.

The Van Houten Library's Information Commons provides a convenient and relaxed atmosphere to search the Web, access electronic databases, view videotapes and other electronic archives of class lectures, or retrieve scholarly publications through digital library subscriptions. Reference librarians are available to help students sort through the vast amounts of information resources available and access what they need.

The Office of Instructional Technology and Media Services provides several facilities used for live and taped broadcast of telecourses as well as satellite downlinks for a wide variety of video teleconferences and other educational and public service satellite broadcasts. Several interactive television studio classrooms provide distance learning between Newark, NJIT's Mount Laurel campus and corporate education centers.

The New Jersey Center for Multimedia Research, a partnership between NJIT and Princeton University, has several facilities on the Newark campus for conducting its coordinated multimedia research program aimed at enhancing education and industrial competitiveness in New Jersey and the region. The center's Multimedia Production and Internet Delivery Studio is fully equipped to provide live Internet webcasting.

In addition to these extensive resources, several departments have special facilities for the support of individual academic programs, including the School of Architecture's award-winning Imaging Laboratory that provides students an opportunity to explore new media and images that alter the way buildings are visualized, interpreted and created.

All students and faculty are encouraged to make full use of the computing facilities including e-mail and personal Web pages. Students may obtain accounts by following an on-line tutorial in one of the many computer labs. Once an account is set up, students may take advantage of an on-line, self-registration system to enroll in courses for subsequent semesters. NJIT alumni are provided free lifetime e-mail.

Accreditation

NJIT is accredited by the Middle States Association of Colleges and Schools (MSACS), Commission on Higher Education.

All of NJIT's eligible professional programs, both graduate and undergraduate, are accredited by the respective accrediting agency for their field:

AACSB	American Assembly of Collegiate Schools of Business
CSAC/CSAB	Computer Science Accreditation Commission of the Computing Sciences Accreditation Board
EAC of ABET	Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology
NAAB	National Architectural Accrediting Board
NLNAC	National League for Nursing Accrediting Commission
TAC of ABET	Technology Accreditation Commission of the Accreditation Board for Engineering and Technology

Addresses and telephone numbers for all of the accrediting agencies are listed in the Accreditation Appendix on page 172.

Consortium with Rutgers-Newark and UMDNJ

NJIT, Rutgers-Newark and UMDNJ, New Jersey's university of the health sciences, offer more than a dozen collaborative and joint graduate degree programs, placing them as leaders in development of programs to prepare individuals for a world increasingly multidisciplinary and technological in nature. NJIT, Rutgers-Newark and UMDNJ have developed The Graduate Center at Newark to provide a range of resources and opportunities. With three leading universities collaborating on graduate research programs across a variety of disciplines, the University Heights section of Newark is a dynamic place of new discoveries and new developments.

The three institutions are also part of University Heights Science Park, designed as a mixed-use, multi-sponsor science and technology park and is a partnership among academia, the community, private industry, and local, state and federal governments. Science Park's creation will provide opportunities to transfer university-based research and technology to public uses. The 50-acre University Heights Science Park is adjacent to the NJIT campus.

NJIT at Mount Laurel

Students may earn a master's degree in a variety of degree programs by attending NJIT at Mount Laurel. Centrally located in Burlington County, NJIT at Mount Laurel offers courses at the new state-of-the-art Technology and Engineering Center, one of South Jersey's finest educational facilities, operated jointly by NJIT and Burlington County College. Students can complete master's degrees in computer science, electrical engineering, and engineering management. Specialized classes via distance learning, graduate certificate programs and continuing professional development courses are also offered at NJIT at Mount Laurel. For additional information about graduate programs at this branch campus, call 1 (800) 222-NJIT or (973) 596-3060.

Continuing Professional Education

NJIT's Division of Continuing Professional Education provides distinctly different career-long learning opportunities through Extension Programs, ACCESS/NJIT Distance Learning, Graduate Certificates, non-credit Professional Development Training and Corporate Customized Training.

Twelve-credit Graduate Certificates, which are also applicable to NJIT master's degrees, are available to those seeking a career upgrade and change. A certificate can be acquired in one calendar year by attending classes on campus, at extension sites throughout New Jersey, or through video/electronic means that are asynchronous, neither time- nor location-bound.

Professional development programs include short courses, certificates and license reviews, with some leading to the award of continuing education units (CEUs). The CEU is used nationally to document the type, quality and duration of study. In general, one CEU is defined as being equal to 10 classroom hours. Taught throughout the year, individual classes typically last one to five days. Certificates and license review programs can entail a significant number of hours of instruction spanning several months.

All professional development courses can be adapted to meet a particular organization's need and conducted as a custom-designed training program at a company site. For more than 50 years, NJIT has been designing and conducting non-credit courses that meet technology-based organizations' needs for high quality, lifelong workforce education. More than 375 courses are available in 17 subject areas.

For further information contact the Division of Continuing Professional Education, at 1 (800) 624-9850 or *www.njit.edu/cpe*.

Extension Programs

Students may take courses and earn degrees throughout the state at NJIT's extension sites listed below. Admissions requirements and the quality of instruction are the same for on-campus and extension programs. Registration, advisement and support services are available at each site.

Atlantic County at the FAA Technical Center: courses leading to completion of a Master of Science in Computer Science and in Information Systems.

Bergen County at Bergen County Community College: courses leading to completion of a Master of Science in Management.

Bergen County at Ramapo College: courses leading to completion of a Master of Science in Computer Science and in Information Systems.

Burlington County at NJIT's Mount Laurel campus: Master of Science degrees are available in Computer Science, Engineering Management, and Information Systems.

Mercer County at Mercer County Community College: courses leading to the completion of a Bachelor of Science in Engineering Technology, Construction Engineering Technology Option.

Mercer County at the Department of Transportation: courses leading to the completion of a Master of Science in Transportation.

Mercer County at the Department of Environmental Protection: courses leading to the completion of a Master of Science in Environmental Science.

Morris County at Drew University: courses leading to Master of Science degrees in Computer Science, in Information Systems and in Management.

Passaic County at William Paterson University: courses leading to Master of Science degrees in Computer Science and in Information Systems.

Somerset County at Raritan Valley Community College: courses leading to the completion of a Master of Science in Management.

The Office of Extension Programs also offers graduate courses on site at technology-based organizations, including AT&T, Bell Atlantic, Dendrite International, Dialogic, Lucent Technologies, Merrill Lynch, and National Starch and Chemical Company. These courses are available only to the employees of the host corporations.

For more information about these and other off-campus programs, call the Division of Continuing Professional Education at (973) 596-3640.

ACCESS/NJIT Distance Learning

ACCESS/NJIT provides students the opportunity to earn college credit through enrollment in on-line electronic-based courses. Each on-line course combines video media with electronic interaction primarily through Web-based and computerized conferencing under the management of an NJIT course mentor. On-line courses are flexible and rigorous educational experience suited to motivated students.

The program's reach is nationwide and international. Course material is transmitted through the Internet, cablecast, wireless cable, compressed digital teleconferencing, and VHS tape distribution. In addition, ACCESS/NJIT originates programming for the National Technology University, a satellite-distributed provider of graduate courses for technological professionals.

ACCESS/NJIT offers two graduate degrees (M.S. in Engineering Management and M.S. in Information Systems), two undergraduate degrees (B.A. in Information Systems and B.S. in Computer Science), select graduate certificates, and courses in many disciplines including the physical sciences, computer science, mathematics, engineering and management. ACCESS/NJIT offerings are listed in the Continuing Professional Education (CPE) Catalog, available upon request from the Division of Continuing Professional Education and via the NJIT Web site, *www.njit.edu/dl*.

ACCESS/NJIT furnishes a convenient alternative to distance learners and students who have scheduling conflicts. In addition, any NJIT student needing course review can use ACCESS/NJIT course material. Several campus workstations in Van Houten Library are set up for viewing.

For more information, contact the Division of Continuing Professional Education at 1 (800) 624-9850.

Graduate Student Association

The Graduate Student Association was founded in 1983 to promote the interests of graduate students, enhance program quality, foster student-faculty communication, and provide for the needs of advanced degree students.

All students currently enrolled in NJIT graduate degree programs and paying the Graduate Student Association fee are members of GSA. A current graduate student and an alternate from each degree program are represented on the GSA Council. Students interested in serving on the council or learning more about GSA should contact the GSA office (973) 596-2993 or the Office of Graduate Studies (973) 596-3462. The dean of graduate studies is the GSA advisor.

Graduate Honor and Professional Societies

Alpha Epsilon Lambda Honor Society

The Sigma Chapter of Alpha Epsilon Lambda, the National Honor Society for Graduate and Professional School Students, was established in 1995 at NJIT and is the first chapter in New Jersey. Membership is based on standards of scholarship, leadership and character, and is by invitation. Contact the Dean of Graduate Studies, (973) 596-3462, for more information.

Other Honor and Professional Societies

Each program offering graduate degrees at NJIT will have information about honor and professional societies open to graduate students in particular disciplines. Contact the dean of the appropriate school or college or the dean of graduate studies for further information. NJIT also has active chapters of Omicron Delta Kappa, a service-oriented society, and Sigma Xi, which focuses on research.

Child Care Center

The NJIT child care center, currently operated by Childtime Children's Centers Inc., is located on the first floor of NJIT's Enterprise Development Center II building, 105 Lock Street. The center is available to children of NJIT employees and students, employees of tenants in the university's incubator program and residents in the neighboring community. The center is licensed by the State of New Jersey.

The center is for children age 6 weeks to 5 years. Programs and activities are divided into levels for infant, young toddler, toddler, young preschooler and preschooler. Developmentally appropriate activities for each age group include hands-on pre-math, science, language and reading activities. An after school program is also offered to children ages 5 through 13.

The center operates year round, 6:30 a.m. to 6:30 p.m. Monday through Friday, excluding university holidays. For further information, call Childtime Children's Centers Inc. at (973) 645-0442.

Parking on Campus

All vehicles parked in NJIT lots and the parking deck must be registered with the Department of Public Safety, and must display a valid parking permit. Access to NJIT parking lots is controlled by using a validated student ID card. The cards are obtained at the Department of Public Safety, which is located in the parking facility. A separate fee is required for on-campus parking. Vehicle registration materials are mailed to all NJIT students who are registered for classes prior to the start of each semester. Registration materials also are available at the Department of Public Safety front desk. For more information, refer to the Parking and Traffic Regulations pamphlet, available at the Department of Public Safety.

NJIT Campus

Located in the University Heights section of Newark, NJIT's 45-acre campus is adjacent to the campuses of Rutgers-Newark and Essex County College and a short distance from UMDNJ. The campus is reached easily via interstate highways and public transportation. New Jersey Transit's City Subway stops on campus, the Pennsylvania Railroad Station is five minutes from campus and Newark International Airport is within 5 miles of NJIT.

The expansion and improvement of NJIT's campus facilities have been vigorous, proceeding pursuant to a carefully drawn long-range plan, providing an environment conducive to accomplishment of the university's mission. Most recently, a new Building Sciences Complex was completed and serves as home to the School of Architecture and the Department of Civil and Environmental Engineering. Renovation of office space for faculty in the College of Science and Liberal Arts also was completed, as was a second technology business incubator and a multi-institutional center for biomedical research.

NJIT's campus is home to some 30 R&D centers supported with industry, state, federal, foundation and university funding. NJIT's three-story Otto H. York Center for Environmental Engineering and Science houses a number of state and federally funded research centers.

The 187,000-square-foot William S. Guttenberg Information Technologies Center houses the Center for Manufacturing Systems and the Multi-lifecycle Engineering Research Center. It also houses the web-casting and production facilities of the New Jersey Center for Multimedia Research, as well as fully equipped television studios, and interactive, distance-learning classrooms with satellite and land-line communications. The building is the site of the computer and information science, and industrial and manufacturing engineering instruction and research facilities.

The campus center houses the Food Court, Dining Room and a more informal eating facility, The Pub. In addition, there is a campus theater in which student productions are staged, an athletic field, tennis courts, and indoor recreational facilities including a swimming pool, racquetball courts, weight rooms, track, aerobics room, and more. The residence halls provide dormitory and apartment-style co-ed living accommodations for close to 1,200 students.

A Look at Student Life

NJIT offers a wide range offers a wide range of extracurricular programs from sports to professional societies.

NJIT has an extensive intercollegiate sports program. Men's sports are baseball, basketball, fencing, judo, soccer, swimming, tennis and volleyball. Women's sports include basketball, fencing, judo, swimming, tennis and volleyball. The intramural program includes all sports available at the intercollegiate team level plus track and field, racquetball, flag football, badminton, softball and archery.

There are 15 social fraternities, most with residential facilities, and 9 sororities, 10 honor societies, and 27 professional recognition societies. The latter include Tau Alpha Pi, Phi Eta Sigma, Tau Beta Pi, Sigma Xi, Alpha Epsilon Lambda, and the American Chemical Society, the American Institute of Aeronautics and Astronautics, the Society for Technology, the Society of Women Engineers, and the Society for Advancement of Management, to name a few. There is an active professional society for almost every major field of study offered by the university.

The Student Senate administers a wide range of programs through the Student Activities Council, various honor societies, and the Cabinet for Professional Societies and Cultural Organizations. Some of these activities include chess, lacrosse, the Vector newspaper, the Nucleus yearbook, ham radio, photography, theater, and radio broadcasting. Graduate students also enjoy participating in the NJIT chapter of Pugwash USA and Computer Club 2 (YACC2).

NJIT is within walking distance of the Newark downtown area and nearby campuses, which, along with NJIT, are located in Newark's University Heights section. Students may take advantage of Newark's nationally ranked museum, library, Symphony Hall, and New Jersey Performing Arts Center (NJPAC) and may enjoy the city's burgeoning art and jazz scene. In addition, students have easy access to the vast cultural resources of the New York/New Jersey metropolitan area. NJIT is located only 20 minutes from midtown and downtown Manhattan, and the city is easy to reach by bus, train, or car. A joint Rutgers/NJIT shuttle bus provides regular free commuting service to principal transportation centers.

There are frequent distributions of discount tickets to shows, museums, concerts, and sports events. The Student Activities Council and many professional and cultural organizations follow their various interests on weekend trips throughout the Northeast United States.

And there's the Hazell Center, where students gather to eat, plan programs and activities, socialize, work on publications, bowl, shoot pool, watch movies, play chess, or just relax.

NJIT provides an environment in which students may learn, not only in the classrooms and labs but on the playing field; not only from their faculty but from each other.

Staff from the Office of the Dean of Student Services are available until 5:45 p.m. Tuesday through Thursday to provide information to evening students. Quarterly throughout the year, evening students are mailed a schedule of special events and academic workshops.

The Counseling Center is open weekdays, including evening hours, to provide counseling, psychological services or referral for adult students who face stress from academic, personal or employment responsibilities.

Student Services

The dean of student services administers and coordinates the activities of the Student Services Division including the Hazell Center, the Counseling Center, Health Services, Residence Life, the University Learning Center, and the University Research Experience. Special services for evening and disabled students are provided. The office also is the liaison for Food Services, The Pub and the NJIT Bookstore.

The office is located in Student Services, Campbell Hall. The phone number is (973) 596-3466/3470.

The Hazell Center

The Hazell Center is a place for cultural, educational and social activities for the NJIT community. The Hazell Center staff strives to provide students, faculty and staff with a relaxing environment where they can enjoy a meal, study, watch a film, play billiards or a variety of other games, participate in the many activities offered, or just socialize with friends. The Offices of Student Activities, Greek Life, Women's Center, and Miniversity are located within the building. The center also houses a wide variety of student clubs and organizations including the Student Senate, Graduate Student Association (GSA), Student Activities Council (SAC), university newspaper (Vector), yearbook (Nucleus), and radio station (WJTB). More than 50 student-run cultural, professional, special interest and social clubs and organizations share office space in the Hazell Center.

On the lower level of the center is a recreation area with bowling, billiards, table tennis and video games. A variety of tournaments are offered each semester. The majority of student organization offices, radio station WJTB and The Pub are also located on the lower level. The main level of the center houses the Food Court, Student Dining Room, Information Desk and offices of the director of the Hazell Center, assistant director for Greek Life, and the reservation manager. The second floor of the center houses the offices of the associate director for student activities, the Women's Center, Miniversity and several student organizations. This floor also contains the Ballroom, which is used for a variety of large events, several meeting rooms, an art gallery and the Faculty/Staff Dining Room.

The Hazell Center Information Desk personnel provide information about the campus, community events, and public transportation. The Information Desk also has a university telephone directory, campus maps, discount tickets for Broadway shows, postage stamps, and mail service. Two computers also are provided for students to check class schedules, grades, and registration information. The Hazell Center Office also provides fax service for a nominal charge. The phone number for the Information Desk is (973) 596-3605.

The Constance A. Murray Women's Center

The Constance A. Murray Women's Center provides a hospitable environment for all women at NJIT. Located on the second floor of the Hazell Center, the women's center offers a wide range of resources, including a multimedia library, computer workstations and access to a World Wide Web database about women in technology. The center contains space for small group meetings, study, tutoring, and research. It provides a forum for women to discuss matters of mutual concern, including issues related to the academic and social environment at NJIT. It sponsors programs and events especially designed to facilitate mentoring and career networking among women. The center also supports research about women and technology and fosters efforts to explore the continued integration of gender into the curriculum. The lounge/study area is open to all members of the NJIT community daily, Monday through Friday.

International Students

The Office of International Students and Faculty offers numerous services and programs to aid students in their adjustment to NJIT. Because immigration regulations frequently change affecting the status of students, all international students holding nonimmigrant visas (especially F and J visas) must attend a mandatory orientation program prior to the beginning of their first semester. F-1 and J-1 students must maintain full-time registration (12 credits per semester), except for special cases as defined by immigration regulations. Students on dependent visas (such as F-2, J-2 and H-4) should consult with the Office of International Students and Faculty if change in status or full-time study is contemplated. The office is located in Eberhardt Hall, Room B10. The phone number is (973) 596-2451.

Students with Disabilities

The coordinator of Student Disability Services assists students with disabilities in the NJIT Counseling Center. Assistance services may include: providing general information; counseling; coordinating academic accommodations such as special testing arrangements or adaptive equipment; coordinating the provision of auxiliary services such as note takers, sign language interpreters, readers; and liaison with faculty, staff and other agencies. Services are provided to students with documented disabilities and require meeting with the coordinator, submitting documentation and completing appropriate forms. For further information or to discuss accommodations, please contact the coordinator of student disability services in the Counseling Center. The Counseling Center, located in Student Services, Campbell Hall, is open from 8 a.m. to 6 p.m. Monday through Thursday and 8 a.m. to 5 p.m. Friday during fall and spring semesters; from 8 a.m. to 5 p.m. Monday through Thursday and 8 a.m. to 4 p.m. Friday during summer sessions. The phone number is (973) 596-3414. Scheduling an appointment is important to ensure availability and make arrangements for appropriate accessibility.

Immunizations

The State of New Jersey and NJIT require all students to submit proof of having two doses of measles vaccine and one dose each of mumps and rubella vaccine. A tuberculin test (PPD) and entrance physical exam also are required. If documentation is unavailable then re-immunization is required. Contact the Office of Health Services for further information.

Health Insurance

The State of New Jersey and NJIT require all students enrolled full-time and all international students to maintain health insurance coverage that provides basic hospital and medical benefits. Coverage must be maintained throughout the student's enrollment. Insurance may be provided by the student or may be purchased through the university. Students may waive participation in the NJIT plan for the full academic year. To waive insurance, the student must complete a waiver form and submit it to Health Services within the 30-day enrollment period at the beginning of the semester. Waiver forms and insurance brochures are available in the Office of Health Services. International students with J-1 visa status must be covered by an insurance package at all times as specified by the U.S. Information Agency, which generally exceeds NJIT's plan coverage. Further information about required coverage and/or enrollment can be obtained from the Office of International Students and Faculty.

Part-time students also may purchase health insurance through NJIT within the 30-day enrollment period at the beginning of the semesters. Insurance also may be purchased for dependents.

Health Services

To function well in a college setting, a student must be physically healthy. To ensure the good health of our students, the Office of Health Services provides primary health care to all enrolled students who have submitted a complete medical examination form.

Services offered to eligible students include the assessment and treatment of health problems and injuries, laboratory tests, health counseling and education. Referrals are made to area hospitals, physicians and other resources when necessary.

The office also coordinates mandatory immunization requirements, which apply to all students. Information on immunization requirements is available at the Office of Health Services.

The office is open 8:30 a.m. to 4:30 p.m., Monday, Wednesday and Thursday and 8:30 a.m. to 6 p.m. Tuesday and Friday during fall and spring semesters. Physicians are available for consultation in the Office of Health Services by appointment during the academic year. Summer hours are 9 a.m. to 4 p.m., Monday through Friday. Health services staff may be reached at (973) 596-3621.

Counseling Center

The Counseling Center, staffed by experienced psychologists and professional counselors, provides services for students seeking psychological, academic, and substance abuse counseling. In addition to the professional counseling staff, a psychiatrist is available for consultation as needed. The Counseling Center also offers workshops on different topics, maintains a library of career and graduate school information, coordinates services for students with disabilities, and administers supportive testing. Students are welcome to come in and browse through the informational materials or call for an appointment with a counselor. Office hours are scheduled so that services are also accessible to adult evening students.

The Counseling Center is open is open from 8 a.m. to 6 p.m. Monday through Thursday and 8 a.m. to 5 p.m. Friday during fall and spring semesters; from 8 a.m. to 5 p.m. Monday through Thursday and 8 a.m. to 4 p.m. Friday during summer sessions. The Counseling Center offers professional counseling to adult students facing stress from academic, personal, family or employment responsibilities. Counseling services are confidential, with limited exceptions. Call us at (973) 596-3414 for an appointment. The center is located in Student Services, Campbell Hall.

Stop-In Center

The Stop-In Center, staffed by trained student peers, provides on-the-spot information and assistance about all aspects of college life. Peer counselors are prepared to talk with fellow students about a wide range of questions or concerns — academic or personal — as well as provide relevant information. If they are unable to resolve a problem directly, they refer students to the person or office that can. No appointment is necessary and students are invited to stop by (downstairs in the Hazell Center, Room 021) and become familiar with the staff and services available. The phone number is (973) 596-3422 and the Stop-In Center is open weekdays during the fall and spring semesters.

Residence Life

NJIT provides on-campus housing for undergraduate and graduate students. The residence halls have 24-hour security at the front desk. Full-time professionals and student staff maintain the residence halls.

Redwood Hall is a coed facility that houses 210 freshmen and some sophomores in double rooms. There are two large bathrooms on each floor and a microwave in the kitchen located on the first floor.

Cypress Hall is a coed facility that houses 420 sophomore, junior, senior, and graduate students in two-room suites and single rooms. Single rooms are reserved for students with disabilities. Each suite has a shared bath, and single rooms have private baths. There are common lounges and kitchenette facilities on each floor. Each lounge has a microwave that is always accessible.

Oak Hall is a coed facility that houses 238 junior, senior, and graduate students in furnished double and triple rooms and five-person apartments. Each apartment has a kitchen and bath. A floor has been designated for graduate students. The 5-person apartment consists of a bathroom, a lounge that includes a kitchen and 2 bedrooms to be shared by the five students (two in one bedroom and three in the other). The double and triple rooms include a kitchen, and a bathroom to be shared with the adjacent room.

Laurel Hall is a coed facility that houses 298 sophomore, junior, senior, and graduate students in two-room suites of various combinations. Single rooms are reserved for upper division and graduate students. Each suite has a shared bath. There are common lounges and kitchenette facilities on each floor. Each lounge has a microwave oven.

Each residence hall provides PC connectivity to on-campus academic computing resources and the Internet.

Students may apply for on-campus housing after being accepted for admission. Residence hall contracts are for the entire academic year. A number of spaces are reserved for new students each year.

Students who are accepted for admission to NJIT will receive information from the Office of Residence Life describing the procedure for applying for space in the residence halls.

Evening Students

Office of the Dean of Student Services staff members are available until 5:45 p.m., Tuesday through Thursday, to provide advisement and needed information to evening students.

The Counseling Center is open to evening students until 6 p.m., Monday through Thursday and until 5 p.m., Friday during fall and spring semesters, offering confidential professional counseling to adult students who face stress from academic, personal or employment responsibilities.

Many other offices including the Registrar's Office remain open after regular hours to assist students taking evening courses. Students should contact individual offices to determine availability.

The Hazell Center features weekly films and activities in the evening. All forums are held in the evening to allow evening students' participation.

Food Services

Three student dining facilities are located in the Hazell Center. NJIT's private food services vendor, Gourmet Dining Services, operates the Student Dining Room and the Food Court. Students who choose to purchase a meal plan can sign up for one of five options at the Gourmet Dining Services office.

The Student Dining Room offers breakfast 7:30 a.m. to 9:30 a.m., lunch 11:30 a.m. to 1:30 p.m., and dinner 4:30 p.m. to 6:30 p.m., Monday through Friday, and brunch 11 a.m. to 1 p.m. and dinner 4:30 p.m. to 6 p.m. on Saturday, Sunday and holidays. Students dining here are permitted to eat as much as they want for one price. Payment is either by cash or through the meal plan. Food cannot be taken out.

The Food Court is open 7:30 a.m. to 10 p.m., Monday through Friday, 8:30 a.m. to 8:30 p.m. on Saturday and is closed on Sunday. The Food Court is open to the entire community. Cash or the student meal plan can be used for payment. Students choose from a variety of dining options: Taco Bell, Nathan's Finest, gourmet pizza bar, and a made-to-order pasta station and deli section. A full salad bar also is available. Food may be eaten at the Food Court or carried out.

The Pub, located in the lower level of the Hazell Center, is operated by a non-profit corporation. The Pub offers sandwiches and snacks, and, to those 21 years of age or older, beer and wine. Student meal cards are not accepted at The Pub.

Physical Education and Athletics

The Division of Physical Education and Athletics encourages students to develop individual physical skills that can be used throughout life, and provides a variety of programs that will meet the diverse needs and interests of the NJIT community. These include programs of skills instruction, intramural and intercollegiate competition, sports clubs, and open recreation.

The Estelle and Zoom Fleisher Athletic Center houses a swimming pool; locker rooms; Fleisher fitness center with a 1/16-mile indoor track; an athletic training room; dance, exercise and fencing areas; conference and audio/visual rooms; four racquet sport courts; and three gymnasia. Lubetkin Field is a multi-purpose, lighted recreational area with a regulation soccer field, softball and baseball fields and a jogging area. There are four lighted tennis courts behind the athletic center. Recreational areas are open from 7 a.m. to 11 p.m. Monday through Friday, from 9 a.m. to 7 p.m. on Saturday, and from noon to 9 p.m. on Sunday. For information, contact the division office in the Physical Education Building. The phone number is (973) 596-3636.

Division of Career Development Services

The Division of Career Development Services (CDS) is responsible for Career Planning and Placement, Cooperative Education and Internships, Student Employment, Community and Public Service, and Alumni Career Services. Students may utilize these services by calling CDS at (973) 596-3100 to schedule an appointment, or stop by to find out if a career counselor is available. Several services are available on line at *www.njit.edu/CDS/*. After registering for this free service, students can connect to several career related hyperlinks to browse job openings in several majors and concentrations. On-line help is available for those who need assistance.

Community and Public Service

See the Academic Programs section in this catalog for more information.

Cooperative Education and Internships

See the Academic Programs section in this catalog for more information.

Career Planning and Placement

The Division of Career Development Services offers students a broad range of career investigation and preparation services. Included are career advising, career development workshops led by staff and industry representatives, job fairs, access to the Career Resource Center, career counseling, and on-campus recruitment by a wide range of prospective employers. Access to information is provided on site and remotely through the CDS On-Line Internet service. In addition, the office maintains full-time job listings. SIGI+, a computerized career assessment instrument, and company information are located in the Career Resource Center. The center is open Monday through Thursday, 8:30 a.m. to 6 p.m., and Fridays, 8:30 a.m. to 4:30 p.m.

For more information, contact the Division of Career Development Services, (973) 596-3100 or *www.njit.edu/CDS.*

Student Employment

The Office of Student Employment offers services and programs to help NJIT students earn money to finance college expenses and acquire practical work experiences through part-time and summer employment. Opportunities are provided for on-campus and off-campus employment for eligible students in all academic disciplines. Through the student employee training and development service, students are helped to succeed on the job. Students may participate in the following programs.

■ **Federal Work Study (FWS):** Students who are U.S. citizens or permanent residents and have received a FWS allocation as a part of their Financial Aid award are eligible to participate. Students may earn up to the amount specified on the award letter from the Financial Aid Office. FWS jobs are available both on- and off-campus.

■ **University Work Study (UWS):** UWS provides on-campus employment opportunities for NJIT students not eligible for the FWS program. Students must be enrolled full- or half-time, accepted into a degree-granting academic program and attending classes to apply for UWS jobs. Eligible international students must also have on-campus employment clearance from the Office of International Students and Faculty.

■ **Grant/Contract Hourly Employment:** NJIT's faculty and staff are often awarded grants or contracts from governmental agencies, foundations or private corporations to conduct research projects or special programs. Eligible NJIT students may be hired for on-campus jobs funded by these grants or contracts. Students should contact their academic departments and/or professors about available positions.

■ **Job Location and Development Services (JLDS):** JLDS provides assistance for any NJIT student seeking part-time or summer employment off-campus. Private and public employers in the New Jersey/New York area send numerous job announcements daily to NJIT. Students may view job postings in the Career Resource Center or access the part-time job listings on the Internet via CDS On-line! Also, a six-week Summer Job Search Club is offered each spring semester to help students find off-campus summer jobs related to their academic major.

For additional information, contact the Division of Career Development Services, (973) 596-6590.

Alumni Career Services

Alumni of NJIT graduate or undergraduate programs have access to a variety of career assistance services and programs provided by the Division of Career Development Services. Whether interested in changing careers or currently out of work, NJIT connections are valuable and offer a good place to begin a personal career search. Alumni can take advantage of these services: individual career counseling, the Career Resource Center, full- and part-time employment listings, support groups, a computerized bulletin board listing experienced-level job openings, direct access to job postings on the Internet, alumni mentors offering career advice and employment leads, and career-related workshops such as resume writing, interviewing skills, networking and job search strategies.

Alumni Association

The Alumni Association of NJIT is a not-for-profit organization that works in partnership with the university family to promote and support NJIT. The Association maintains a relationship with alumni to provide them with a voice and a means of fellowship and growth.

The association offers numerous programs and services: free and lifetime use of the university's computer network and e-mail service, including the association's home page on the NJIT Web site; seminars and business forums; a variety of annual award programs to recognize the accomplishments of NJIT's constituency, students and faculty members; the annual Financial Aid Scholarship Program that provides needed aid for aspiring NJIT students; grants that provide financial support and recognition to NJIT organizations and departments; development and support of U.S. and international association chapters; free subscription to the association newsletter, The Voice, published four times a year; free miniature copy of the student's diploma upon graduation; access to the A.J.J.A. Wilson Alumni Center's seminar/conference rooms and lounge, the Robert W. Van Houten Library, and the gymnasium facilities, pool and tennis courts.

The Alumni Association works closely with the Division of Career Development Services to assist alumni faced with unemployment, early retirement, and second careers.

The Foundation at NJIT

The Foundation is a privately incorporated resource development organization that supports excellence in teaching, research and public service programs at NJIT. The NJIT Board of Overseers has leadership and fiduciary responsibility for the Foundation. The Foundation's mission includes fund-raising and, through the Board of Overseers, soliciting private philanthropy on behalf of the university.

Admissions

Every application for admission is processed through the Office of University Admissions and is reviewed by the Graduate Admissions Committee. Candidates are notified of their admission status by mail. Admission decisions cannot be communicated by telephone, e-mail, fax, in-person, or to third parties.

For admissions information contact:
Office of University Admissions
New Jersey Institute of Technology
University Heights
Newark, NJ 07102-1982
(973) 596-3300, fax (973) 596-3461, e-mail: admissions@njit.edu
For on-line application for admission, see NJIT on the Internet at *www.njit.edu*

Test Requirements

Graduate Record Examinations (GRE) The GRE (general test) is required of all applicants to doctoral programs, all applicants seeking financial support, and all applicants whose most recent degree was awarded from an institution outside of the United States.

Specific master's programs: applied physics, architecture, history, infrastructure planning, interdisciplinary studies, materials science and engineering, and professional and technical communication require all applicants to submit official GRE scores. The environmental policy studies master's program requires GRE verbal, analytical and quantitative scores only.

The GRE can be used to fulfill test requirements for the master's programs in information systems and in public health.

The GRE is highly recommended for all other programs.

For further information about taking the GRE, contact: Educational Testing Service, P.O. Box 592, Princeton, N.J., 08541; phone, (609) 771-7670, 8 a.m. to 9:45 p.m.; *www.ets.org.*

Graduate Management Admission Test (GMAT) The GMAT is required for all applicants for the M.B.A. in Management of Technology and the M.S. in Management programs. The GMAT also can be used to fulfill test requirements for the master's programs in information systems and in public health.

For further information about taking the GMAT, contact: Educational Testing Service, P.O. Box 592, Princeton, N.J., 08541; phone, (609) 771-7670, 8 a.m. to 9:45 p.m.; or *www.ets.org.*

Law School Admission Test (LSAT) The LSAT can be used to fulfill test requirements for the master's program in public health.

For further information about taking the LSAT, contact: Law School Admission Council, (215) 968-1001 or *www.lsac.org*

Medical College Admission Test (MCAT) The MCAT can be used to fulfill test requirements for the master's programs in information systems and in public health.

For further information about taking the MCAT, contact: Association of American Medical Colleges, (202) 828-0600 or *www.aamc.org/stuapps/admiss/mcat/start.htm.* For registration materials, contact: MCAT Program Office, P.O. Box 4056, Iowa City, Iowa, 52243; or phone, (319) 337-1357.

Test of English as a Foreign Language (TOEFL) International students applying to a doctoral program must show a TOEFL score of at least 550 (paper-based)/213 (computer-based). International students applying to a master's program must show a TOEFL score of at least 525 (paper-based)/197 (computer-based). If admitted, students with TOEFL scores between 525 (paper-based)/197 (computer-based) and 550 (paper-based)/213 (computer-based) must take and successfully complete an ESL course in the first semester. Applicants with scores below 525 (paper-based)/197 (computer-based) are not considered for admission.

For further information about taking the TOEFL, contact: TOEFL/TSE Services, P.O. Box 6151, Princeton, N.J. 08541; phone, (609) 771-7100 Monday-Friday, between 8 a.m. and 9:45 p.m. and Saturday, between 9 a.m. and 4:45 p.m. New York time, for recorded information or personal assistance; or see *www.toefl.org/.*

For further details about TOEFL and NJIT's English as a Second Language course requirements, see "International Students and TOEFL," page 21.

■ MASTER'S DEGREE PROGRAMS

Master's degree programs provide advanced education needed by professionals in an era of rapidly expanding technology and normally require more specialization in the academic discipline of the student's bachelor's degree.

Admissions Requirements for Master's Study

Applicants for admission to graduate study must have completed an undergraduate program accredited in the United States or its equivalent and demonstrate superior academic achievement in an appropriate discipline. Students are expected to have placed in the top half of their graduating class and program and to have achieved a cumulative GPA no lower than 2.8 on a 4.0 scale. Individual departments may impose requirements that are more stringent. Applicants with undergraduate degrees in engineering technology must have ranked in the top quarter of their class and have a cumulative GPA of at least 3.0.

All applicants should submit supplementary evidence of their potential for successful graduate work. Letters of recommendation, GRE or GMAT scores, a publications record, prior research experience, a record of exceptional career development, a statement of the applicant's objectives, interests, and professional experience are examples of appropriate supplementary evidence.

Bridge Program Students who seek a master's degree in an academic discipline different from the bachelor's degree may be admitted to a master's degree program and may be required to complete appropriate undergraduate and/or graduate prerequisites in addition to the normal graduate degree requirements of the program. The program of courses will be individually designed in consultation with their graduate advisor. Bridge courses must be completed before 9 credits of graduate degree courses are earned. Bridge courses are not counted as degree credits but do count in graduate GPA calculations if the course is numbered 500 (500 G for architecture) or higher.

Admissions Procedures for Master's Study

An Application for Admission to Graduate Study form may be obtained from the Office of University Admissions or submitted via the Internet, *www.njit.edu.* A non-refundable fee of $50 must accompany the application. Applications may be deferred for one semester for a delay in admission without incurring another $50 fee. Official transcripts from all colleges and universities previously attended are required. To be accepted as official, transcripts must be sent directly to the Office of University Admissions by the institutions concerned. Applications for fall (September) admission must be received by June 5; for spring (January) admission by October 15. Applications for financial support for fall (September) must be received by January 15. Applications for financial support for spring (January) must be received by October 15. Supporting documents must also reach the Office of University Admissions by the above dates. Incomplete applications or applications received after these dates will normally be processed for the following semester.

Program Transfers Students who wish to transfer from one master's degree program at NJIT to another at NJIT must complete an application for admission to the new program and provide appropriate supporting materials. Courses taken in one program are not necessarily transferable to another, nor may credits be applied to more than one degree, except as provided by the M.S./M.S. program. Students admitted to one degree program are required to be in the original program

for at least one semester before admission and enrollment in another degree program.

Joint Master's Degrees with Other Universities The university cooperates with Rutgers-Newark and with UMDNJ in unique offerings of joint master's programs. Specific information about application and admission requirements for each is provided in the degree program descriptions located in the Degree Program section of this catalog. Programs that lead to joint master's degrees are applied physics, biology, environmental science, and history with Rutgers-Newark; biomedical informatics with UMDNJ; and public health with Rutgers-Newark and UMDNJ.

M.S./M.S. Program For information about this program, see page 39.

DOCTORAL PROGRAMS

New Jersey Institute of Technology offers doctoral programs to fill society's need for creative research scientists and engineers.

Admissions Requirements for Doctoral Study

Applicants are required to have an appropriate academic background as described by the individual degree programs, which are located in the Degree Programs section of this catalog, and a GPA of at least 3.5 on a 4.0 scale in prior study. GRE scores are required for admission to all doctoral programs. International applicants must show a TOEFL score of at least 550. Individual programs may establish additional or more stringent requirements.

An applicant who wishes to pursue a doctoral degree in a field different from that of previous study, and who is otherwise qualified, may establish eligibility by satisfactorily completing a program of study recommended by the department in which they seek admission.

Applicants who wish to complete a master's degree while pursuing a doctorate, must apply for admission to the master's program.

Mid-career scientists and engineers interested in part-time study may wish to consider the collaborative doctorate program described in the Academic Programs section of this catalog.

Admissions Procedures for Doctoral Study

Admissions procedures are the same as for a master's degree. In addition, three letters of recommendation are required from individuals who can best judge the applicant's ability to pursue independent research and complete a doctoral program.

Joint Doctoral Degrees and Cooperative Doctoral Programs with Other Universities NJIT cooperates with other universities in Newark in operating and developing doctoral programs of mutual interest.

The university participates in unique offerings of joint doctoral programs with Rutgers-Newark and UMDNJ. Students may apply and be admitted through either university. Programs that lead to joint degrees are applied physics, biology, and mathematical sciences with Rutgers-Newark and biomedical informatics with UMDNJ.

NJIT coordinates the computer and information systems specialization of the doctoral program in management offered by Rutgers-Newark. NJIT faculty supervise Rutgers doctoral students in this program. Admissions to the doctoral program in management is handled by Rutgers-Newark.

Collaborative Doctorate For information about this program, see page 39.

Admission Classifications

DEGREE (MATRICULATED) STUDENTS

Regular Admission

Applicants who meet NJIT standards and have an appropriate undergraduate academic background for the degree program to which they are seeking admission will be offered regular admission as degree-seeking (matriculated) students.

Conditional Admission

NJIT expects applicants to have a superior academic record, but recognizes that interest, creativity, maturity, and motivation are also important. Conditional admission to the university may be granted to applicants who do not have the appropriate academic background required for a particular degree program, but who have an academic record that meets NJIT's scholastic standards.

Once granted conditional admission, students must complete conditional or bridge courses specified by the university within their first two semesters. Such courses may be at either the undergraduate or graduate level and are NOT counted as degree credits although all courses numbered 500 (500 G for architecture) or higher are calculated in the cumulative GPA. Students must attain grades specified by the university and are not permitted to take more than 9 credits that count as graduate degree credits at NJIT before meeting the terms of conditional admission. Failure to meet these conditions may result in dismissal from the university.

Contingent Admission

Students who apply for admission to graduate programs before completing their bachelor's degree, and whose records demonstrate superior academic achievement, may be offered admission to NJIT contingent on their showing proof of receiving a bachelor's degree appropriate for the degree program for which they are seeking admission. Such students must show proof of graduation before being permitted to enroll in a graduate program.

Change of Major

Students are admitted to one graduate degree program and not to the university as a whole. Students who wish to change major on arrival at NJIT must file an application for the new program and remain in the original program for at least one semester and until the application is approved. There is no guarantee or requirement that the new application will be successful. Those on support are liable to loss of support from the original department and cancellation of a current award.

Change of Level

Students who wish to change current degree level must file an application for admission to the new degree level. There is no requirement or guarantee that the application will be successful. Students who wish to drop down to a master's program from a doctoral program should be aware of the impact of this action on current and future financial support. Students who wish to raise their level from a master's to a doctoral program should be aware of any impact on incomplete master's theses or projects.

NON-DEGREE (NON-MATRICULATED) STUDENTS

Students who wish to take graduate courses without seeking a degree (non-matriculated status) should contact the Office of University Admissions for a Non-Degree Application Form.

Non-matriculated students may be permitted to take a maximum of 9 graduate-level credits over three registration periods, except students seeking a graduate certificate. These students may take a maximum of 12 graduate-level credits over four registration periods. Students wishing to take credits beyond these limits must apply and be accepted to a degree program as a matriculated student.

Academically qualified students who do not desire to enter degree programs may enroll in certain individual graduate courses. Such students must present transcripts of previous academic work or other appropriate evidence at each registration in order to indicate adequate preparation for the course work involved. If approved by the Office of University Admissions, registration will be permitted if space is available. Permission to enroll as a non-matriculated student does not imply eventual admission to a degree program.

Graduate Certificate Programs

NJIT offers designated courses in concentrated areas for students wishing to obtain a graduate certificate in specific areas. These require completion of 12 NJIT credits at the graduate level. Students in these programs are considered to be non-matriculated students for the duration of the certificate program. Graduate certificate programs must be completed before students may be admitted to a matriculated graduate program making use of any certificate credits. Students in a matriculated degree program are not permitted to seek a certificate (move back to non-matriculated status) until completion of the matriculated program. Any certificates after completion of a degree program cannot be duplicates of the degree or part of the degree although substitute courses may be approved.

Students Matriculated at Other Universities

Graduate degree students at other colleges or universities may take courses for credit at NJIT for transfer back to their home institution. In addition to satisfying the course prerequisites, students must furnish a letter of approval from an appropriate administrative officer of their home institution.

NJIT Undergraduates

NJIT undergraduates may register for graduate courses, 500- or 600-level, with written approval from both their undergraduate advisor and from the graduate advisor in the department in which the course is taught.

NJIT students in the B.S./M.S. program are required to take at least 6 graduate-level credits while undergraduates to satisfy program requirements.

Rejected Applicants

Students whose application for admission to a degree program is unsuccessful are not permitted to register as non-matriculated students.

International Students

International students on F-1 and J-1 visas are not permitted to register as non-matriculated students. Students on other visas should consult the Office of University Admissions regarding non-matriculated status.

Auditors

Students who wish to attend courses for which they are qualified, but who do not wish to be graded in the course, may be permitted to enroll as auditors. Registration will be approved only after a review of credentials by the Office of University Admissions and only if space is available. A notation signifying that the course was audited will be made on the student's record, but no credit will be granted for the course. Students who wish to audit a course must state their intention at the time of registration. A change to, or from, auditor status is not permitted once a semester has begun. Students who audit a course are required to pay full tuition and fees. There is no tuition remission for audited courses. Audited courses do not count in determining full-time status for students who must maintain full-time status.

TRANSFER STUDENTS

Students enrolled in graduate programs at other institutions may apply for transfer to NJIT by completing the normal admission procedure. Transfer students may apply for credit for courses taken at other U.S. educational institutions by following procedures outlined in "Transfer of Credits from Outside NJIT" in the Academic Policies and Procedures section of this catalog. In addition, international students wishing to transfer from other educational institutions in the United States must:

- Demonstrate a cumulative GPA of at least 3.0 in graduate courses taken at other U.S. educational institutions;
- Complete the required immigration procedures for transfer; and
- Be eligible for admission to the NJIT program of their choice.

INTERNATIONAL STUDENTS AND TOEFL

New Jersey Institute of Technology welcomes applications from international students with records of superior academic achievement. In addition to the procedures stated below, international students are required to provide evidence of English language proficiency by submitting Test of English as a Foreign Language (TOEFL) scores.

For further information about taking the TOEFL, contact: TOEFL/TSE Services, P.O. Box 6151, Princeton, N.J. 08541; (609) 771-7100 Monday-Friday, between 8 a.m. and 9:45 p.m. and Saturday, between 9 a.m. and 4:45 p.m. New York time, for recorded information or personal assistance; or see *www.toefl.org/*.

International students entering NJIT to pursue a master's degree are required to take an ESL (English as a Second Language) course if their TOEFL scores are between 525 (paper-based)/197 (computer-based) and 550 (paper-based)/213 (computer-based). Students must satisfactorily complete the ESL course in their first semester. The director of the ESL program may exempt students from this requirement. Students also are exempt if they pass the NJIT English Test, which is given at the beginning of each semester. The test has three parts: listening, grammar, and writing. The exemption test must be taken prior to beginning the first semester at NJIT.

Students with TOEFL scores of 550 (213 CBT) or better are not required to take an ESL course but are encouraged to improve their English-language skills by doing so voluntarily.

All ESL courses are graded on an S/U (Satisfactory/Unsatisfactory) basis. The course credits count towards the 12 credits required for full-time status; however, the credits do not count towards degree credits.

International Students Who Seek Financial Support

Those seeking financial support from NJIT at the time of admission will be required to achieve a TOEFL score of at least 550.

INTERNATIONAL STUDENT FINANCIAL STATEMENT

In accordance with U.S. Immigration and Naturalization Service requirements, international students must also submit to the Office of University Admissions an International Student Financial Statement to demonstrate financial resources sufficient to meet the academic and living costs of their anticipated stay at the university. Forms for this purpose are included with admission materials; additional copies may be obtained from the Office of University Admissions. International students should note that they will be required to pay non-resident tuition rates. Immigration papers (e.g., I-20, IAP-66, etc.) will NOT be issued until the International Student Financial Statement is on file with the Office of University Admissions.

Academic Credential Equivalents for International Students

Undergraduate degrees must be equivalent to the typical four-year program in the United States. NJIT is working with a number of countries and universities to provide a transition from two- and three-year degree programs to baccalaureate and later graduate study. To be eligible for admission to graduate study at NJIT, international students must have the following minimum academic qualifications.

Argentina	Licenciatura
Bahamas	Honors Bachelor's degree
Barbados	Honors Bachelor's degree
Bolivia	Licenciatura
Brazil	Bacharel or Licenciado
Canada	Honors Bachelor's degree or the equivalent
Chile	Bachillerato, Licenciatura or Titulo of at least four-year duration
People's Republic of China	Bachelor's degree
Colombia	Licenciatura or Titulo
Dominican Republic	Licenciatura of at least four-year duration
Ecuador	Licenciatura or Titulo
Egypt	Bachelor's degree
El Salvador	Licenciatura
France	Maitrise or equivalent
Germany	Diplomgrad, Staatsexamen, or Magister Artium
Greece	Ptychion
Guatemala	Licenciatura
Haiti	Diplome d'Etudes Superieures or Licence of at least four-year duration
Honduras	Licenciatura of at least four-year duration
Hong Kong	Honors Bachelor's degree

India	Bachelor's degree (first class) in Engineering or Architecture, Master's degree in other subjects
Indonesia	Sarjana or Insinyur
Iraq	Bachelor's degree
Israel	Bachelor's degree
Italy	Laurea
Jamaica	Honors Bachelor's degree
Japan	Bachelor's degree
Jordan	Bachelor's degree
Korea	Bachelor's degree (Taehak Taehakkyo)
Kuwait	Bachelor's degree
Lebanon	Bachelor's degree, Licence of at least four-year duration, or Maitrise
Libya	Bachelor's degree
Malaysia	Bachelor's degree
Mexico	Licenciatura of at least four-year duration
Morocco	Licence or Ingenieur d'Etat
Netherlands	Doctorandus, Ingenieur, or Meester
Nicaragua	Licenciatura
Nigeria	Honors Bachelor's degree
Norway	Cand. Mag.
Pakistan	Bachelor's degree in Engineering or other four-year Bachelor's degree or Master's degree
Panama	Licenciatura
Paraguay	Licenciatura of at least four-year duration
Peru	Bachillerato, Licenciatura, or Profesor from a four-year university program
Philippines	Bachelor's degree
Saudi Arabia	Bachelor's degree
Singapore	Honors Bachelor's degree
Sweden	Filosofie Kandidatexamen or Ekonoexamen
Switzerland	Licence or Diplom of at least a four-year duration
Syria	Licentiate or Bachelor's degree
Rep. of China (Taiwan)	Bachelor's degree
Thailand	Bachelor's degree
Trinidad and Tobago	Honors Bachelor's degree
Turkey	Lisans or Bachelor's degree
United Kingdom	Honors Bachelor's degree
Uruguay	Licenciatura of at least four-year duration
Venezuela	Licenciatura or equivalent

Students from countries whose universities do not provide transcripts, or who experience exceptional difficulty in obtaining transcripts, should contact the Office of University Admissions for special instructions. Students whose credentials cannot be evaluated by the Graduate Admissions Committee will be required to submit a Credential Evaluation Report from an approved agency. For further information, contact World Education Service, Inc., Old Chelsea Station, P.O. Box 745, New York, N.Y. 10113-0745, (212) 966-6311; e-mail: info@wes.org.

Tuition and Fees

New Jersey Institute of Technology reserves the right to increase tuition and fees as required.

Students incur a legal obligation to pay tuition and fees when they register for classes. Unless the registrar receives written notice by the fifth day of the semester that a student will not be attending classes, the student will be billed for payment.

Liability for Charges

A student who registers for a course is liable for all tuition and fees. Receipt of a properly completed withdrawal notice by the Registrar's Office will effect the amount of refund, if any to be issued.

Tuition and Fees 1999-2000 (in U.S. dollars)

Effective July 22, 1999 the charges for tuition and fees for graduate programs are as follows:

TUITION

	New Jersey Resident	Non-Resident
Full-time	$3,605/semester	$5,066/semester
Part-time	388/credit	534/credit

NOTES: Part-time = 1-11 credits per semester. Full-time = 12 or more credits per semester. However, for more than 19 credits, each credit is paid for in addition to the full-time tuition rate and is charged at the part-time rate.

FEES

Full-Time (fees per semester)	
Registration	$ 66
Academic Facilities	250
Student Services	51
Graduate Student Association	35
Athletics	20
Health Services	10
Technology Infrastructure Fee	50
Total	$482
Part-Time (fees per credit)	
Academic Facilities	$ 24
Student Services	6
Graduate Student Association	3
Athletics	2
Technology Infrastructure Fee	6
Total	$ 41
Part-Time (fee per semester)	
Registration	$ 66
Health Services	10
Total	$ 76

International Student Fee $15 per semester

International students are charged as non-New Jersey residents.

Health Insurance $95 per academic year

HEALTH INSURANCE

New Jersey statutes require all full-time students and all international students (whether full- or part-time) to show evidence of existing health insurance, or they will be required to purchase coverage from the university for $95 per academic year. Students with comparable coverage may waive the fee for this insurance by completing a waiver card and submitting it to the Office of Health Services during the 30-day enrollment period at the beginning of the semester. Students must be registered for at least 3 credits to be able to purchase insurance from the university. International students with less than 3 credits must contact the Office of Health Services for further information. Students with J-1 visas, see "Health Insurance" under "Student Services" in this catalog for further information.

Part-time students and students interested in supplemental coverage for spouses and families should contact the Office of Health Services for more information.

APPLICATION AND SPECIAL FEES

Application Fee A nonrefundable fee of $50 must accompany applications for admission. Students who wish to change their degree program must file a new application and pay an additional $50 fee.

Late Payment Fee Students are charged $50 if they do not pay tuition and fees within the period stipulated in payment instructions.

Late Registration Fee Registration is required each semester. A late registration fee of $50 is required after the deadline specified in registration instructions.

Maintaining Registration Fee Students admitted to degree programs and who find it necessary to temporarily discontinue their studies, may maintain their enrollment by paying $50 for each semester they do not register for courses. The mechanism for maintaining registration is the notation MR on the registration form.

International students on F-1 and J-1 status may not maintain registration unless they have obtained **written prior** permission **from the Office of International Students and Faculty.**

Doctoral students in the dissertation stage and master's students in the thesis or project stage of their programs are not permitted to maintain registration by this mechanism and must be enrolled in dissertation, thesis or project credits until completion of the dissertation, thesis or project. Additional tuition and fees may be imposed for failure to be enrolled in dissertation, thesis or project credits as required. Other limitations on MR exist for those in academic difficulty.

If international students must interrupt their studies temporarily, they are required to first consult with the Office of Graduate Studies as well as the Office of International Students and Faculty to obtain permission for a leave of absence.

Readmission Application Fee A nonrefundable fee of $50 must accompany applications for readmission.

Transcript Request Fee There is a $3 fee for each copy of a transcript requested. Requests for transcripts are not honored if there is an unpaid balance on the student's account. Normal services require 10 business days to process a request. Twenty-four hour rush service will be provided upon payment of a $20 rush fee.

Schedule Change Fee A fee of $15 is charged for each schedule change requested after the deadline specified by the registrar.

Thesis and Dissertation Fees Upon acceptance by the Office of Graduate Studies, a fee of $45 is charged for binding one original and two copies of master's theses; and $90 for binding one original and two copies of doctoral dissertations. Binding fees for additional copies are $15 each for master's theses and $30 for doctoral dissertations (up to five copies total). Arrangements and payment for full publishing and copyright services are handled through the Office of Graduate Studies and by agreement with University Microfilms International.

Commencement Fee A $70 fee is charged each time students apply for graduation. If the degree requirements are not completed and a student is not certified for graduation, the student must reapply for graduation and pay the $70 graduation fee again.

Parking Fee NJIT students who have registered for classes may purchase a parking permit. Parking fees (per semester) are $125 for full-time students (12 credits or more) and $65 for part-time students (less than 12 credits). Adjustments to parking fees to reflect changes in full-time or part-time status will automatically be made on the fifth day of the semester only. Written requests for refunds will be granted by the Department of Public Safety only until the fifth day of each semester.

Additional Fees From time to time, additional fees may be necessary, or current fees may need to be increased. Currently these include:

Distance Learning	$34 per semester

Continuing Professional Education (CPE) Tuition and Fees

In some cases, there is a differentiation in fees for CPE programs. See *www.njit.edu/cpe/* for a current listing of fee labels and fee amounts or call CPE at 1 (800) 624-9850.

Refunds for Withdrawal

Total Withdrawals during Fall or Spring Semesters

When students withdraw from all courses voluntarily (a complete withdrawal) they may receive a refund of some part of the tuition provided they have properly completed and submitted a withdrawal application to the Registrar's Office. The date of the withdrawal is considered to be the date upon which the Registrar's Office received the withdrawal application. Forms for withdrawal are available from the Registrar's Office. The percentage of charges refunded is determined according to the following schedules. The refund schedules for federal financial aid recipients and non-recipients differ slightly.

INSTITUTIONAL (federal aid recipients see below)

Students receive refunds of tuition for complete withdrawal according to the following schedule:

Through the end of	% Refunded
Week 1	100%
Week 2	90%
Weeks 3 and 4	50%
Weeks 5, 6, and 7	25%
After week 7	0%

FEDERAL STUDENT FINANCIAL AID RECIPIENTS

When a student who has received federal financial aid (Federal Pell Grant, FSEOG, Federal Perkins Loan, Federal Work Study, Federal Subsidized and Unsubsidized Direct Loans, and Federal Direct PLUS Loans) withdraws completely, a refund and repayment calculation must be done to determine if a portion of the aid funds must be returned to their respective programs. The calculations use the following percentage refund schedules:

FEDERAL AID RECIPIENTS THAT HAVE ATTENDED NJIT FOR TWO OR MORE SEMESTERS

Students who have attended NJIT for two or more semesters and who receive federal financial aid are refunded the following percentages of tuition, room and board, certain fees and certain other charges. The refund may require federal aid funds to be returned to the federal student assistance programs.

Through the end of	% Refunded
Day 1	100%
Day 2 – Week 2	90%
Weeks 3 and 4	50%
Weeks 5, 6, and 7	25%
After week 8	0%

FEDERAL AID RECIPIENTS IN THEIR FIRST SEMESTER OF ENROLLMENT AT NJIT

Students in their first semester and receive federal aid are refunded the following percentages of tuition, room and board, certain fees, and certain other charges. The refund may require a portion of financial aid funds to be returned to the federal student assistance programs.

Through the end of	% Refunded
Week 1	90%
Weeks 2 and 3	80%
Week 4	70%
Weeks 5 and 6	60%
Week 7	50%
Weeks 8 and 9	25%
After week 9	0%

When financial aid funds must be returned to the federal student aid programs as determined through the refund and repayment calculation, the funds are distributed in the following order:

1. Unsubsidized Federal Direct Stafford Loans
2. Subsidized Federal Direct Stafford Loans
3. Federal Direct PLUS Loans
4. Federal Perkins Loans
5. Federal Pell Grants
6. FSEOGs
7. Other SFA programs
8. Other federal, state, private, or institutional sources of aid
9. The student

Examples of common refund situations for federal student aid recipients are available in the offices of the Bursar and Financial Aid.

Partial Withdrawals during Fall or Spring Semesters

The percentage of tuition refunded for credit reductions short of complete withdrawal (a partial withdrawal) in a semester is:

Week 1	100% (plus all fees)
Week 2	90%
Weeks 3-15	0%

After the last day of the second week of classes each semester, students who reduce credits, but remain enrolled will not receive any refund of tuition or other charges. For federal and state financial aid purposes, enrollment status is determined on the 15th day of classes, no adjustment from full-time to part-time status is made after the end of the second week of classes.

Refund policy and procedures for summer sessions are published in summer session registration materials.

Emergency Withdrawal

When the Office of the Dean of Graduate Studies approves emergency withdrawals, those students shall receive a refund pro-rated according to the number of weeks the student attended in the term. Students may request emergency withdrawal for the following reasons: medical circumstances that prevent completing the term; call to military service that prevents completing the term; and mental conditions that prevent completing the term.

Unofficial Withdrawal

Financial aid recipients whose term record shows zero (0) earned credits because of F and/or W grades will be reviewed for class attendance. A withdrawal date will be assigned to any student whose attendance or participation in class cannot be documented, and any federal aid may be reduced or canceled.

Students are strongly encouraged to use the official withdrawal procedure through the Registrar's Office should it become necessary to cease attendance in all courses. Students should also contact the Office of Graduate Studies to complete a discontinuance form.

Payment

Payment for tuition and fees may be made using any of the following methods:

Checks and Money Orders

Checks or money orders made payable to NJIT. Write the student ID number on the face of the check or money order. The university reserves the right to add missing ID numbers to checks for payment.

Cash
Cash payments can be made only at the Bursar's Office.

Credit Cards
For credit card payment, the university accepts Visa and MasterCard only. To take advantage of paying by credit card, students complete the provided required authorization, including student ID number. Payment will not be processed without it.

Deferred Payment
Students may use the NJIT deferred payment plan. In order to take advantage of this plan, the student must pay one-half of the bill plus a $25 deferral fee. Students with prior debts are not eligible to defer payments.

Student Residency for Tuition Purposes

Residency status for the purpose of tuition assessment will be made by the university based upon N.J.S.A. 18:62-1 et seq. and New Jersey Administrative Code Title 9. These statutes set forth the standards for individuals to legally reside in the state for 12 months prior to enrollment to be eligible for in-state tuition rates.

The procedures outlined below will govern the determination of residency status for the purpose of calculating tuition. All students who are not legal residents of New Jersey within the meaning of the statutes will be assessed out-of-state tuition rates.

Initial Determination of Residency
When an application is submitted for admission to any graduate or undergraduate program the admissions office will determine the applicant's resident status for tuition assessment. This determination will be based upon information supplied by the applicant on the application for admission. Applicants who are not citizens of the United States must complete the non-resident portion of the application and supply documentation of their non-immigrant status.

The university reserves the right to correct any errors in resident status based upon incorrect or insufficient information supplied by the student which directly or by inference leads to an inaccurate tuition assessment. When an error has been identified and corrected, tuition will be recalculated for the terms affected, and the student will be held liable for any additional tuition.

Legal Determination of Residence
The following statement from the New Jersey Statutes Annotated defines residence for higher-education purposes: "Persons who have been domiciled within this State for a period of 12 months prior to initial enrollment in a public institution of higher education are presumed to be domiciled in this State for tuition purposes. Persons who have been domiciled within this State for less than 12 months prior to initial enrollment are presumed to be non-domiciliaries for tuition purposes."

The university reserves the right to request the student to have the Internal Revenue Service or the New Jersey Division of Taxation forward tax records to the appropriate university office for review or to request same directly from the student.

An individual who claims to have established a new domicile in New Jersey must show (1) a physical abandonment of the previous domicile, together with an intent not to return to it, and (2) actual presence in New Jersey with the intention of remaining permanently in the state for reasons other than attending school.

An individual from another state or country who has enrolled in any type of educational institution in New Jersey prior to applying to NJIT will be presumed to be in New Jersey primarily for educational purposes and will be presumed not to have established domicile in New Jersey. Although the student may present proof to overcome these presumptions, it must be noted that continued residence in New Jersey during vacation periods or occasional periods of interruption to the course of study does not of itself overcome the presumptions.

THE EFFECTS OF MARRIAGE ON RESIDENCY
A U.S. citizen or permanent resident who marries a bonafide New Jersey legal resident assumes the domicile of that spouse for tuition purposes in the term following marriage. The same test for residency will be applied to spouses when marriage is claimed as the basis for domicile.

No change in status will occur when a legal resident student marries a non-legal resident.

FOREIGN NATIONALS
International students studying under a non-immigrant status (such as F, J, and all others) may be eligible to pay resident tuition upon receipt of their permanent resident card. In addition to receipt of permanent resident status in the United States, students must comply with the definition of "Domicile" as described in that section of the catalog. Any other non-immigrant alien (H-1, E-1, etc., status) will be classified as a non-resident for the assessment of tuition.

Residency will be determined as of the first term following the admission date on the permanent resident card. Applications for residency will not be processed unless a photocopy of both sides of the permanent resident card is included with the application. A tuition refund will be issued if the admission date on the permanent resident card precedes the start date of the current term.

Residence established solely for the purpose of attending a particular college or university cannot be considered as fulfilling the definition of domicile.

Refugees Students attending NJIT as documented refugees may be eligible to pay resident tuition rates provided they are domiciled in New Jersey and maintain good academic standing. Their status will be reviewed each semester by the director of financial aid.

Political Asylum Students who have been granted political asylum in the United States may be eligible to pay resident tuition rates effective the semester after which asylum has been granted.

Request for a Change of Residency Status
Requests for a change in residency status must be submitted to the registrar no later than four weeks before the end of the term for which a change in status is sought. A Residency Analysis Form with all supporting affidavits, deemed appropriate by the registrar pursuant to N.J.A.C. 9A:5-1.1 et seq., must be filed at the time of application. Students who qualify for resident tuition assessment based on the information supplied with their request will have their status changed only for the current and subsequent terms. No adjustments in tuition assessments will be made for prior terms.

Residency Appeals
Appeals on the determination of residency status will be made to the registrar and will be accepted no later than one month after the date of notification of any such determination. Unresolved appeals will be forwarded to the assistant vice president for academic affairs: enrollment planning. The assistant vice president will respond to the appeal within 30 working days of receipt of the appeal.

The decision of the assistant vice president for academic affairs: enrollment planning will be final.

Student Responsibilities
Students are responsible for providing relevant and accurate information upon which a residency determination can be made. The burden of proving residency status lies solely upon the student. Moreover, it is considered the obligation of the student to seek advice when in doubt regarding eligibility for in-state tuition assessment. If the student delays or neglects to question eligibility status beyond the period specified above, the student forfeits the right to a residency assessment to which he or she might have been deemed eligible had an appeal been filed at the appropriate time.

Students who are classified as resident students but who become non-residents at any time by virtue of a change of legal residence are required to notify the registrar immediately.

An independent student loses residency status for in-state tuition payment immediately upon abandonment of the New Jersey domicile. Assessment of non-resident tuition charges will take effect the term following the date of abandonment.

Penalties
If a student has obtained or seeks to obtain resident classification by deliberate concealment of facts or misrepresentation of facts or fails to come forward with notification upon becoming a non-resident, he or she is subject to disciplinary action before the university's professional conduct committee.

Factors Considered in Determining Residence for Tuition Assessment

CLASSIFICATION

Students residing in New Jersey for a period of 12 months before first enrolling at a public institution of higher education in the State of New Jersey are presumed to be state residents for tuition purposes.

Students who have been domiciled within this state for less than 12 months prior to the date of enrollment are presumed to be non-residents for the purpose of calculating tuition. Students who assert residency but whose resident status is challenged by the university, must prove their domicile according to the following regulations.

DOMICILE

"Domicile" means the place where a person has his or her true, fixed, permanent home and principal living establishment, and to which, whenever he or she is absent, he or she has the intention of returning.

Although actual presence is not necessary to preserve domicile once it has been acquired, a person, if absent from the state, must have the intention of returning to New Jersey in order to remain a legal resident.

In determining whether legal resident status has been shown, mere physical presence and the assertion of a declaration of intent to remain in the state may not be sufficient. To assist in determining whether a person is a New Jersey legal resident, the primary evidence of residency, although not dispositive, is a notarized affidavit setting forth domicile and a copy of New Jersey income tax return substantiating employment in New Jersey as the applicant's primary reason for residing in the state. In the case of dependent students, a copy of the parent's or legal guardian's New Jersey tax return will be required in addition to the affidavit. The following additional items may be considered: voter registration of the individual in New Jersey; a New Jersey driver's license and/or a registration or such other information as the university deems acceptable. In unusual circumstances, if primary evidence is not available, the institution may make a determination of New Jersey domicile based exclusively on supplementary evidence; however, supplementary evidence may not be deemed sufficient to justify a determination of legal resident status.

If a student resides with his or her parents or legal guardians for more than six consecutive weeks last or this year, or is dependent upon them for food, clothing, or shelter during the present or prior year, or is claimed, or will be claimed, as a dependent for income tax purposes for the last or current year, the student is deemed to be financially dependent. In such case, the domicile of the individual's parent or legal guardian for the year prior to the term of admission will determine the domicile of the dependent student.

Conversely, if a student has not lived, and will not live, with parents or legal guardians for more than six consecutive weeks during the present or prior year; and has not received and will not receive financial assistance from parents or legal guardians of more than $750 in support of any kind including food, clothing and shelter last year and this year; and has not been claimed as an exemption on parents' or legal guardians' tax return last and this year; and has resources, which should be at least equal to the level of public assistance in the preceding calendar year, the individual is deemed to be financially independent and student's own domicile, for the year prior to the term for which New Jersey domiciliary status is sought, will determine his or her legal resident status.

PRESENCE IN NEW JERSEY DUE TO MILITARY SERVICE

As a general rule, in the absence of any intention to effect a change of domicile, the domicile of a person is not affected or changed by reason of his or her entry into the military service.

United States military personnel and their dependents who are living in New Jersey are regarded as residents of the state for tuition purposes.

Financial Support

Financial Support and Graduate Awards

Various financial support and graduate award options are available to NJIT graduate students. Financial support comes from either NJIT internal funds or from external sources. Eligibility and selection criteria are summarized in the following table. Funds for these are not guaranteed.

Type of Support	Contact	Who Is Eligible
Federal Loans	Financial Aid (973) 596-3479	U.S. citizens, permanent residents; students enrolled at least half time, based on financial need; must file the Free Application for Federal Student Aid.
Federal Work-Study	Financial Aid (973) 596-3479	U.S. citizens, permanent residents, based on position availability and financial need; must file the Free Application for Federal Student Aid.
Industry Co-op	Cooperative Education (973) 596-3100	Full-time students, based on position availability; master's only
B.S./M.S.	Cooperative Education (973) 596-3100	Participating undergraduate students continuing in NJIT master's programs
Hourly Jobs	Student Employment (973) 596-3100	U.S. citizens, permanent residents, international students, full-time students, based on position availability
Scholarships, Fellowships, Grants	Graduate Studies (973) 596-3462	Based on funding source, full-time students, often supporting underrepresented groups
Assistantships	Graduate Studies (973) 596-3462	Full-time, based on academic merit or priorities and on funds available

NJIT AWARDS

Close to 400 teaching, research, and graduate assistantships, based on academic merit, are awarded to qualified full-time students.

Prospective students can apply for financial support by using the Application for Admission to Graduate Study. Prospective students seeking financial support are urged to apply no later than the January 15th for the fall semester of the following academic year and October 15th for the spring semester of the current academic year. Applications received after these dates may be placed on a waiting list.

Current students seeking financial support must submit an Application for Graduate Financial Support. These forms are available from the Office of Graduate Studies. GRE (general section) or GMAT scores must be available for any student, prospective or current, seeking financial support. Transcripts and other records of courses taken at the undergraduate and graduate level also must be available.

Competition for financial support is strong and only successful applicants are notified. Teaching, research, and graduate assistantship offers may include full or partial tuition, a stipend or both. Additional funds for the summer may be awarded.

Assistantships

Each year, there are over 300 teaching and research assistantships in academic and research departments, which are funded internally or externally. Teaching assistants conduct recitation, discussion, laboratory, or other sections of elementary or intermediate undergraduate-level courses, under supervision of permanent faculty. These duties are considered part-time work and typically include six to nine class contact hours per week. Research assistants conduct research under the supervision of NJIT faculty. Non-academic departments also employ students as graduate assistants. Duties range from academic support to day-to-day operation of administrative offices.

Presidential Fellows A limited number of fellowships, with average stipends of $16,200, are offered to outstanding doctoral students. Residence, research, and summer support can supplement the stipend. Full tuition and fee support is provided.

Teaching Fellows Teaching fellows provide services similar to those of an adjunct instructor and their stipends are based on the adjunct salary scale. A maximum of two courses, or six contact hours, per week may be assigned. Tuition remission of 3 credits for each course taught may be awarded in addition to the stipend.

Grader A grader is appointed for part-time service and grades course work under the direction and supervision of a faculty member. Graders may either be hired on an hourly basis through the Office of Student Employment, or through the Office of Graduate Studies. Compensation is based on hourly rates established for this position.

Special Awards Special awards for service may be established each year. Students should contact the Office of Graduate Studies for further information.

B.S./M.S. Fellowship NJIT undergraduates in the B.S./M.S. program may receive one semester of support, depending on availability of funds and student eligibility, if they pursue full-time graduate study at NJIT immediately after completing their undergraduate degrees. Ten hours per week of university service, designated by NJIT, are required for support. In order to receive support, students must have been in the B.S./M.S. program as undergraduates for at least two semesters, have taken at least 6 credits toward their master's degree while undergraduates, and have GRE or GMAT scores. Grades of B or better must be earned in each of the graduate courses. Students in these programs who choose to participate in cooperative education assignments in their first semester after completion of the undergraduate degree are not eligible for these awards.

Non-service Fellowships or Scholarships Private, state, federal, or foundation awards that do not require service to NJIT may supplement service-based awards.

Stipend Support Levels

Teaching/Research Assistant (not supported by grants):

Master's	$8,100	9 months at $900/month
Doctoral students	$12,150	9 months at $1,350/month
Doctoral candidates (those who have completed all requirements other than dissertation)	$13,050	9 months at $1,450/month

Research Assistants (on external funds from grants/12 months):

Master's	$10,800-$15,000
Doctoral	$16,000-$23,400

Graduate Assistant: non-academic based positions requiring advanced educational skills, $6,750 for 9 months; and positions not requiring advanced educational skills, $6,075 for 9 months.

Partial awards are possible for all categories of awards. Stipends are paid every other week. Award periods are scheduled for two consecutive 4 1/2-month periods with no gaps between fall and spring award periods. Support levels are reviewed annually.

Summer Support

Depending on availability of funds, students may be eligible for stipends and tuition support for June, July and August. NJIT has two summer award periods, the first covering late May and June, the second covering July and most of August. The split of summer award periods is based on the combination of the semester-based academic calendar used at NJIT and the changeover to a new fiscal year on July 1. Students receiving support for a summer award period may not be otherwise employed in these months without approval from the Office of Graduate Studies. Interested students should consult their faculty advisors in March or April.

International Students

Private loans are available through the Office of Financial Aid. These loans require a co-signer who is a U.S. citizen or permanent resident alien.

International students may not receive NJIT support or be employed on-campus during periods of practical training. International students must be in status with the Immigration and Naturalization Service (INS) and must attain a TOEFL score of at least 550 to be considered for financial support upon admission. Those with TOEFL scores below 550 are required to attend ESL classes and may be eligible for support after satisfactory completion of the required ESL courses. International students are eligible only for merit-based NJIT financial support, as indicated above, and NOT for need-based state or federal funds.

INS regulations require that international students attest to having funds sufficient to cover the expense of the entire course of study before they will grant a visa. Students are expected to demonstrate the availability of funds for the duration of studies at NJIT as a requirement for admission to the university.

GOVERNMENT-FUNDED SUPPORT FOR GRADUATE STUDIES

University Research Experience (URE) The State of New Jersey established URE to encourage and support underrepresented groups to engage in undergraduate research and pursue graduate study on a full-time basis. Contact the URE office for further information, (973) 596-6470.

Minority Academic Career Program (MAC) The MAC program supports doctoral students interested in faculty positions in New Jersey. Contact the Office of Graduate Studies for information on this and other state programs.

NSF and NRC Programs The National Science Foundation and the National Research Council support doctoral stipends and tuition. Application deadlines for these programs are one year in advance of anticipated study, usually in early fall. Contact the Office of Graduate Studies for information on these and other federal programs.

GEM The National Consortium for Graduate Degrees for Minorities in Engineering and Science, Inc. supports graduate students within in industry and academe-based consortia. Contact the Office of Graduate Studies for information on this and other industry programs.

Federal Direct and Perkins Loans, and Work-Study Programs U.S. citizens and permanent residents are eligible to apply for federal loans through the William D. Ford Federal Direct and Federal Perkins Loan programs and for federal work-study. Applicants for these programs must file the Free Application for Federal Student Aid (FAFSA) with the Federal Student Aid Programs Processing Center. The amount of graduate tuition remission a student receives is considered when determining eligibility for loans and work-study. Before loans are disbursed, students must sign a promissory note and first-time loan recipients must complete entrance counseling. The FAFSA is available from the Office of Financial Aid and will be mailed upon request. For further information, contact the Office of Financial Aid, (973) 596-3479.

TERMS AND CONDITIONS OF AWARDS

Award Selection

All NJIT awards are merit-based and are offered only to academically superior students who meet all selection requirements. Many things are considered in evaluating applications and nominations for NJIT awards. Among these are GPAs, GRE and GMAT scores, undergraduate and graduate academic performance, educational preparation, TOEFL scores for international students, skill and talent required for available positions, institutional priorities, availability of funds, special skills, and prior experience. TOEFL and ESL requirements are noted in the "International Students and TOEFL" and "Test Requirements" in the Admissions section of this catalog.

Although there is no minimum eligibility score for the GRE or GMAT, NJIT may establish them for certain awards. For instance, GRE mathematical scores between 700 and 800 are typical of NJIT award recipients. Students must take the GRE or GMAT and arrange to have official score reports to be sent to NJIT before they may become eligible to receive awards.

Graduate students who have not already received awards or been offered an award on admission must attain a minimum GPA of 3.5 for support from internal funds and 3.0 for support from external funds. Any graduate or undergraduate course taken by a student in graduate studies at NJIT is counted in the GPA (as calculated by the Office of Graduate Studies) for evaluating selection criteria, including courses that were repeated or excluded. GPAs are checked at the beginning of each support period to verify that awards are warranted. GPAs only establish eligibility and neither guarantee or entitle students to receive financial support.

The Office of Graduate Studies evaluates criteria for support from internal funds each year. The criteria reflect both average grade point performance levels and availability of funds. A student who has received support from NJIT funds for one degree cannot receive NJIT support for another degree of the same or lower level or type. Criteria and full details of terms and conditions of awards are available from the Office of Graduate Studies. A handbook of financial support policies and procedures also is available.

Need-based support programs administered by the Office of Financial Aid and by the Office of Student Employment have different criteria for selection. These offices should be consulted for further information. Funds distributed for hourly employment through the Office of Student Employment are not considered awards.

Service-Based Awards

A service-based award is one in which the student is required to perform a service in return for a stipend. The following awards are service-based: graduate assistants, teaching assistants, research assistants, presidential fellows, teaching fellows, graders, and others as noted.

Terms and Conditions

By accepting an award, students agree to comply with the following terms and conditions unless exceptions are indicated in their award offer letter:

- Students are required to work, up to a maximum of 20 hours per week, throughout the period of their award except on legal and NJIT holidays. Students are therefore required to work during semester breaks, either for their supervisor or, with the consent of the supervisor, on their own research.
- Students not receiving the maximum award for their award category and degree status are required to work a pro-rated number of hours (less than 20) based on a comparison of their award to the maximum stipend level allowed for that award. A maximum of 40 hours per week, with appropriate increase in support level, may be permitted for service during the two summer award periods.
- Full-time registration in one of NJIT's graduate degree programs must be maintained at all times throughout the period of an award. Full-time status is accorded to those who complete at least 12 credits per semester, or to those who are certified by the Office of Graduate Studies or designee as full-time students. Students should review "Refunds for Withdrawal" and "Enrollment Status" in the Tuition and Fees section and the Academic Policies and Procedures section respectively in this catalog to be assured that they are following full-time certification requirements.

- Students who initially register for a full-time load but withdraw during a semester and thus become part-time cannot receive tuition remission for that semester and may have their tuition award terminated and stipend award curtailed.
- No other work for compensation, whether on- or off-campus, may be undertaken during the period of the award unless approved by the dean of graduate studies. Students who do not comply with this requirement may be prohibited from receiving future support and have their current award terminated.
- Unsatisfactory performance, inadequate academic progress, or violation of any of the terms and conditions shall constitute grounds for the immediate cancellation of an award.
- Award offers must be accepted in writing, on an appropriate form, and must be received by the date indicated in the award offer.
- Students who resign, or are dismissed from an appointment during a semester, must repay any tuition remitted for that semester.
- Students must report to their supervisor by no later than the first day of each semester. Students who fail to do so will be deemed to have resigned and will have their award cancelled.
- Appointments are made for the period specified in the award offer. Neither renewal nor summer support can be guaranteed.
- Support based on external grant, contract, scholarship or fellowship awards are subject to the limitations established by the external agency.
- Students may not receive an award from NJIT funds to pursue a second master's degree or second doctoral degree when the first degree has been earned at NJIT.
- Students who change to a master's degree program from a doctoral program will have the current award cancelled and no future awards will be permitted. Students who register in courses inappropriate to their program of record or unapproved by their advisor will have the award immediately terminated.
- All doctoral students and students on support are required each semester to attend the seminar course offered by their program unless a specific waiver for sound academic reasons has been granted by the dean of graduate studies. Waivers for doctoral students to allow off-campus employment through pre-completion practical training authorization or to accept a cooperative education work assignment will generally not be approved.

Tuition Remission Awards

Tuition support has no service condition associated with it. Students accepting this support must not leave the program for which the support is offered without the approval of the support sponsor and the dean of graduate studies. Approval will be granted only for sound academic or other compelling reasons. Departure to accept employment is not considered a valid reason. All tuition support provided will be re-billed to the student if this condition is violated.

Cancellation of Tuition Remission

NJIT reserves the right to cancel tuition remission awards when students do not meet requirements or violate the conditions of an award. NJIT also reserves the right to cancel tuition remission for ineligible courses or courses for which the grades of F, U, W, or I are received. Audited courses, courses outside the approved courses for the program, and excess courses not needed for program completion are ineligible for tuition remission. If tuition remission is cancelled, students are re-billed accordingly and are responsible for payment in full.

Sick Leave

Students receiving awards are entitled to a total of three paid days of sick leave during the academic year. Additional days of sick leave may result in the cancellation of an award or a reduction in a stipend.

Unsatisfactory Performance

A student's performance is considered unsatisfactory if it does not meet the criteria set by the award supervisor.

Criteria for Maintaining Award

Students must earn at least a 3.0 GPA each semester, as well as attain a cumulative GPA of 3.0 to keep receiving their awards. A 3.0 GPA will also maintain awards that initially required higher GPAs to receive them. Any graduate or undergraduate course taken by a graduate student is counted in the GPA for evaluating maintenance of awards and even includes courses that were repeated or excluded. Except for the specified period of the award offer, these criteria neither guarantee nor entitle students to receive continued financial support.

Effect of Incomplete Grades and Grade Changes

Students whose transcripts show incomplete (I) grades in the semester before being selected or becoming eligible for an award must resolve them within the four weeks after grades are posted. This also applies to changes in grades that would affect eligibility.

Extension of the deadline to the fourth week of the subsequent semester will be considered if the student and the instructor provide written justification. Otherwise, any award offer for that semester will be withdrawn and tuition remission cancelled. Students will be billed for tuition accordingly and will be responsible for payment in full.

Award Duration and Renewal

Student eligibility for awards is evaluated each semester, as is renewal of award offers. Each award has unique eligibility, funding, duration and renewal circumstances. Students are responsible for understanding and following the terms and conditions of the particular award offer made to them. The Office of Graduate Studies should be consulted to determine individual terms and conditions. Award duration is based on calendar time, not on whether awards are full or partial.

- Students enrolled in master of science or masters of arts programs may not receive NJIT-funded, full or partial, assistantship or fellowship support for more than one academic year except in the cases listed below for B.S./M.S. students, and U.S. nationals and permanent residents who are members of underrepresented groups. The academic year is defined as two semesters and one summer. The summer includes two award periods.
- Students enrolled in doctoral degree programs may not receive NJIT-funded, full or partial, assistantship or fellowship support for more than four academic years. This is defined as eight semesters and four summers.
- Master's students are eligible to receive awards for a maximum of four semesters and two summers from all sources. This does not apply to students in the Master of Architecture program. Doctoral students are eligible to receive awards for a maximum of ten semesters and five summers from all sources.
- Students enrolled in the 97-credit Master of Architecture program may not receive NJIT-funded, full or partial assistantship or fellowship support for more than three academic years. Three academic years are defined as six semesters and three summers.
- Students enrolled in the Master in Infrastructure Planning program are considered as master of science students for award duration.
- Full-time master's students in the B.S./M.S. program are eligible to receive three semesters and one summer of financial support from internal funds. Only one semester of support can be from a specifically designated B.S./M.S. fellowship.
- U.S. nationals and permanent residents enrolled in master of science programs who are members of underrepresented groups are eligible for three semesters and one summer of financial support from internal funds.
- Doctoral students who fail their qualifying examinations may not receive further awards from NJIT funds until they pass. Departments may request a review and continuation of their financial support status if they pass some but not all parts of qualifying examinations.
- No student may receive support for more than twelve semesters and six summers from any combination of sources or for any number of degrees.
- When eligibility for NJIT-funded awards is completed, students may receive additional support from external sources. Check with the Office of Graduate Studies to obtain further details.

Resignations

Students who wish to resign from an award should inform their advisor and the dean of graduate studies at least one calendar month before the resignation is to take effect.

Students who resign during a semester will not be eligible for tuition remission for that semester. The semester in which the resignation is received is counted as a supported semester when determining award renewals.

Taxation of Stipends and Awards

The Internal Revenue Service requires that stipends and awards be taxed at the source, even if students are eligible for a tax refund. All students are exempt from Social Security taxes. Tuition and fee remissions are not subject to tax withholding.

Students should contact the Finance Office and the Office of Graduate Studies for tax information and applications for exemption from Social Security taxes. International students should contact the Finance Office and the Office of International Students and Faculty for information on tax treaties.

TUITION REMISSION

Tuition Remission Processing

All students receive bills for tuition. The bill statements for students receiving tuition remission and fees, if applicable, are marked "Possible Tuition Remission." After expiration of the official withdrawal period, a credit for the tuition and fees should appear on the statement.

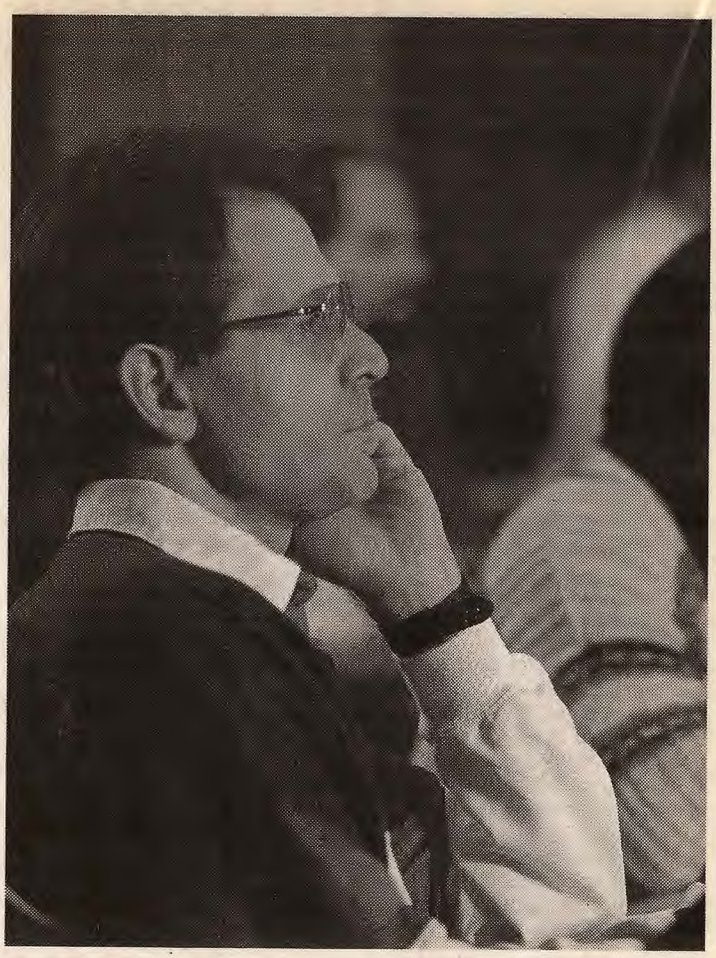
Students who pay tuition bills in full and then receive tuition remission can expect to receive a refund after expiration of the withdrawal period. Students receiving only partial tuition and fee awards are responsible for payment of the remaining tuition and fees and should pay these promptly. In particular, full-time students should ensure that they have continuous health insurance coverage by payment of appropriate fees.

Credit Limitation

Awards do not cover tuition for courses that are not part of a student's degree program or courses not approved by their advisor. Students are responsible for payment for these courses. Students in programs that require more than 30 credits may be permitted to take more than 12 credits in a semester and receive tuition remission.

Tuition remission is allowed for courses taken at other institutions in which there is a cross-registration agreement with NJIT. These courses must be part of the student's degree program and approved by the student's advisor.

Full-time students who take 12 to 19 credits per semester pay an inclusive tuition block rate. Any credits that students take beyond 19 credits are not included in tuition remission awards. Students will be billed for these credits.



Academic Policies and Procedures

Registration

Registration is required each semester. The Registrar's Office is located in the Student Services Mall, on the ground floor of the parking facility. The office is open when classes are in session, Monday through Thursday, from 8:30 a.m. to 6 p.m. and Friday, 8:30 a.m. to 4:30 p.m. Registration procedures for each category of student are listed below.

NJIT has an advance self-registration system that obligates all students currently enrolled in graduate degree programs to register in advance for their courses. An approved registration guarantees class seats until the first class meeting. Students who do not attend the first class meeting may lose their place in class.

All admitted students register on-line via the registrar's Web site at *www.njit.edu/Registrar.*

Extension and ACCESS/NJIT distance learning students, whose application for admission is pending, can register on line at *www.njit.edu/cpe*, or by mailing/faxing information to NJIT, Division of Continuing Professional Education, University Heights, Newark, N.J. 07102-1982. Fax: (973) 596-3288.

Responsibility for Registration

NJIT mails notices in advance, but cannot guarantee postal delivery. Regardless, students are expected to obtain all necessary information and comply with all registration procedures on time. New international students are only permitted to register after attending the required international student orientation program and must register in-person. Students who receive financial support must be in attendance at NJIT and will not be permitted to have other persons register for them.

Currently Enrolled Students Currently enrolled students are informed of registration procedures for the fall and spring semesters by the Office of the Registrar during April and October respectively, and must then register during the advance registration period. Students who fail to comply with these instructions are charged a late fee. Instructions for the summer session are provided separately and mailed to the student. Currently enrolled extension and distance learning students are informed of registration procedures for fall, spring and summer semesters by the Division of Continuing Professional Education.

New and Readmitted Students The Office of University Admissions informs prospective and readmitted students of registration procedures.

Non-matriculated Students Non-matriculated students should contact the Office of University Admissions for details of admission and registration procedures at least one month before the date of intended enrollment. Extension and distance learning students should contact the Division of Continuing and Professional Education.

Approval of Initial Registration

NJIT degree programs are purposely flexible to meet a variety of career and personal objectives within minimum requirements. Students are required to arrange a conference with their graduate advisor as soon as possible after notification of admission to formulate a course of study that meets the requirements of the particular degree program and reflects the interests and aspirations of the individual student. **New students are required to obtain advisor approval for initial course registration.** Advisors are usually available for international students during the international student orientation program.

Course Additions and Schedule Changes

Students who add a course to their program will be charged the full tuition and fee for the course added. If, within the first five class days of the semester, students change their schedule, they must fill out a schedule change form, present it to the registrar, and pay a schedule change fee.

Courses cannot be added after the fifth day of the semester. Student's attending courses for which they are not properly registered will not receive credit for such courses.

Continuous Registration Requirement

Once admitted to a degree program, students must be continuously registered for credit each semester until they complete degree requirements.

Students are not permitted to register for MR (Maintaining Registration) if their project, thesis or dissertation is unfinished without approval for a leave of absence by the dean of graduate studies.

Students who complete work for projects, theses or dissertations over several semesters receive a grade in the semester in which the work is completed and the final document is approved and received in proper format.

Multiple Registration

A student generally cannot be matriculated in more than one graduate degree program at a time. Special circumstances may require the approval of the dean of graduate studies. This also applies to programs run cooperatively with Rutgers-Newark and UMDNJ. Currently enrolled graduate students who wish to enroll in a subsequent graduate degree program should NOT file an application for admission to the new program until they are in the final semester of their initial program. In addition, students may not be enrolled in both a degree and a non-degree graduate program or as an undergraduate and graduate student simultaneously.

Students should consult the Office of University Admissions when contemplating a change in program enrollment. Students should refer to "Change of Major" under Admissions in this catalog.

Cross-Registration Procedures

Students may take courses at UMDNJ and Rutgers-Newark College of Arts and Sciences provided that the:

- Course is used toward a degree.
- Course is not offered at NJIT, or, because of a conflict in schedule, cannot be taken at NJIT.
- Approval is obtained, in advance, from the student's advisor.
- Approved cross-registration form is submitted by the student to the host school. The course must also be included on the NJIT registration form.

Students in joint programs should register at the school that admitted them to their current degree program. Students from Rutgers-Newark and UMDNJ must be matriculated in graduate programs at their home institution to cross-register for NJIT courses. Students from Rutgers-Newark and UMDNJ who cross-register into NJIT are considered NJIT non-matriculated students and are therefore limited to 9 credits maximum. In order to take more than 9 credits, these students would have to apply and be admitted as matriculated students for an NJIT graduate degree program.

Summer course registration procedures, and inclusion of courses on NJIT transcripts for students wishing to take courses at Rutgers-Newark and UMDNJ, are determined by the registrar. In general, students enroll as non-matriculated students at the other institution for summer courses.

Registration at Another College

To take graduate courses at colleges other than those in the cross-registration program, students must obtain prior approval from their advisor and the dean of graduate studies. Students should review the section on "Transfer of Credit" if they wish to transfer these courses to an NJIT program.

Tuition remission from NJIT is not available for courses taken at educational institutions not participating in NJIT's cross-registration program.

Undergraduate Registration in Graduate Courses

Undergraduate students who wish to take 500- or 600-level courses must obtain the written approval of the graduate advisor for the

program that offers the course and their undergraduate advisor. If undergraduates wish to take 600-level courses, they must also obtain written approval from the chairperson of the department offering the course. Undergraduates are not permitted to take 700-level courses.

Undergraduate students who enroll in graduate courses for undergraduate credit pay tuition at the undergraduate rate. Grades will follow the graduate grading system.

The undergraduate and academic advisor will review the student's academic record prior to approval. Approval can be granted only to students who have completed the appropriate prerequisites for the course and are in satisfactory academic standing. The approval will be noted on a form that requires appropriate signatures and reports the student's cumulative undergraduate GPA. Students shall have a cumulative undergraduate GPA of 2.5 to be approved for registration in 500-level courses (500G for Architecture) and 2.8 for registration in 600-level courses.

Students whose undergraduate GPA is below the 2.5 or 2.8 minima, are considering courses out of the student's current major, are lacking appropriate prerequisites, have completed any prior graduate courses with a grade below a B, or have already completed 9 or more credits at the 500 level and above (15 credits for those in the B.S./M.S. program), or have an excessive number of credits for the undergraduate degree will also require review by the dean of graduate studies and the program advisors.

Undergraduate students should be aware that need-based financial aid may not be sustainable for registration in graduate courses.

Graduate Registration in Undergraduate Courses

Graduate students may be asked to register in undergraduate courses as conditions of admission, as bridge courses or by direction of the graduate advisor for their current program. Enrollment in other undergraduate courses requires the approval of the dean of graduate studies or the graduate advisor, and the undergraduate department offering the course. Tuition for these courses is assessed at the graduate rate.

Transfer of Credits from Outside NJIT

Transfer credits are calculated by NJIT according to the total number of instructional minutes earned at the other institution. The equivalent instructional minutes of a maximum of 9 credits of graduate work, taken within seven years, from accredited U.S. educational institutions may be transferred and applied to degree requirements at NJIT. Credits from educational institutions outside the United States (except Canada) cannot be transferred. On a case by case basis, up to 9 credits may be waived for non-collegiate based instruction. The university does not grant transfer credit for work experience or other non-instructional activities.

Credits are transferred only if the courses were taken for full academic credit, were never applied to any other degree, and a final grade of at least B was attained. In addition, the student's graduate advisor and the Office of Graduate Studies must agree that such courses directly relate to the student's program of study before they can be transferred.

Requests for transfer credit must be submitted on a form available from the Office of Graduate Studies, accompanied by course descriptions from the other educational institution. Students must also arrange for the other institution to send an official transcript to the Office of Graduate Studies at NJIT. Requests may be submitted and approved at any time but are not added to a student's record until matriculation is granted. Grades that are transferred will not be calculated in cumulative GPAs.

Transfer of Credits within NJIT

A student may transfer credits from one program to another program within NJIT under certain circumstances.

B.S./M.S. Program

For information about this program, see page 39.

M.S./M.S. and Dual Master's Programs

For information about these programs, see page 39.

Scheduling of Classes

Graduate courses at NJIT and at Extension Sites are, in general, scheduled for late afternoon and evening hours and Saturdays for the convenience of those employed full-time. Evening courses normally begin at 6 p.m. and end at 9 p.m. Some laboratory sessions begin at 6 p.m. and end at 9:50 p.m.

Courses in heavy demand may be scheduled for additional sections if adequate enrollment can be assured. Day and evening classes during the summer months are possible under the same conditions. Special programs such as the Executive Management program and those offered by Distance Learning have their own schedules.

Course Cancellations

The university does not guarantee offering all or any of the courses listed in this catalog. When there is inadequate registration, a course may be cancelled without notice. The registrar will attempt to notify all students of course cancellations before the first meeting of the semester.

Room Changes

Room and laboratory changes are announced on the bulletin boards outside the Office of the Registrar. Changes are posted adjacent to doors of originally scheduled rooms, as well.

Enrollment Status

Full-time Students Students registered for 12 credits or more throughout an entire semester are considered full-time.

International students must be in full-time status every semester.

Part-time Students Students registered for fewer than 12 credits during a semester.

Half-time Students For federal and other reporting purposes, half-time graduate student status may be defined for students registered for 6 credits or fewer during a semester. Contact the Office of Graduate Studies for more information.

Full-time Certification Graduate students must be registered for not less than 12 credits each semester in order to be accorded full-time status.

The Office of Graduate Studies may certify students as full-time even if they are not registered for 12 credits, provided that:

- Students have fewer than 12 credits remaining for completion of all degree requirements and are registered for all credits needed to complete the degree. This certification can only be given for one semester.
- Doctoral students preparing for qualifying examinations or research proposal presentations register for at least 9 credits.
- Doctoral candidates have completed all course work, other degree and credit requirements, and are registered in Dissertation Research and seminar for at least 3 credits each semester.
- Students originally registered for 12 credits but have substantial extenuating circumstances that require a reduction in course load. Normally this certification applies only in cases of medical or similar emergencies which incapacitate a student for a significant part of a semester. Improper course registration, failure to seek proper advisement, inadequate academic progress, or risk of earning a weak or failing grade are not extenuating circumstances.
- Students on a full-time cooperative education assignment are registered in a graduate co-op work experience or equivalent course. When students are in their final semester of study, they may be certified as full-time and approved for co-op. The Office of Graduate Studies should be consulted for limits on cooperative education because cooperative education has an influence on full-time certification and allowable time to complete the degree.
- Audited courses and withdrawn courses do not count toward full-time status; ESL (English as a Second Language) courses do count as one course each.

Graduate Degree Requirements

Graduate degree candidates must achieve a cumulative GPA of at least 3.0 in all graduate-level courses and satisfy other academic and non-academic requirements. These include financial obligations to the university. Until the Office of Graduate Studies verifies that all tuition bills and fees have been paid, and that the master's thesis or doctoral dissertation and abstracts have been completed in the appropriate format, degrees will not be certified. Students whose programs require a thesis, project or dissertation, must complete these within time limits, format, and policy prescribed by the Office of Graduate Studies. Master's theses and doctoral dissertations must be submitted for final approval

to the Office of Graduate Studies. Master's projects need to be submitted only to the advisor or program office. At least three program approval signatures are required for master's theses; at least five are required for doctoral dissertations. Fees that must be paid include, but are not limited to, the binding fee, full publishing fee, copyright fee, and graduation fee.

GRADE POINT AVERAGE CALCULATION

GPAs are calculated for each semester and cumulatively for the entire graduate record. In order to obtain a graduate degree, candidates must have a cumulative GPA of at least 3.0 in all graduate-level courses, exclusive of grades in master's project, master's thesis or doctoral dissertation. All 500-level or higher courses are included in the cumulative GPA, regardless of applicability to a specific degree. Only the initial grades for graduate courses that have been repeated are excluded from GPA calculations. Undergraduate credits taken by graduate students are not counted. Some programs also may require a 3.0 GPA in designated core course requirements.

In addition, the cumulative GPA for all courses counted for the degree, exclusive of master's project, master's thesis or doctoral dissertation, must be 3.0 or better. Grades for master's project or thesis must be a B or better. Completion of the doctoral dissertation and its defense will be assigned a grade of P for passing. The P grade is for dissertation credits taken in the student's final semester.

Expiration of Credit

For all degrees, credits expire seven years after completion of the semester in which they are earned. Expired courses cannot be used to fulfill degree requirements and must be replaced by current credits.

Degree requirements must be completed within seven consecutive years of original admission. Approved leaves of absence do not count against the seven-year limit for completion of the degree although the validity of individual courses may still expire during this time. Requests for waivers of the seven-year limit for extenuating circumstances, other than mere failure to register, are made to the dean of graduate studies. The technical content and remaining currency of courses is considered in evaluating these requests. The majority of courses in rapidly changing fields (such as computer science) are not likely to be accepted after seven years.

THESES AND DISSERTATIONS

Theses and dissertations submitted for graduate degrees must follow a prescribed university format. The approved format is based on the Estrin/Roche manual: Guidelines for Scientific and Professional Theses and is available in the NJIT Bookstore. The Office of Graduate Studies provides seminars, guidance documents and continuing assistance for students. The office should be consulted for more information.

INDEPENDENT STUDY

Some programs permit up to three independent study courses (a total of 9 credits) towards graduate degree requirements. Independent study is for students who want highly specialized study in areas in which courses are not normally available. Students should see their advisors regarding independent study options. For students in doctoral programs, a maximum of two independent study courses may be used to satisfy the 700-level course requirements.

AWARDING OF DEGREES

Degrees are awarded three times each academic year: August, January and May. Candidates for graduation must file an Application for Candidacy with the registrar. The application must be consistent with the student's program of admission and current record. Applications received after the specified deadline are accepted at the discretion of the registrar and are subject to a late fee. Forms are available at the Registrar's Office. Unsuccessful applications will be automatically added to the next commencement list and students will be billed for the appropriate fees.

■ MASTER IN INFRASTRUCTURE PLANNING

See Master in Infrastructure Planning on page 71.

■ MASTER OF ARTS

See Master of Arts in History and Master of Arts in Teaching (History) on page 68.

■ MASTER OF BUSINESS ADMINISTRATION IN MANAGEMENT

See Master of Business Administration in Management on page 75.

■ MASTER OF SCIENCE

Master of science degrees require a minimum of 30 credits: 18 credits in an area of specialization that may include a 6-credit thesis or 3-credit project, and 12 credits of electives. Some programs may require students to take more than 30 credits to fulfill degree requirements. The particular programs and departments establish the necessity and requirements for a master's project or thesis and defense.

The 18 credits in an area of specialization must be courses numbered 600 or above, depending on program requirements. With the written approval of the department of major study, 6 of these credits may be in courses numbered 500 to 599.

The 12 credits of electives are subject to advisor approval. Typically, students are permitted to take at least 6 elective credits outside the department of major study.

More detailed descriptions of individual degree requirements may be found in the Degree Programs section of this catalog.

Bridge Program: Students who seek graduate degrees in an academic discipline different from the discipline in which they received their baccalaureate degree may be required to take additional courses. The program of courses will be individually designed in consultation with their graduate advisor. Such courses must be taken before beginning graduate curricula. They may include undergraduate courses. These courses are not counted toward degree requirements but if they are numbered 500 (500 G for architecture) or higher, they are calculated in the cumulative GPA.

■ MASTER'S DEGREES OFFERED BY THE SCHOOL OF ARCHITECTURE

A full description of these requirements may be found under "Architecture" in the Degree Programs section of this catalog.

■ DOCTOR OF PHILOSOPHY

The number of credits required for completion of doctor of philosophy degrees varies with the program and the level of entry into the program. Students holding a prior master's degree will require a minimum of 60 graduate credits beyond the master's degree (which is assumed to have included at least 30 graduate credits beyond the bachelor's degree). Students entering the doctoral program with a bachelor's degree and who do not wish to complete a master's degree while pursuing the doctoral degree will be required to complete a minimum of 84 graduate credits beyond the bachelor's degree for programs offered by the Newark College of Engineering and 78 graduate credits beyond the bachelor's degree for programs offered by the College of Science and Liberal Arts. Doctoral program credit requirements for programs offered by Rutgers-Newark with NJIT collaboration are defined by Rutgers-Newark. Doctoral program credit requirements for joint programs, with both university names to appear on the diploma, are to follow the requirements of the program as approved by the two universities, generally a minimum of 72 credits beyond the bachelor's degree. Similarly, joint programs with UMDNJ are to follow requirements established jointly by the two universities.

In addition to overall credit requirements, each program includes the following minimal requirements:

- For those entering the program with master's degrees, 24 credits of course work beyond the master's degree of which at least 12 credits must be at the 700 level and none at the 500 level.
- For both entry levels, at least 12 credits of course work at the 700 level; no more than two independent study courses may be used to satisfy this requirement. Master's project or thesis cannot be used to satisfy this requirement.
- 36 credits of doctoral dissertation research for programs offered by Newark College of Engineering.
- 30 credits of doctoral dissertation research for the program in computer science.
- Dissertation research credits in accordance with the program approval documents for programs offered by the College of Science and Liberal Arts, jointly with Rutgers-Newark, by Rutgers-Newark directly, UMDNJ or jointly with UMDNJ. In no case will this be fewer than 36 credits for NJIT programs.

• Seminar attendance each semester. Nominal credit values, if any, for registration in seminar do not count toward fulfillment of overall credit requirements.

Students who wish to complete a master's degree while pursuing a doctorate, must apply for admission to the master's program, and satisfy all requirements for the master's degree, including any thesis or project requirement. As also discussed under "Terms and Conditions of Awards" in this catalog, students in doctoral programs initially, who terminate their studies at the master's level, will lose further eligibility for support.

Qualifying Examination

Students must pass a qualifying examination within two years of being admitted into doctoral programs. Exceptional students, only having bachelor's degrees, who are admitted into doctoral programs must take the qualifying examination within one and one-half years of admission and must pass it within two years. Students are only permitted to take the examination twice. The passage of qualifying examinations is reported to the Office of Graduate Studies. Each department determines its own policies with regard to format, confidentiality, grading, and review of examinations by faculty and students. Students are, at their request, permitted to view their examination papers in the presence of a designated faculty member and to see correct examination answers.

Dissertation and Pre-doctoral Research Credits

Students may register for doctoral dissertation credits (course number 790) only after passage of the qualifying examination. They may register for a maximum of 6 credits of pre-doctoral research (course number 792) prior to passage of the qualifying exam. These credits may count toward the required number of dissertation credits for the degree. Dissertation and pre-doctoral dissertation credits are either grade S or U except that P is assigned to the last registration for doctoral dissertation upon completion of the degree.

Dissertation Advisor, Dissertation Committee and Research Proposal

Doctoral students are required to have a dissertation advisor selected, a dissertation committee formed, and research proposal approved within one year of passage of the qualifying examination.

Department chairpersons or doctoral program directors are responsible for approving formation of dissertation committees. Most dissertation committee members are faculty from the student's program or department. The dissertation committee chairperson typically is the doctoral candidate's dissertation advisor, but other faculty may be selected, provided that they are from the student's program or department. The committee consists of a minimum of five members, one of whom is external to the program, or to NJIT. For candidates whose program is interdisciplinary and in more than one department, the external member must not be connected to the student's program or discipline. Two committee members, including an external member, may serve as co-advisors for the dissertation. Changes in advisor or committee memberships require the approval of the dean of graduate studies.

Each doctoral program has specific requirements for preparing, presenting and accepting proposals. Research is expected to investigate or develop a unique contribution to science and technology. Research may be experimental, analytical, applied, or theoretical, provided it satisfies this criteria and is approved by the dissertation committee. It should be of a quality to warrant scholarly presentation or paper submission to reputable journals in accordance with program practice.

Residency

Doctoral candidates must spend at least one academic year in full-time residence. This requirement is sometimes waived with the approval of the dissertation committee and the Office of Graduate Studies. Such waivers are granted when a candidate's dissertation research requires use of research facilities at an approved off-campus site. A typical example for residency requirement waiver would apply in the case of students in the collaborative doctorate program.

Doctoral Candidacy

Doctoral candidates are doctoral students who have completed all other requirements for the degree except for completion of the dissertation and the defense. This includes, as a minimum, passage of the doctoral qualifying examination, approval of the research proposal and completion of all course work. Status as a doctoral candidate does not imply candidacy for the degree.

Dissertation and Defense

The dissertation should be a scholarly publication of the quality to warrant conference presentation or paper submission to reputable journals. The dissertation must be defended in a publicly announced oral defense. Successful defense of the dissertation is determined by vote of the dissertation committee. All members of the committee must be present to hear the defense.

Each program has its own policies on scheduling and submitting dissertation drafts to members of the dissertation committee. Students are responsible for following their program's dissertation policies. In regard to format, the standard reference is the latest edition of the Estrin/Roche manual: Guidelines for Scientific and Professional Theses. Office of Graduate Studies policies on number of copies, deadlines, fee payments, information documents, and grade submission for acceptance of the final dissertation and abstracts and degree certification are also to be followed.

Every member of the dissertation committee must sign and date the approval page of the final dissertation document.

The Office of Graduate Studies provides guidance and assistance to students working on the final details of the dissertation. Students should contact the office for appointments early in the final semester.

GRADUATE CERTIFICATE REQUIREMENTS

Certificates require completion of 12 specified credits with a GPA of 3.0 or better. The cumulative GPA of the entire graduate record at NJIT also must be 3.0. Graduate certificate credits may be applied to a following master's degree. Dual use of credits from a completed first master's degree to a second and following certificate is not permitted.

Students in these programs are considered to be non-matriculated students for the duration of the certificate program. Graduate certificate programs must be completed before students may be admitted to a matriculated graduate program making use of any certificate credits. Students in a matriculated degree program are not permitted to seek a certificate (move back to non-matriculated status) until completion of the matriculated program. Any certificates after completion of a degree program cannot be duplicates of the degree or part of the degree although substitute courses may be approved.

Academic Standing

GRADES

The following grades are used for graduate courses:

GRADE	GPA	SIGNIFICANCE
A	4.0	Excellent
B+	3.5	Good
B	3.0	Acceptable
C+	2.5	Marginal Performance
C	2.0	Minimum Performance
F	0.0	Failure
I		Incomplete
W		Approved Withdrawal
AUD		Audited (no academic credit)
S or U		Satisfactory or Unsatisfactory
P		Passing for Doctoral Dissertation and Defense

Grade Reports

The registrar issues a grade report to each student at the end of each semester. Grades also may be viewed using a confidential password and identification number at *www.njit.edu/Registrar*, the registrar's home page.

Grade Changes

Grade change requests will not be accepted after the end of the subsequent semester.

Grade Disputes

Students are expected to resolve disputes about grades with their instructors. If they cannot reach a satisfactory settlement with their instructor, students are permitted to request the intervention of the

chairperson of the department and the dean of the school or college. The dean of graduate studies may be consulted.

In all cases, final authority to award grades rests with the instructor.

Special Circumstances

Students should bring to the attention of the dean of graduate studies any special circumstances which may adversely affect academic standing. This action must be taken as soon as such circumstances develop.

Incomplete

A grade of I (Incomplete) is given when courses cannot be completed because of special circumstances. Students on academic probation are not permitted incompletes without permission from the Office of Graduate Studies. Required course work may be finished at the discretion of the instructor, no later than the end of the subsequent semester. A letter grade must be assigned or a grade of F will be given. Students nominated for financial awards must have I grades resolved by the fourth week of the subsequent semester to allow a determination of their eligibility for the award. This grade cannot be changed. A grade of I cannot be given for thesis, project, dissertation, seminar, pre-doctoral research, co-op, or English as a Second Language (ESL) courses.

Withdrawal from Course(s)

Students who wish to withdraw from one or more courses should first determine if the withdrawal would have an impact on full-time status, financial support, or academic standing and progress. They should consult their advisor or the Office of Graduate Studies in advance. Withdrawals are done by completing and submitting a Schedule Change Form to the Registrar's Office by the end of the ninth week of the semester. This form requires the signature of the instructor(s). It is available at the Registrar's Office. Failure to submit this form to the registrar by the deadline will result in a final grade other than W.

Discontinued attendance or verbal approval to withdraw alone will not result in a W and most likely will instead result in an undesirable final grade.

Auditing a Course

Students who wish to audit a course must state their intention to do so at the time of registration. Change in auditing status is not permitted once a semester has begun. Students who audit are required to pay full tuition and fees for the course. Financial awards are not applicable to audited courses. Audited courses are not counted in determining full-time status. Students on probation are not permitted to audit.

Satisfactory and Unsatisfactory

The grades S or U report progress in project, thesis, dissertation, and pre-doctoral research courses. These also can be final grades in seminar, co-op, teaching methods, and ESL courses. The grade of S is given for satisfactory progress and U is given for unsatisfactory progress. Students who fail to meet with their advisors or do not satisfy relevant attendance requirements will receive a U grade. Credits for courses in which U is received cannot count toward a degree.

Course Repetition

Graduate students may request approval to repeat a course using a form available from the Office of Graduate Studies. The grade received in a repeated course is calculated in the cumulative GPA, but the first grade still appears on the transcript. A maximum of two courses may be repeated in graduate studies. Students may not repeat a course without prior approval from the department and the Office of Graduate Studies. Students who receive an F in a course will be required to repeat that course. The dean of graduate studies should be consulted if the course is no longer offered or not applicable to the student's current program.

Final Grades in Project, Thesis, Dissertation and Research

Letter grades are given for satisfactory completion of project, thesis, or pre-doctoral research requirements. Projects and theses must be submitted first, before a grade can be given. The final grade for a completed and approved dissertation and defense is P. Theses and dissertations are submitted to the Office of Graduate Studies. Projects are submitted to the project graduate advisor. Semester and cumulative GPA calculations by the registrar only include courses for which a letter grade is given. For the purpose of the GPA, the registrar only calculates the grades for credits earned in the semester in which the project, thesis or dissertation is completed. Letter grades cannot be given for an unfinished project, thesis, dissertation, or pre-doctoral research nor for work not submitted. Receipt of two U grades for project, thesis, dissertation, or pre-doctoral research will result in a letter grade of F in place of the second U and dismissal from the program.

Transcript of Grades

Students who wish to obtain a transcript issued on their behalf must submit a request in writing to the registrar. A $3 fee for each copy must accompany written transcript requests. Please allow 10 days to process the request. Transcripts will not be issued to or on behalf of a student with outstanding financial obligation to the university. Official transcripts bearing the university's raised seal will be issued only to other educational institutions, government agencies, or employers. Under no circumstances will official transcripts be issued to students.

PROGRESS TOWARD DEGREE

Academic Performance and Satisfactory Progress Policy

New Jersey Institute of Technology requires that students maintain satisfactory progress in working toward a degree. Federal and state regulations governing financial aid and awards require that students receiving aid from government agencies must meet academic performance and progress requirements defined by the university and approved by the appropriate government agencies. Students are responsible for checking regularly with the office of the department of major study or the Office of Graduate Studies to determine if they are fulfilling degree requirements.

The Office of Graduate Studies, along with academic departments, reviews academic standing of all graduate students at the end of each semester. To have satisfactory academic standing, students must have a cumulative GPA of 3.0 or above, meet all university requirements and satisfactorily progress toward a degree. Students who do not have satisfactory academic standing are subject to academic warning, academic probation, or academic dismissal.

ACADEMIC WARNING

Students who have completed one semester, or less than 15 credits, and do not have satisfactory academic standing may be asked by the Office of Graduate Studies to visit in-person to review their academic record and also meet with their graduate advisor. This is not noted on the permanent academic record.

ACADEMIC PROBATION

Students who have completed two or more semesters, or more than 12 credits, and do not achieve satisfactory academic standing may be placed on academic probation or subject to dismissal. Conditions for continuing graduate studies at NJIT are sent, in writing, to students on academic probation. The Office of Graduate Studies will work with students to determine approaches toward successful program completion. Course repetition or the taking of up to 6 additional credits are typical of recommendations for students whose GPA is below 3.0 and have the ability to raise the GPA to 3.0 with appropriate grades.

Students on academic probation may not maintain registration without the approval of the Office of Graduate Studies. Academic probation is noted on the permanent academic record.

DISMISSAL

Students may be dismissed from Graduate Studies for cause at any time. Cause shall include, but is not limited to:

- Failing to meet the conditions of admission.
- Failing to maintain a cumulative GPA of at least 3.0 after completing one semester or attempting at least 12 credits.
- Failing to make satisfactory progress toward a degree.
- Failing to meet the requirements for graduation.
- Failing a required or repeated course more than once.
- Failing to satisfy requirements for project, thesis, or dissertation within the required time limits.
- Failing doctoral qualifying and similar examinations required for continuing studies in the program, or failing to take examinations within prescribed time limits.

- Professional conduct offenses as defined in the Student Handbook.
- Making a false representation relating to admission, registration, or the awarding of financial support.
- Failure to pay all tuition, fees, and other charges within the required time limits.

Dismissal is noted on the permanent academic record.

Appeals

Decisions relating to a graduate student's academic status are made in accordance with regulations approved by the faculty and its standing committees. Committees include, but are not limited to, the Graduate Council and the Committee on Academic Affairs.

Students who disagree with a decision should attempt to resolve the matter with those immediately responsible. When a matter cannot be resolved at this level, students should appeal to the chairperson of the department and then to the dean of the college. At any time, the student may request that the dean of graduate studies be consulted.

A graduate student who remains dissatisfied may appeal the decision to the Committee on Graduate Appeals through the Office of Graduate Studies. The committee's decision, made in writing, is final. Student requests for review or appeal must be in writing and state accurately and completely the decision being appealed, when it was made, by whom, and the reason for the request. Requests should be sent to the dean of graduate studies. A copy of the request together with transcripts, test scores, and other information that form the student's record are distributed to the committee members for their consideration.

Readmission if Dismissed

Students dismissed from NJIT may apply for readmission to another degree program after at least one calendar year.

Students dismissed for professional conduct offenses or for making false representation will not be readmitted to NJIT.

Other dismissed students who seek readmission after dismissal should apply to the Office of University Admissions at least two months before the date of intended readmission. These students must complete, in full, the application for admission and provide all requested documentation, regardless of previous applications. Readmission is treated as a new application. Readmits compete against all other applicants for admission that semester. The circumstances and conditions of the dismissal will be considered in the readmission process.

Students who reapply should also include supportive material to justify readmission. Such material may include, but not be limited to, scores obtained in the GRE or GMAT, grades obtained in graduate level work at other institutions, letters of recommendation, and statement by the applicant. A non-refundable fee of $50 must accompany applications.

Discontinuance

Students enrolled in graduate programs who find it necessary to temporarily discontinue their studies may either maintain registration, request a leave of absence, or voluntarily discontinue. A discontinuance form must be filed with the Office of Graduate Studies. International students may not discontinue studies, but may seek approval for a leave of absence at which time maintaining registration may be authorized. Students who have discontinued must follow procedures defined by the offices of University Admissions and Graduate Studies.

Maintenance of Registration

Students enrolled in a degree program who find it necessary to temporarily discontinue their studies are permitted to maintain registration for a fee of $50 for each semester they do not register. Students working on project, thesis or dissertation are generally not permitted to register for maintaining registration. International students on F-1 and J-1 visa status may not maintain registration unless they have obtained prior written permission from the Office of International Students and Faculty.

Students who maintain registration are mailed registration notices for the following semester and are not required to reapply for admission. To maintain registration, students must register for "Maintaining Registration" on the registration Web site.

Each semester in which registration is maintained is counted in the total time period allotted to complete degree requirements except for students with an approved leave of absence.

LEAVE OF ABSENCE

Students who anticipate a protracted absence from the university may request a leave of absence from the Office of Graduate Studies. Students requesting a leave of absence for medical reasons will be required to consult with the Office of Health Services first. Leaves are granted for up to one year and may be extended for a second year. Leaves of absence are not counted toward the seven-year period in which the degree must be completed, but rules regarding expiration of credit do apply for course work, projects, thesis, and dissertation research. Students returning, on-time, from an approved leave of absence are not required to apply for readmission but are required to inform the Office of Graduate Studies and the Office of University Admissions on their return. They also are required to consult with their graduate advisor. The university complies with all state and federal laws related to military service.

Readmission after Voluntary Discontinuance

Students who have voluntarily discontinued their studies without receiving a leave of absence, and who have not been dismissed from the NJIT graduate program must apply for readmission to the Office of University Admissions by the application deadline. A nonrefundable application fee of $50 must accompany applications. Applicants are subject to all probationary and unmet conditions in force at the time they discontinued their studies. Program requirements at the time of readmission will apply in addition to satisfaction of any prior unmet conditions. Application deadlines are:

For the fall semester .....June 5
For the spring semester .....October 15

Project, Thesis and Dissertation

Students may not register for project, thesis, or dissertation credits until they arrange for a department- or program-approved faculty advisor to supervise the work. Continued registration for additional thesis, project, or dissertation credits will be allowed as long as the advisor grades the work to show that there is satisfactory progress. Credits for which a U (unsatisfactory) grade is given are not counted as degree credits toward completion of the thesis, project, or dissertation. Doctoral dissertation registration may be 3 credits during a summer session.

Master's project or master's thesis registration must be at least 3 credits during a semester or summer session. Doctoral dissertation registration must be at least 6 credits during a semester until the total dissertation credit requirement is reached, at which time 3 credit registrations are permitted.

All students must have their advisor's signature and section identification each time they register for project or thesis. Students must register for thesis, project, or dissertation work within the deadlines established by the registrar.

Maximum credit registration each semester is 12 credits for the doctoral dissertation, 6 credits for the master's thesis and 3 credits for the master's project. Additional credit registrations, beyond 12, for doctoral dissertations, will require approval of the dean of graduate studies.

Once a student has begun a master's project, master's thesis or doctoral dissertation, the student must register for these courses each semester until the project, thesis, or dissertation is completed. Unapproved interruptions in project, thesis or dissertation may be subject to billing for omitted credits.

Students must be registered in project, thesis or dissertation in any semester or summer session in which completion is expected. The advisor for thesis or dissertation assigns a final grade when the Office of Graduate Studies confirms it has received all documents in final and approved form and all related bills have been paid.

Approval by the graduate program advisor and the Office of Graduate Studies must be obtained if the student wishes to interrupt the thesis, project, or dissertation for a semester or more. Students may neither maintain registration, nor fail to register without notifying and getting approval from the graduate program advisor and the Office of Graduate Studies. If a master's project is not completed after two semesters' registration, a final grade of F is given. Failure to complete a master's project by students who receive financial support may result in dismissal. The university complies with all state and federal laws related to military service.

No more than four semesters and two summers of registration for a master's thesis are permitted. Failure to complete a master's thesis within this period will result in a final grade of F, and may result in dismissal.

No more than six years of registration for doctoral dissertation is permitted. Failure to complete a doctoral dissertation in this period will result in a final grade of F, and dismissal from the program.

Students who require additional time to complete a project, thesis, or dissertation should appeal for an extension, in writing, to the graduate program advisor, the academic department, and the Office of Graduate Studies. If the appeal for an extension is denied, the student may appeal further in the following order: department chairperson, dean of the school or college, and finally to the Committee on Graduate Appeals. Appeals may be accompanied by any materials that the student believes appropriate. Appeals to the Committee on Graduate Appeals should be directed to the dean of graduate studies. All decisions of the Committee on Graduate Appeals are final.

DEADLINE WAIVER

Applicants for January or May graduation whose master's thesis or doctoral dissertation is substantially complete, but who are unable to submit it in final form by the specified date, may request a deadline waiver from the Office of Graduate Studies before it is due. Students granted a waiver may be permitted until a date specified by the Office of Graduate Studies to submit the final copy of the work to the office. Such students may then apply for the next scheduled graduation without having to pay for additional thesis or doctoral dissertation credits. Contact the Office of Graduate Studies for further information.

Students who do not meet the deadline waiver will be required to register for master's thesis or doctoral dissertation in the subsequent enrollment period to obtain a final grade.

Rights and Responsibilities

Code of Professional Conduct

New Jersey Institute of Technology requires students to conduct themselves with decorum and to adhere to standards of ethical and professional behavior. NJIT has adopted, and requires all students to comply with, a Code of Professional Conduct. The policies and procedures governing this code are contained in a separate publication, the Student Handbook, and are deemed incorporated into this catalog. A copy of the handbook may be obtained from the Office of the Dean of Student Services.

Identification Card

All students must carry an NJIT identification card while on campus. An ID card must be presented at the request of a university administrator, faculty member or public safety officer. Facilities, parking, building access, and services of the university require presentation of a valid university ID.

Students should obtain an ID card as soon as possible after registration is completed. Photographs for ID cards are taken throughout the semester in the Department of Public Safety, located in the parking facility. Dates and times to obtain an ID are posted at the Hazell Center Information Desk. Proof of registration in the form of a tuition receipt or registrar's receipt is required to obtain an ID card. These receipts also will be accepted as NJIT identification until the ID card is issued. ID validation stickers are issued each semester and are available at the Department of Public Safety or the Hazell Center Information Desk.

Lost or stolen IDs should be reported as soon as possible to the Department of Public Safety. A replacement for a lost card is obtained by paying a $25 charge at the Bursar's Office cashier's window in the Student Services Mall and presenting the receipt at the Department of Public Safety where the card will be re-issued.

NJIT cards are not transferable. Cards are not to be loaned to anyone for any reason. ID cards are the property of NJIT and must be returned upon request.

Family Educational Rights and Privacy Act

The Federal Family Educational Rights and Privacy Act of 1974 gives students the right to inspect any educational records about them maintained by NJIT. Students have the right to a hearing to challenge the contents of these records, and also have the right to add to their records an explanation of information they challenge. Unless specifically exempted by the public law, NJIT is mandated to keep student records strictly confidential.

The university registrar is responsible for student records. Educational records are defined as transcripts, admission files and registration forms. To review their files, students must contact the registrar, in writing, to specify the items they want to see. Student health records are maintained by the Director of Health Services and may only be examined by a health professional chosen by the student.

Educational records defined by the public law must be made available within 45 days after a student requests to see them. A catalog of educational records kept by NJIT is available from the registrar. Exceptions to the right of inspection include financial aid records and records of institutional, supervisory, and administrative personnel, and ancillary educational personnel.

For a nominal service fee, copies of these records may be made for students.

Only those at NJIT acting in the student's interest are allowed access to student files, including personnel in the registrar's, admissions, student services, and finance offices; and academic personnel within the limitations of their need to know.

With the exceptions stated in the law, no one outside NJIT shall have access to a particular student's educational record without the written consent of the student, except in extraordinary circumstances such as emergencies. Accrediting agencies carrying out their accrediting function and certain state and federal officials are permitted access. A record of, and reasons for, granting access will be kept by the university and will be available to the student.

The university, at its discretion, may provide directory information, in accordance with the provisions of the law including a student's name, address, telephone listing, date and place of birth, major field of study, participation in officially recognized activities and sports, weight and height of members of athletic teams, dates of attendance, degrees and awards received, and the most recent previous educational agency or institution attended by the student. Students who desire directory information to be withheld should notify the registrar in writing within the first two weeks of initial registration.

Request for non-disclosure will be honored by the university for ONLY ONE ACADEMIC YEAR AT A TIME. Authorization to withhold directory information must be filed annually in the Office of the Registrar.

Students who disagree with an entry may challenge its accuracy with the Office of the Registrar. If this remedy fails, either NJIT or the student may request a formal appeal hearing. The law mandates that such hearings be held within 30 days of requests, and be conducted by a university official or other person with no direct interest in the outcome. Students will be given a full and fair opportunity to present relevant evidence and be represented by their own counsel.

Students may include a written statement in their file explaining a disputed entry following an unfavorable determination of an appeal. A written decision will be rendered within 15 working days after the hearing of an appeal.

Students who believe that they are treated unfairly or improperly and contrary to the provisions of the law may request, in writing, assistance from the provost of the university or the provost's designee. Students who believe that their rights have been abridged may file complaints with the appropriate federal agency.

Anti-Discrimination Policy

New Jersey Institute of Technology reaffirms its commitment to a policy of non-discrimination on the basis of race, sex, sexual orientation, age, religion, ethnic origin, handicap or veterans' status in its employment policies, educational programs and activities under university control.

Assuring a climate of equal opportunity is the direct responsibility of all levels of management. Administrative and supervisory personnel are required to comply with applicable government regulations and the affirmative action goals of the university. Among these are Executive Orders 11246 and 11375 (Affirmative action); the Civil Rights Act of 1964, as amended; Title IX of the Education Amendments of 1972 (Sex Discrimination); Section 504 of the Rehabilitation Act of 1973; Americans with Disabilities Act (Non-discrimination on the Basis of

Handicap); The New Jersey Law Against Discrimination, Title 10, Chapter 5, 10:5-1 to 10:5-28, NJ Revised Statutes, as amended; and the New Jersey Governor's Code of Fair Practices, Executive Order No. 21 (1965), as amended and Executive Order No. 39 (1991), "Prohibition in State Government of Discrimination Based on Sexual Orientation."

Any reported act of discriminatory behavior will be investigated through the Office of the Dean of Student Services, the Office of Compliance and Training, or the Office of General Counsel and Employment Policy Relations.

Sexual Harassment Policy

It is the continuing objective of the university to offer a work and study environment to its employees and students that rewards career and educational goals based upon relevant factors such as ability and work performance. Sexual harassment of employees and students is unacceptable. It is a barrier to educational and professional development and contrary to law and university policy.

In accordance with the NJIT Sexual Harassment Policy and Procedures, persons found to have violated university policy will face investigation, managerial review and possible disciplinary action up to and including employment termination and or dismissal from the university (for students). For a full copy of the university's policy prohibiting sexual harassment, please contact the Office of General Counsel and/or the Office of Compliance and Training.

Copyright Ownership

NJIT believes that its role as an educational institution is best served by disclosing to the public all academic research, dissertations and theses developed by students during the course of their studies or employment at the university.

Projects, theses and dissertations created by students shall be governed by the following provisions as outlined in NJIT's copyright policy under "Ownership and Disposition of Copyrightable Materials":

D. Copyright ownership of projects, theses and dissertations generated by research which is performed in whole or in part by the student with financial support in the form of wages, salaries, stipend, or grant from funds administered by the University shall be determined in accordance with the terms of the support agreement, or in the absence of such terms, shall become the property of the University.

E. Copyright ownership of projects, theses and dissertations generated by research performed in whole or in part utilizing equipment or facilities provided to the University under conditions that impose copyright restriction shall be determined in accordance with such restrictions.

F. Copyright in projects, theses and dissertations not within the provisions of Categories D and E of this policy shall be the property of the author. However, the student must, as a condition of a degree award, grant royalty-free permission to the University to reproduce and publicly distribute copies of the project, thesis or dissertation.

Requests for permission to publish Category D and E should be addressed to the Office of Intellectual Property.

For further information, call the Office of Intellectual Property, (973) 596-2457.

Ownership of Intellectual Property

NJIT retains all right, title and interest to any and all intellectual property (i.e. inventions, discoveries, creative works, trade secrets and know how) developed by students who are attending or are employed by the university.

To protect against premature disclosure or publication of a proprietary nature, students must immediately report the same to the Office of Intellectual Property. Students must neither publish nor discuss proprietary information with anyone other than the director of the dffice of intellectual property or members of the University Patent Committee. When a project, thesis or dissertation covers such material, the student or the advisor must report the existence of such material to the Office of Graduate Studies and the Office of Intellectual Property; the university will expedite its review. If necessary, the Office of Graduate Studies and the Office of Intellectual Property will take steps to sequester patentable material in archival documents such as theses and dissertations. If the university applies for a patent, the student will sign an agreement specifying royalties, licensing, and sale. All income derived from intellectual property will be shared between NJIT and the student. The size of the share is determined by university policy and/or special agreement.

For further information, call the Office of Intellectual Property, (973) 596-2457.

Property Loss and Damage

NJIT is not responsible for loss of property by fire or theft in its buildings or grounds. NJIT is not responsible for property damaged as the result of vandalism in its buildings or grounds.

Drug Abuse Prevention Program

New Jersey Institute of Technology prohibits the use of illegal drugs on its premises. University policy concerning possession and consumption of alcoholic beverages on campus subscribes to strict enforcement of the laws of the State of New Jersey, the County of Essex, the City of Newark, the City of Mount Laurel, and the County of Burlington. In addition, the policy stipulates that any consumption must occur within a responsible social framework wherein beverages are not the focus of the event.

Students with drug and alcohol abuse problems should be aware that they can receive information, counseling and referral assistance from the Office of the Dean of Student Services, the Counseling Center, the Health Services Office, or the Stop-In Center. The professional staff of the Counseling Center can provide substance abuse counseling and assessment in some situations and will refer more serious problems to off-campus facilities and services.

In addition, the university, through the Division of Student Services, offers a series of educational programs focused on the areas of drug and alcohol information and substance abuse prevention.

Drug-Free Workplace Policy

Student employees are subject to university policies regarding employment. New Jersey Institute of Technology is committed to maintaining a drug-free workplace in compliance with applicable laws. The university is further committed both to rigorous enforcement of applicable laws and policies and to support for those trying to cope with drug-related problems. The unlawful possession, use, distribution, dispensation, sale, or manufacture of controlled substances is prohibited on university premises. Any NJIT employee determined to have violated this policy or engaged in drug-related problems that have an impact upon the workplace may be subject to disciplinary action up to and including termination. At the discretion of the university, any employee convicted of a drug offense involving the workplace shall be subject to employee discipline (up to and including termination) and/or required to satisfactorily complete a drug rehabilitation program as a condition of continued employment.

The illegal use of controlled substances can seriously injure the health of employees, adversely affect the performance of their responsibilities, and endanger the safety and well-being of fellow employees, students, and members of the general public. Therefore, the university urges employees engaged in the illegal use of controlled substances to seek professional advice and treatment. Anyone who is employed at NJIT who has a drug problem is encouraged to contact the Director of the Employee Assistance Program (EAP), who will assist in obtaining available treatment. Employees engaged in contracts with the U.S. Department of Defense are additionally subject to Department of Defense requirements and may be required to submit to tests for the illegal use of controlled substances.

As a condition of employment, an employee of NJIT will notify his/her supervisor if he or she is convicted of a criminal drug offense involving the workplace within five days of the conviction. In the event any such conviction involves an employee working on a federal contract or grant, the university will notify the granting or contracting federal agency within ten days of receiving notice of a conviction. A copy of this statement shall be given to all employees.

This statement and its requirements are promulgated in accordance with the requirements of the Drug-Free Workplace Act of 1988 enacted by the United States Congress. The university will continue its efforts to maintain a drug-free environment by adhering to the above policy and by providing through the EAP and the offices of Human Resources, and Compliance and Training, ongoing drug awareness programs.

Academic Programs

B.S./M.S. and Dual Degree Programs

This accelerated dual degree program permits undergraduates to earn credits toward a master' s degree. Students take 6 credits of graduate course work in their senior year. These may be counted towards both a bachelor' s degree and a following master's degree if enrollment as a graduate student in the master's degree program occurs within two years of completion of the bachelor's degree. After enrollment as a graduate student, those who wish to apply the 6 credits to the graduate degree program should contact the Office of Graduate Studies.

Full-time undergraduate students become eligible to apply after they complete at least five courses in their major, and have maintained a GPA of 3.0 or better. Students must submit the application for admission to the B.S./M.S. program to the Division of Career Development Services no later than one year prior to graduation. Applicants must fulfill all university requirements for admission to graduate programs and must submit GRE and GMAT scores.

Graduate study may be completed full- or part-time.

B.S./M.S. students may become eligible for a B.S./M.S. fellowship or a graduate assistantship. All university requirements for receiving financial support must be satisfied. Contact the Office of Graduate Studies about this or other opportunities.

Information and applications can be obtained from the Division of Career Development Services, (973) 596-3100.

Several other combinations of bachelor's and master's degrees exist or are under development. The number of dual-use credits for these combinations may exceed 6 credits in accordance with specific program requirements. An example is the B.Arch./M.S. in Management program, which allows 12 dual-use credits.

M.S./M.S. and Dual Master's Programs

The M.S./M.S. program allows students to pursue a second NJIT master of science degree on completion of the first and to count two courses (6 credits) from the first degree toward the second. The option must be exercised within two years of completion of the first degree. The approval of the advisors of the two programs is required. The Office of Graduate Studies will direct the registrar on transfer of the two dual-use courses to the second program. The M.S./M.S. program option is not intended for students who have left the doctoral programs without completion of the degree. Up to 6 credits may be transferred to the second master's degree from outside NJIT. Thesis, project, predoctoral research, independent research, and similar courses may not be used.

Several other master's degree combinations involving the Master of Architecture, the Master in Infrastructure Planning and the M.S. in Management allow dual use of courses from the first degree to the second. The number of dual use credits for these combinations may exceed 6 credits in accordance with specific program arrangements.

The Executive Program: Master of Science in Management

The Executive Program, operated by the School of Management, is an accelerated 14-month M.S. in Management degree program for rising executives, specifically designed to meet the needs of business professionals and the demands of corporate life. The curriculum emphasizes the use of information systems, strategic planning and the integration of business functions. The program addresses competition in the global marketplace, the deployment and use of technology, environmental issues, and ethical standards for business leaders. The Executive Program is accredited by AACSB.

The program begins with a five-day residential session. A second residential session involving an international study tour is held approximately nine months later. The remainder of the program is taught on campus, Fridays and Saturdays, every other week. Classroom meetings are separated by 12 days or more to accommodate business travel. The Executive Program is offered three times a year. Classes at the Newark campus start in February and August and in October at the NJIT at Mount Laurel campus.

Interest from the business community has been enthusiastic. For more information, contact the Executive Program, (973) 596-6378.

Collaborative Doctorate

This doctoral program is designed to meet the workforce needs of the knowledge-dependent global economy of the 21st century recognizing the particular requirements of the professional practitioner. This program is designed to meet the needs of engineers, managers, scientists, military personnel and educators who wish to pursue doctoral studies while employed full-time in the private, public and not-for-profit sectors.

Academic requirements are the same as for other NJIT doctoral programs but the collaborative nature of the program also allows participants to draw on the combined expertise and resources of the university and their employer. The program includes significant flexibility with opportunities for distance learning and independent study that are integrated with face-to-face classes.

To participate in this Ph.D. program, students must be nominated by their employer. These nominations serve as letters of recommendation in the admissions process. In addition to nominating students, employers must commit to a proposed area of research and appoint a senior researcher or manager to serve on the student's dissertation committee.

Students nominated by employers must meet university requirements for admission to doctoral programs. Prior work, related research activity, publications, and honors will be evaluated in addition to traditional academic criteria.

Doctoral students are expected to have been employed in their field for at least five years, and to have completed a related master's degree. They are expected to continue employment until they complete all degree requirements. Annual reviews of progress will be conducted. Students may perform dissertation research at their employer's facilities. Dissertation research can be derived from interests of the student and may be related to their professional activity.

Dissertation research must satisfy university policies. The student's dissertation committee defines residency requirements. It is expected that the employer will permit a concentrated effort on dissertation research. Seminar requirements are also defined by the dissertation committee and may include presentations or attendance at professional society meetings.

Course requirements are based on previous activities and the current state of knowledge of the student. Dissertation research is expected to investigate or develop an original contribution to science, technology or management. Research may be experimental, analytical, applied or theoretical provided that it satisfies all criteria set by the dissertation committee.

Employers who have proprietary interest in dissertation research including patent, copyright and technology transfer rights are expected to execute formal agreements with the university before research begins.

Student Exchange/Study Abroad

NJIT offers a number of international exchange opportunities for undergraduate and graduate students in Europe and the Far East. Through established exchange agreements, participants are provided with opportunities to enhance their technological skills, expand their cultural horizons, and gain educational experience from an international perspective. Students gain firsthand knowledge of political, social, and economic systems of a rapidly changing world.

Students may elect to study for one semester or for a full academic year. NJIT students pay tuition and fees at NJIT and room and board at the host institution. Financial support may be applied to these expenses.

With the prior written approval of the student's academic advisor, academic credit may be awarded for courses taken while participating in an international exchange program. Some programs may require proficiency in the language of the host country, especially if the language of instruction for course work is not English.

For further information, contact the Office of International Students and Faculty, (973) 596-2451.

Cooperative Education

The Cooperative Education Program provides students with an experiential and applications approach to education. Through cooperative education, students gain academically integrated work experience that is related to their degree. Qualified graduate students gain salaried professional experience while they earn their degrees.

Co-op work experiences are concurrent or alternate with full- or part-time graduate study. During placement periods students are enrolled in the graduate co-op work experience course. Graduate co-op work experience periods are not limited to academic semesters. Students may begin work in the second semester of attendance at NJIT (except for international students).

All co-op student participants must be able to produce U.S. employment authorization. Immigration and Naturalization Service (INS) regulations require students with F-1 visas to be in valid status for nine consecutive months before they can be placed in co-op employment. International students become eligible to apply during their second semester of study. They must secure employment authorization from the Office of International Students and Faculty before beginning a co-op work experience. There are additional restrictions on co-op employment for students on financial support or involved with research activity and thesis or dissertation work. The Office of Graduate Studies may be consulted about policy issues.

Community and Public Service

Graduate students may also receive financial support through participation in the NJIT Service Corps. Through experiential learning activities, students link classroom theory and concepts with practical application, contribute their expertise and develop leadership, decision-making and interpersonal skills through involvement with non-profit and governmental agencies and community-based organizations.

- **Community Service Work Study:** Off-campus employment that is course- and major-related in non-profit and governmental agencies and community-based organizations for eligible Federal Work Study graduate students.
- **Housing Scholars:** Merit-based, competitive full-time summer employment in community-based organizations that design and develop plans for affordable housing projects around the state. Students pursuing graduate degrees in civil engineering, management, computer science, and computer engineering who are U.S. citizens or permanent residents, have completed 6 credits of graduate study, are in good academic standing, have satisfied all other university requirements for financial support, and are approved by their department's co-op advisor are eligible to apply. Architecture students may apply after completing 14 credits of first-year required graduate courses and if they have an overall cumulative 3.2 GPA or above. However, participation cannot begin until 28 credits are completed.
- **Service Learning:** Course-based, students can register for classes that include a community Service Learning option or register for faculty-monitored independent study that includes a community Service Learning component.

For more information, contact the Division of Career Development Services, Community and Public Service, (973) 596-3100.

Degree Programs

Applied Physics

Administered by: Federated Physics Departments of NJIT and Rutgers-Newark

Federated Chairperson and Chairperson (NJIT): Anthony M. Johnson
Chairperson (Rutgers-Newark): Earl D. Shaw
Associate Chairperson (NJIT): Frederick Tomblin

Joint Graduate Programs Director and Graduate Advisor: Ken K. Chin (973) 596-3297 (Room 466 TIE), e-mail chin@admin.njit.edu

NJIT Faculty
Distinguished Professors: Goode, Johnson, R. Levy, Poate
Professors: Buteau, Carr, Chin, Fink, Gautreau, Ravindra, Savin
Associate Professors: Farmer, Federici, Gary, Russo, H. Wang
Assistant Professors: Jermakian, Tyson
Distinguished Research Professor: Hensel, Zirin
Research Professors/Special Lecturers: Kohn, Moeller, H. Opyrchral, Piatek, Tomblin, Yu

Rutgers-Newark Faculty
Professor Rank II: Murnick
Professor: Shaw
Associate Professor: Wu
Assistant Professor: Burke

Degrees Offered: Master of Science in Applied Physics; Doctor of Philosophy in Applied Physics. Both degrees are offered jointly by NJIT and Rutgers-Newark.

The federated NJIT and Rutgers-Newark departments of physics offer a unique opportunity to pursue master's and doctoral degrees in applied physics in a federated/joint program combining the resources of two of New Jersey's public research universities.

Interdisciplinary applied physics research is available in collaboration with faculties of NJIT, Rutgers-Newark and Rutgers-New Brunswick, and UMDNJ in areas such as device physics, materials research, ultrafast optical and optoelectronic phenomena, imaging technology, surface physics, free electron laser physics, biophysics, discharge physics, solar physics, and applied laser physics. Cooperative research efforts are underway with the National Solar Observatory, Lucent Technologies Bell Labs Innovations, U.S. Army Research Laboratory, and other industrial and federal research laboratories.

■ MASTER OF SCIENCE IN APPLIED PHYSICS

The program is for students with an undergraduate degree in physics, applied physics, or engineering, who wish to apply physics to optical science, microelectronics, device physics, materials science, surface science, laser physics, solar phenomena, and other related areas.

Admission Requirements

A bachelor's degree in physics, applied physics, or related areas from an accredited institution is required. An undergraduate GPA above 3.0 is required. Students must submit GRE (general test) scores. In addition, applicants are required to provide letters of recommendation from their previous academic institutions. Students for whom English is not their native language are required to have TOEFL scores no lower than 550.

Degree Requirements

A minimum of 30 degree credits (600 or 700 level), including a 6-credit thesis or a 3-credit project is required. Of the 30 credits, 18 must be physics courses (including 3 credits of mathematical physics or applied mathematics). The remaining 12 to 15 credits are elective courses.

Seminar — In addition to the minimum 30 degree credits required, all students who receive departmental or research-based awards must enroll each semester in Phys 791/26:755:791 Applied Physics Seminar.

REQUIRED
12 credits:

Phys 611/26:755:611	Advanced Classical Mechanics
Phys 621/26:755:621	Classical Electrodynamics
Phys 631/26:755:631	Quantum Mechanics
Phys 641/26:755:641	Statistical Mechanics

PROJECT OR THESIS (required)

3 credits:	Phys 700/26:755:700	Master's Project *or*
6 credits:	Phys 701/26:755:700	Master's Thesis

ELECTIVE
12 credits if completing a master's thesis; *15 credits* if completing a master's project: Selected in consultation with a graduate advisor.

■ DOCTOR OF PHILOSOPHY IN APPLIED PHYSICS

This program is for superior students in applied physics who are interested in and committed to scholarly research.

Admission Requirements

Applicants are expected to have a master's degree in physics, applied physics, or related engineering disciplines from an accredited institution. Highly qualified students with bachelor's degrees may be accepted directly into the doctoral program. A GPA of at least 3.5 in undergraduate and previous graduate studies is normally required for admission. The GRE (general test) and advanced (physics) test scores are required. Applicants are required to provide three letters of recommendation from their previous academic institutions. Students for whom English is not their native language are required to have TOEFL scores no lower than 550.

Degree Requirements

For students entering with B.S. or B.A. degrees, the Ph.D. requires 75 (600 or 700 level) credits as follows:

39 credits of course work, of which 24 credits are physics courses (including 3 credits of mathematical physics or applied mathematics), and 15 credits are electives. No less than 12 credits must be at the 700 level.

36 credits of Phys 790/26:755:790 Doctoral Dissertation

For students entering with M.S. or M.A. degrees, the Ph.D. requires 54 (above 600 level) credits as follows:

18 credits of course work, of which 9 credits are physics courses (including mathematical physics or applied mathematics), and 9 credits are electives. No less than 12 credits must be at the 700 level.

36 credits of Phys 790/26:755:790 Doctoral Dissertation

Seminar — All doctoral students must enroll in Phys 791/26:755:791 Applied Physics Seminar each semester, including each semester they are enrolled in Phys 790/26:755:790 Doctoral Dissertation.

REQUIRED
18 credits:

Phys 611/26:755:611	Classical Mechanics
Phys 621/26:755:621	Classical Electrodynamics
Phys 631/26:755:631	Quantum Mechanics
Phys 641/26:755:641	Statistical Mechanics
Phys 721/26:755:721	Classical Electrodynamics II
Phys 731/26:755:731	Quantum Mechanics II

The four 600-level physics courses can be replaced by other courses for entering students who have M.S. degrees and have taken these courses in the master's program.

Qualifying Examination and Research Examination — The student must pass a written qualifying examination and oral research examination. The written qualifying examination is administered yearly to test general academic preparation and competence for research in applied physics. Within one year after passing the written qualifying examination, the student is required to pass the oral qualifying examination to achieve Ph.D. candidacy, in which the prospective Ph.D. candidate presents a preliminary research proposal for approval by the dissertation committee. The student will be allowed two attempts to pass the written or oral qualifying examination.

Dissertation and Defense — An oral presentation and defense of the doctoral dissertation is required. A five-member committee, chaired by the dissertation advisor, must approve the content and presentation of the dissertation research.

Applied Science

Administered by: Applied Science Committee

Program Director and Graduate Advisor: Leon Buteau (973) 596-3291, e-mail buteau@admin.njit.edu

Faculty: from NJIT's College of Science and Liberal Arts and Newark College of Engineering, as appropriate

Degree Offered: Master of Science in Applied Science

Applied Science is a program in which teachers teach teachers about modern science and technology. Developed in 1975 in response to requests from secondary school teachers, the M.S. in Applied Science program is designed to strengthen an educator's background in the appropriate subject matter with practical laboratory applications. The program is run by a multi-disciplinary committee, and students are encouraged to undertake interdisciplinary program of study.

MASTER OF SCIENCE IN APPLIED SCIENCE

A multidisciplinary program for secondary school teachers to strengthen their backgrounds in science, mathematics and computing.

Admission Requirements

Applicants should be practicing secondary school teachers who have bachelor's degrees. Individuals who seek admission to the program are considered on an individual basis. Students who lack an appropriate background in science may be asked by the department to take an individually-designed program of courses (that may include undergraduate courses) before beginning their graduate curriculum. These courses are not counted toward degree requirements.

Degree Requirements

Students must complete a minimum of 30 credits: 6 credits of core course, 3 credits of master's project and 21 credits of elective courses in an area of specialization. The area of specialization and courses are selected in consultation with a graduate advisor.

CORE AND PROJECT

9 credits:

These courses are in development. See the program director for information.

AREAS OF SPECIALIZATION

The following are suggested areas of specialization and typical courses that may be offered. Students may develop an individual area of specialization in consultation with a graduate advisor. Realistic combinations involving mathematics and computing, physics and mathematics, or environmental science and chemistry (to name a few) are encouraged.

Mathematics

21 credits from:

Math 515	Introduction to Advanced Calculus I
Math 516	Introduction to Advanced Calculus II
Math 611	Numerical Methods for Computation
Math 661	Applied Statistics
Math 630	Linear Algebra and Applications

Remaining courses selected in consultation with graduate advisor.

Computing

21 credits from:

CIS 505	Programming, Data Structures, and Algorithms
CIS 601	Object-Oriented Programming
CIS 631	Data Management System Design
CIS 635	Computer Programming Languages
CIS 677	Information System Principles

Remaining courses selected in consultation with graduate advisor.

Science

21 credits from:

Chem 502	Advanced Organic Chemistry I
Chem 552	Laser Chemistry and Technology
Chem 625	Geochemistry
Chem 661	Instrumental Analysis
Chem 662	Air Pollution Analysis
Chem 705	Independent Study
Phys 601	Mechanics I
Phys 603	Electricity and Magnetism I
Phys 607	Topics in Astronomy and Cosmology
Phys 651/26:755:651	Atomic and Molecular Physics
Phys 675/26:755:675	Cellular Biophysics
Phys 687/26:755:687	Physics of Materials
Phys 690/26:755:687	Directed Study of Applied Physics

Architecture

Administered by: School of Architecture

Dean: Urs P. Gauchat
Associate Dean: James E. Dyer
Graduate Program Director: Peter C. Papademetriou
Graduate Program Associate Director: Timothy Wood
Infrastructure Planning Program Director: Antonio de Souza Santos
Graduate Program and Admissions Coordinator: Fred Little
Sponsored Chair: Ezra Ehrenkrantz
Distinguished Professor: Mostoller
Professors: Celik, Ehrenkrantz, Franck, Gauchat, Goldman, Greenfield, Hawk†, Papademetriou, Santos, Weisman
Associate Professors: Elwell, B. Jackson, Moore, Schuman, Wall, West, Zdepski

Graduate Advisor: Peter C. Papademetriou (973) 596-3078 (Room 345 WES), e-mail m-arch@admin.njit.edu

MSAS Graduate Advisor: David Hawk (973) 596-3019 (Room 3024 CAB), e-mail hawk@admin.njit.edu

Co-op Advisor: Timothy Wood (973) 596-3078

† Joint appointee with the School of Management

Degrees Offered: Master of Architecture (professional and post-professional options); Master of Science in Architectural Studies; Master in Infrastructure Planning; and dual Master of Architecture (professional, or post-professional) and either Master in Infrastructure Planning, or Master of Science in Management or Master of Science in Civil Engineering

An architect today must be educated to play a leading role in the planning, design and construction of the built environment. New dynamic economic, political, social and technological forces have radically altered how architecture is made and what role architects exercise in the process. The architect envisions and imagines both what is possible, and what ought to be. As a process, design gives form to society and the economic and technological aspects of environmental order.

For students in the Professional M.Arch. Program, partnerships through dual degree tracks in infrastructure planning, management and civil engineering can broaden a general education in architecture. Post-professional opportunities for specialized career directions, scholarly inquiry and research are also offered through degree programs in architectural studies and infrastructure planning.

The faculty comprises practitioners and scholars whose expertise and professional reputation are based on both breadth and depth of achievement. Their work directly engages the architectural discourse through research, publication, public lectures, symposia and professional practice. Many members have received scholarly recognition and design awards.

The School of Architecture offers the only publicly supported professional program in New Jersey and is committed to NJIT's reputation as a nationally recognized technological university.

To become registered as a licensed architect in the State of New Jersey, you must earn a degree accredited by the National Architectural Accrediting Board (NAAB). NJIT's M.Arch. degree program is one of only two NAAB-accredited degree programs in the State of New Jersey.

The following statement is taken from the current edition of NAAB's *Conditions and Procedures for Professional Degree Programs in Architecture:* "In the United States, most state registration boards require a degree from an accredited professional degree program as a prerequisite for licensure. The National Architectural Accrediting Board (NAAB), which is the sole agency authorized to accredit U.S. professional degree programs in architecture, recognizes two types of degrees: the Bachelor of Architecture and the Master of Architecture. A program may be granted a five-year, three-year, or two-year term of accreditation, depending on its degree of conformance with established educational standards.

Master's degree programs may consist of a pre-professional undergraduate degree and a professional graduate degree, which when earned sequentially, comprise an accredited professional education. However, the pre-professional degree is not, by itself, recognized as an accredited degree."

The NJIT Master of Architecture (M.Arch.) is a professional degree fully accredited by the NAAB.

MASTER OF ARCHITECTURE (M.Arch.)

There are two degree options in the M.Arch. program: professional M.Arch. and post-professional M.Arch.

Professional M.Arch. For students with undergraduate or graduate degrees who do not have previous architectural design courses or experience; the full-time program of study comprises seven semesters and meets the education requirements for the Architecture Registration Examination (ARE). It is also appropriate for students who have undergraduate degrees in architecture or related fields, those who have a non-NAAB accredited architecture degree, and all international students who would enter the program with advanced placement. Advanced placement, which reduces the 97-credit degree requirement, is determined at the time of admission through an evaluation of previous academic work.

Post-professional M.Arch. For students who have an NAAB-accredited professional Bachelor of Architecture (B.Arch.) degree.

Dual Degree M.Arch. and Master of Infrastructure Planning (M.I.P.) Open only to students in the M.Arch. program options, the dual degree program permits students to obtain an M.I.P. in substantially less time than if taken separately; in some cases in only one more semester of full-time study. Also see the program description under "Infrastructure Planning" in this catalog.

Dual Degree M.Arch. and M.S. in Management Open only to students in the M.Arch. program options, the dual degree program permits students to obtain an M.S. in Management in substantially less time; in some cases in only one more semester of full-time study. Also see the program description under "Management" in this catalog.

Dual Degree M.Arch. and M.S. in Civil Engineering Open only to students in the M.Arch. program options. The dual degree program permits students to obtain an M.S. in Civil Engineering in substantially less time; in some cases in only one more semester of full-time study. Also see the program description under "Civil Engineering" in this catalog.

Admission Requirements for all M.Arch. Options

In addition to completing the application required by NJIT's Office of University Admissions, M.Arch. applicants must also submit School of Architecture supplementary materials forms. To ensure prompt consideration, students should request the forms when they apply for admission to the university.

Applicants are expected to have a minimum undergraduate GPA of 3.0. GRE (general test) scores are required. Applicants to the M.Arch./M.S. in Management degree option may submit GRE scores in lieu of the GMAT scores which are normally required for admission to the M.S. in Management program. Exclusive of the GMAT/GRE requirements, dual degree applicants must satisfy admission requirements for both the School of Architecture and the School of Management.

Admission to the M.Arch. program is based on the applicant's personal statement, letters of recommendation, design portfolio, and previous academic and work experience. Applicants should have an appropriate academic background in physics, calculus, or statistics; students who lack such a background will be expected to take equivalent course work before entering the second year of the M.Arch. program. International students with professional degrees in architecture are required to have transcripts evaluated by Educational Credential Evaluators (information is included with School of Architecture supplementary materials). TOEFL scores are required for all international students.

Degree Requirements for Professional M.Arch.

This 97-credit program consists of a 61-credit core and an options sequence of 21 credits of required and 15 credits of elective courses. Students are expected to complete the core sequence in a minimum of two years. Before registering for courses, all students must consult with the graduate advisor to plan an appropriate course of study.

Students must submit a portfolio of design work at completion of the core courses. The portfolio will be reviewed in connection with advising students on their further program of study.

Core courses in the M.Arch. program represent the minimum background necessary to meet NAAB standards. If students demonstrate that they have previously completed equivalent course work, degree credit requirements may be reduced to less than the 97 credits required for the program.

To remain in good academic standing, students must maintain a cumulative GPA of 3.0 in graduate courses. Students must repeat any design studio course in which they receive a grade of C. A grade of C+ in any design studio must be followed by a subsequent grade sufficient to raise the cumulative design studio GPA to 2.75. Incomplete (I) grades for studio and prerequisite courses must be removed before students will be permitted to register for continuing course work in the program.

Degree credits appear in parentheses following the course titles below.

CORE

61 credits as follows:

Arch 500G Computer Programming and Graphics Problems (2)
Arch 501G Architectural Design I (5)
Arch 502G Architectural Design II (5)
Arch 503G Architectural Design III (5)
Arch 504G Architectural Design IV (5)
Arch 511G Structures I (3)
Arch 512G Structures II (3)
Arch 513G Structures III (3)
Arch 521G Construction I (3)
Arch 522G Construction II (3)
Arch 523G Building Performance (3)
Arch 524G Environmental Control Systems (3)
Arch 528G History of Architecture I (3)
Arch 529G History of Architecture II (3)
Arch 555G Architectural Graphics (3)
Arch 569G Building and Development (3)
6 additional credits of architectural history, selected in consultation with graduate advisor

Core courses must be completed before proceeding to the options sequence.

OPTIONS SEQUENCE

REQUIRED

21 credits minimum:

Arch 505G Advanced Design Options I (6)
Arch 506G Advanced Design Options II (6)
{ Arch 507G Advanced Design Options III (6) *or*
{ * MARC 701 Master of Architecture Thesis (6)
‡ Arch 579G Professional Architectural Practice (3)

ELECTIVE

15 credits selected in consultation with graduate advisor, of which a minimum of 9 credits are architecture electives.

Degree Requirements for Post-Professional M.Arch.

Consists of a minimum of 30 credits. Thesis is optional.

REQUIRED

12 credits minimum:

Arch 506G Advanced Design Options II (6)
{ Arch 507G Advanced Design Options III (6) *or*
{ * MARC 701 Master of Architecture Thesis (6)

ELECTIVE

18 credits consisting of 12 credits of architecture electives and 6 credits of free electives selected in consultation with graduate advisor.

Degree Requirements for Dual M.Arch. and M.I.P.

This dual degree option is available to students in the M.Arch. degree program. The dual degree program permits students to obtain the M.Arch. and the M.I.P. in substantially less time than if each degree was

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* Arch 661 Directed Studies of Architecture (3) is prerequisite for MARC 701 Master of Architecture Thesis. Arch 661 may be taken as an elective.

‡ For those pursuing the dual M.Arch. and M.S. in Management, Arch 579G fulfills Mgmt 691 Legal and Ethical Issues required for the M.S. in Management.

pursued separately. M.Arch. students may partially fulfill M.I.P. course work while completing the M.Arch. program of study. A maximum of 15 credits may be used to satisfy requirements of both degrees.

For more information about the M.I.P. program, see "Infrastructure Planning" in this catalog.

REQUIRED
15 credits:

Arch 507G	Advanced Design Options III (fulfills MIP 601) (6)
Arch 631H	History and Theory of Infrastructure (taken as M.Arch. architecture history elective and fulfills MIP 631) (3)
Arch 673	Introduction to Infrastructure Planning (taken as M.Arch. elective and fulfills MIP 673) (3) *or*
Arch 674	Infrastructure Planning in Practice (taken as M.Arch. elective and fulfills MIP 674) (3)
Arch 675	Elements of Infrastructure Planning (taken as M.Arch. elective and fulfills MIP 675) (3)

Additional requirements to complete M.I.P. program

REQUIRED
21 credits:

MIP 602	Interdisciplinary Infrastructure Studio II (6)
MIP 612	Introduction to Environmental Policy Studies (3)
MIP 615	Introduction to Transportation Studies (3)
MIP 618	Public and Private Financing of Urban Areas (3)
MIP 652	Geographic Information Systems (3)
MIP 655	Land Use Planning (3)

Degree Requirements for Dual M.Arch. and M.S. in Management

The dual degree option is only available to students pursuing the M.Arch. The dual degree program permits students to obtain both an M.Arch. and a M.S. in Management in substantially less time; in some cases in only one more semester of full-time study. A maximum of 15 credits may be used to satisfy the requirements of both degrees.

Students take additional credits shown below to fulfill requirements for the M.S. in Management. There is no thesis requirement.

At the time of admission to the dual degree program, the School of Management graduate advisor will determine if any M.S. in Management course requirements can be waived.

The requirements to obtain the M.S. in Management degree are:

‡ **CORE**
18 credits:

Arch 650	Economy of Building (fulfills M.Arch. elective) (3)
Arch 651	Real Estate Analysis for Architects (fulfills M.Arch. elective) (3)
Arch 652	Architectural Project Management (fulfills M.Arch. elective) (3)
Fin 516	Principles of Financial Management (fulfills M.Arch. elective) (3)
HRM 601	Organizational Behavior (fulfills M.Arch. free elective) (3)
Mgmt 680	Entrepreneurial Strategy (3) *or*
Mgmt 692	Business Strategy (3)

REQUIRED
3 credits:

Fin 618	Public and Private Financing of Urban Areas (fulfills M.Arch. free elective) (3)

ELECTIVE
9 credits from:

Acct 615	Concepts of Strategic Cost Analysis (3)
Fin 624	Financial Management (3)
Mgmt 640	New Venture Management (3)
Mgmt 645	New Venture Finance (3)
MIS 645	Operations Management, Planning and Control (3)
Mrkt 630	Models of Consumer Behavior (3)
Mrkt 638	Sales Management for Technical Professionals (3)

Degree Requirements for Dual M.Arch. and M.S. in Civil Engineering

This dual degree option is a specific tailoring of the construction engineering and management specialization in the M.S. in Civil Engineering program and is only available to students pursuing the M.Arch. degree.

‡ For those pursuing the dual M.Arch. and M.S. in Management, Arch 579G fulfills Mgmt 691 Legal and Ethical Issues required for the M.S. in Management.

The dual degree program permits students to obtain both an M.Arch. and a M.S. in Civil Engineering in substantially less time than if each degree was pursued separately. A maximum of 15 credits may be used to satisfy requirements of both degrees.

Students take courses shown below to fulfill requirements for the M.S. in Civil Engineering, or their equivalent. There is no thesis requirement. Students without a bachelor's degree in civil engineering must complete the bridge program; these courses do not count toward degree requirements. See the undergraduate catalog for descriptions of these courses.

At the time of admission to the dual degree program, the civil engineering graduate advisor will determine if any M.S. in Civil Engineering course requirements can be waived.

The requirements to obtain the M.S. in Civil Engineering degree are:

BRIDGE

CE 200	Surveying (3)
CE 200A	Surveying Lab (1)
CE 501	Introduction to Soil Behavior (3)
Math 105	Elementary Probability and Statistics (3)
Math 119	Applied Calculus and Finite Math (4)

CORE

CE 610	Construction Management (fulfills M.Arch. free elective) (3)
CE 611	Project Planning and Control (3)
CE 616	Construction Cost Estimating (3)
EM 632	Legal Aspects in Construction (3)

REQUIRED
12 credits:

Arch 650	Economy of Building (fulfills M.Arch. elective) (3)
Arch 652	Architectural Project Management (fulfills M.Arch. elective) (3)
Arch 675	Elements of Infrastructure Planning (fulfills M.Arch. elective) (3)
MIS 645	Operations Management, Planning and Control (fulfills M.Arch. free elective) (3)

ELECTIVE
6 credits from:

CE 615	Infrastructure and Facilities Remediation (3)
CE 631	Advanced Reinforced Concrete Design (3)
CE 642	Foundation Engineering (3)
CE 702	Special Topics in Civil Engineering (3)
CE 710	Systems in Building Construction (3)
CE 711	Methods Improvement in Construction (3)
EnE 662	Site Remediation (3)
EnE 671	Environmental Impact Analysis (3)

Co-op Work Experience in Architecture and the **Housing Scholars Program** give students an opportunity to gain additive credits and salaried employment.

To become eligible to take the architecture registration examination in New Jersey, professional M.Arch. graduates must complete three years of practical work experience apprenticeship that meet specific criteria set by the New Jersey State Board of Architects. Co-op internship work experiences in architecture meeting these criteria are acceptable equivalents for such apprenticeships, and are available to NJIT students. Students become eligible after completing the first year of M.Arch. core courses.

The Housing Scholars Program provides college students with paid summer internships at non-profit, community-based affordable housing organizations, and is jointly administered by NJIT's Division of Career Development Services and the New Jersey Department of Community Affairs. Housing Fellows are placed with community-based, non-profit organizations that initiate affordable housing and related projects. Graduate students who have completed at least 28 credits of core courses and who have an overall cumulative GPA of 3.2 or above are eligible to participate. Scholars are selected through a competitive application to the Division of Career Development Services and an interview process throughout February and March, and begin their internship in early June.

Students should consult the School of Architecture co-op advisor for details on work experience and the Housing Scholars program.

■ MASTER OF SCIENCE IN ARCHITECTURAL STUDIES (MSAS)

A non-professional, non-design degree program for careers in architectural research and scholarship. Studies often involve interdisciplinary course work.

Admission Requirements

Applicants are expected to have either an NAAB-accredited B.Arch., or a bachelor's degree in architecture or disciplines related to production, operation or use of buildings.

In addition to completing the application required by NJIT's Office of University Admissions, M.S.A.S. applicants must also submit School of Architecture supplementary materials forms. To ensure prompt consideration, students should request the forms when they apply for admission to the university.

Applicants are expected to have a minimum undergraduate GPA of 3.0. GRE (general test) scores are required.

Degree Requirements

The program consists of 36 credits of required and elective courses and may be taken either full- or part-time. A thesis is required. Students are required to design their programs in consultation with the graduate advisor.

To remain in good academic standing, students must maintain a cumulative GPA of 3.0 in graduate courses.

REQUIRED

18 credits:

Arch 661	Directed Studies of Architecture (3)
Arch 686	Research Methods for Environmental Design (3)
Eng 541	Advanced Technical and Research Report Writing (3)
Math 687	Quantitative Analysis for Environmental Design Research (3)
MSAS 701	Master of Science in Architectural Studies Thesis (6)

ELECTIVE

18 credits selected in consultation with the MSAS graduate advisor.

■ MASTER IN INFRASTRUCTURE PLANNING

See "Infrastructure Planning" in this catalog for program description.

Biology

Administered by: Federated Biological Sciences Department of NJIT and Rutgers-Newark

Program Director: David Kafkewitz (973) 353-1306 (Room 135 Smith Hall), e-mail biosci@newark.rutgers.edu

Graduate Program Coordinator: Doina Ganea (973) 353-1162 (Room 135 Smith Hall), e-mail ganea@newark.rutgers.edu

Graduate Program Administrator: Amy Trimarco (973) 353-1235 (Room 135 Smith Hall), e-mail trimarco@newark.rutgers.edu

NJIT Faculty

Associate Professor: Recce
Assistant Professors: Hahn, Nadim

Rutgers-Newark Faculty

Professors: Cali, Feder, Frenkel, Ganea, Hart, Jonakait, Kafkewitz, Kirby, Weis
Associate Professors: Bonder, Kasper, Morrison, Schnell
Assistant Professors: Hamerlynk, Henebry, Knox

Degrees Offered: Master of Science in Biology; Doctor of Philosophy in Biology. Both degrees are offered jointly by NJIT and Rutgers-Newark.

Departmental equipment, housed at Rutgers-Newark, includes a microscope facility second-to-none in the state of New Jersey. This facility comprises scanning and transmission-electron microscopes, a confocal microscope, and five image-processing stations. In addition, the department boasts an oligo synthesizer, automated DNA sequencer, ultracentrifuges, phosphor-imager, scintillation and gamma counters, FPLC, and AAALAC-approved animal facility, and a greenhouse. Individual research laboratories house tissue culture facilities, electrophysiological equipment, fluorescence microscopes, and thermal cyclers. Additional facilities are available at neighboring institutions. Affiliations are maintained with UMDNJ and industrial research laboratories.

■ MASTER OF SCIENCE IN BIOLOGY

The Master of Science in Biology is designed to provide students with advanced knowledge of both plant and animal biology and microbiology.

Admission Requirements

Applicants are expected to have an accredited undergraduate degree in biology from an accredited institution. Candidates with other appropriate backgrounds will be considered. The following cognate undergraduate courses are required: general chemistry, organic chemistry, physics, and calculus.

Bridge Program — To ensure academic success in their graduate studies, students may be required to take additional undergraduate or graduate courses before beginning graduate curricula. Such courses are not counted toward degree requirements.

Degree Requirements

A minimum of 30 credits is required. These must include at least one 3-credit course in each of four of the following five areas: cell biology and biochemistry, molecular biology, physiology, ecology, and plant biology. After taking one course from each of four of the five areas, students may choose to concentrate their remaining credits in any of these five areas. A research component may be satisfied by either writing a thesis or submitting a research paper. Students electing to write a thesis must complete a minimum of 24 credits of course work and 6 credits of research and must pass an oral defense of the submitted thesis. Students who choose the research paper option are required to take 30 credits of course work, pass a written comprehensive exam and complete a research paper.

REQUIRED

30 credits selected in consultation with graduate advisor

THESIS OR RESEARCH PAPER (required)
6 credits: master's thesis research, topic selected in consultation with graduate advisor *or*
non-credit bearing research paper written on completion of 30 credits of course work.

■ DOCTOR OF PHILOSOPHY IN BIOLOGY

The Ph.D. in Biology is designed to provide students with advanced knowledge of research in the areas of cell/molecular/biochemistry or ecology/evolution.

Degree Requirements

The doctoral curriculum in biology is divided into two tracks. Students may select either the cell/molecular/biochemical track or the ecology/evolution track. Each track has a set of required courses that provide a formal foundation in research fields covered in each track. Students must earn at least a grade of B in order to receive credit for these courses. The remainder of the course work is chosen in consultation between the student and the advisor and the Standards Committee with permission of the graduate program director. During the first year all doctoral students undertake rotations through at least two departmental research laboratories.

REQUIRED

36 credits of course work, including three core courses
36 credits minimum of doctoral dissertation research

CORE (required)

Cell/Molecular/Biochemical

9 credits:

26:120:515	Molecular Biology of Eukaryotes
26:120:526	Cell Biology
26:120:571	Biochemistry

Ecology/Evolution
3 credits from:
16:215:565 Community Dynamics
26:120:586 Landscape Ecology
26:120:587 Systems Ecology: Ecosystems in the Landscape
3 credits from:
16:215:533 The Behavior of Animal Populations
16:215:590 Population Ecology
26:120:593 Physiological Ecology
3 credits from:
26:120:503 Plant Morphology
26:120:532 Evolution
26:120:594 Systematics

Qualifying Examination — At the completion of the core course requirements and of 6 credits of successful laboratory rotations, the student takes the qualifying examination. The examination consists of a written and oral examination in the cell/molecular/biochemical track; and a written review paper, an oral presentation, and an oral examination in the ecology/evolution track.

Formation of Dissertation Committee — After successful completion of the qualifying examination, the student chooses an advisor, begins research for the dissertation, and forms a dissertation committee. The dissertation committee for all students is composed of the student's thesis advisor, and at least three other members of the graduate faculty. One member must be from outside the program. The dissertation committee administers at least one dissertation prospectus meeting and the final defense of the dissertation. In addition, the dissertation committee may meet with the student once every six months to assess the student's progress.

Biomedical Engineering

Administered by: Biomedical Engineering Committee

Program Director and Graduate Advisor: Stanley Reisman
(973) 596-3527 (Room 347 ECE), e-mail reisman@admin.njit.edu

Faculty: from NJIT's Newark College of Engineering and College of Science and Liberal Arts, as appropriate

Degree Offered: Master of Science in Biomedical Engineering

The M.S. in Biomedical Engineering program stresses the application of the principles and practices of engineering, science and mathematics in solving clinical problems in medicine and surgery. Biomedical engineering students can concentrate on the chemical, computer, electrical, industrial or mechanical engineering aspects of biomedical engineering. Major research areas include modeling, simulation and analysis in the areas of cardiovascular dynamics; signal processing of electrocardiograms, electroencephalograms, and electromyograms; clinical image processing; and the design and analysis of clinical instrumentation and prosthetic devices such as knees, heart valves, hips, voice boxes, and ostomy devices.

Research is conducted cooperatively between NJIT and the medical and dental schools of UMDNJ, the Kessler Institute for Rehabilitation, St. Barnabas Medical Center, Veteran's Administration Medical Center in East Orange, and several hospitals in the New Jersey-New York metropolitan area. In addition, cooperative research opportunities exist with a number of biomedical and pharmaceutical companies within a short commuting distance from NJIT.

■ MASTER OF SCIENCE IN BIOMEDICAL ENGINEERING

The M.S. in Biomedical Engineering is designed for students who wish to pursue a professional career in biomedical engineering. The master's program integrates the traditional branches of engineering with medical and biological systems. Upon completion of the program, graduates have the background for employment by a medical instrument or device company, for biomedical research, or for continued education toward a more advanced degree in biomedical engineering or medicine.

Admission Requirements

Applicants are expected to have an undergraduate degree in science or engineering and courses in thermodynamics, differential equations, scientific computer programming, statics and/or dynamics, and an introductory course in electrical engineering.

Bridge Program — Students who lack an appropriate background are required to make up deficiencies before beginning their graduate curriculum. The program of courses is designed in consultation with graduate advisors and may include undergraduate courses. These courses are not counted toward degree requirements.

Degree Requirements

Students must take at least 30 course credits consisting of required courses and elective courses chosen within an area of specialization as described below.

Seminar — In addition to the minimum 30 degree credits, all students who receive departmental or research-based awards must enroll each semester in a graduate seminar. The seminar is selected in consultation with the graduate advisor.

REQUIRED
9 credits:
BME 667 Systems Studies in Biomedical Engineering
* BME 669 Quantitative Physiology for Engineers
Math 661 Applied Statistics
3 credits from:
BME 627 Introduction to Biomedical Engineering
BME 672 Biomaterials
ME 671 Biomechanics of Human Structure and Motion

THESIS
6 credits: BME 701 Master's Thesis

AREAS OF SPECIALIZATION
Choose one area of specialization with the approval of the program director. Additional courses may be taken with approval of the program director. The courses and areas are suggestions only, students can develop their own area with approval of the program director.

Instrumentation
6 credits:
ECE 686 Instrumentation Systems and Microprocessors
ECE 687 Design of Medical Instrumentation

Imaging
6 credits:
ECE 643 Digital Imaging Processing I
ECE 789 Selected Topics in Electrical and Computer Engineering

Signal Processing
6 credits:
ECE 640 Digital Signal Processing
ECE 740 Advanced Digital Signal Processing

Biomechanics
6 credits:
ME 622 Finite Element Methods in Mechanical Engineering
ME 635 Computer-Aided Design

Biomaterials
6 credits:
BME 698 Selected Topics in Biomedical Engineering
BME 699 Selected Topics in Biomedical Engineering

Biomathematics
6 credits:
Math 672 Biomathematics I: Biological Waves and Oscillations
Math 673 Biomathematics II: Pattern Formation in Biological Systems

Biotechnology
6 credits:
Chem 601 Special Topics in Chemistry
Chem 673 Biochemistry

Man-Machine Interaction
6 credits:
IE 661 Man Machine Systems
IE 669 Human Design Factors in Engineering

* BME 669 may be waived with permission of the program director if a student has passed a physiology course previously. An elective may be substituted.

ELECTIVE
Select from the following courses. Other courses, such as those available at UMDNJ's Graduate School of Biomedical Sciences, can be taken if approved by the program director. See the program director for information about UMDNJ courses.

6 credits if completing a master's thesis; *12 credits* if not completing a master's thesis:

BME 672	Biomaterials
ChE 624	Transport Phenomena I
ChE 626	Mathematical Methods in Chemical Engineering
ChE 645	Fundamentals of Rheology
CIS 653	Microcomputers and Applications
CIS 661	Systems Simulation
CIS 662	Model Analysis and Simulation
CIS 670	Artificial Intelligence
ECE 601	Linear Systems
ECE 643	Digital Image Processing I
ECE 657	Semiconductor Devices
ECE 660	Control Systems I
ECE 673	Random Signal Analysis I
ECE 684	Advanced Microprocessor Systems
ECE 686	Instrumentation Systems and Microprocessors
ECE 687	Design of Medical Instrumentation
Math 651	Applied Mathematics I
Math 652	Applied Mathematics II
Math 672	Biomathematics I: Biological Waves and Oscillations
Math 675	Partial Differential Equations
Math 707	Advanced Applied Mathematics IV: Special Topics Biology
ME 632	Instrumentation
ME 653	Control of Electromechanical Networks
ME 671	Biomechanics of Human Structure and Motion

Biomedical Informatics

Administered by: Department of Computer and Information Science and UMDNJ

Program Director: Syed Haque (UMDNJ) (973) 972-6871, e-mail haque@umdnj.edu

Associate Program Director and Graduate Advisor: James Geller (NJIT) (973) 596-3383 (Room 4307 GITC), e-mail geller@homer.njit.edu
Faculty: from UMDNJ and Department of Computer and Information Science, as appropriate

Degrees Offered: Master of Science in Biomedical Informatics; Doctor of Philosophy in Biomedical Informatics. Both degrees are offered jointly by NJIT and UMDNJ.

Biomedical informatics is the study, invention, and utilization of health computing solutions and systems. This field covers a broad spectrum of information relating to all aspects of health care, including, but not limited to, hospital billing, medical education, clinical and laboratory data management, medical and surgical diagnoses, medical imaging, biomedical modeling and simulation, and health sciences and pharmaceutical research.

■ MASTER OF SCIENCE IN BIOMEDICAL INFORMATICS

The master's program prepares students for the application of computer and information sciences to support and manage health care and hospital management systems, laboratory automation, quality assurance, resource allocation, biomedical research, clinical decision making, and biotechnology systems.

Admission Requirements

Applicants are expected to have an undergraduate degree in any field of the health sciences (including medicine, dentistry, allied health, nursing, public health, pharmacy), biological sciences, computer science, engineering or an equivalent field of study.

Bridge Program — Students are expected to have basic proficiency in a procedural programming language, database concepts, elementary calculus and differential equations. Those who lack this background are expected to take UMDNJ's BINF 4000 Essentials of Health Computer Science or its equivalent. Students who lack an academic background in the health science disciplines are required to take a course in engineering physiology or an equivalent.

Graduate Certificate Program — A 12-credit graduate certificate in health care information systems is available as a step toward this degree. Students can complete this certificate in part through classes conducted via electronic communications. See "Graduate Certificates" in this catalog. For further information about extension programs and graduate certificates, call the associate vice president of continuing and distance education, Division of Continuing Professional Education, 1 (800) 624-9850 or (973) 596-3060; e-mail cpe@njit.edu

Degree Requirements

Students must complete at least 36 degree credits: 18 in required core courses; 6 in an area of emphasis; 6 in electives (in consultation with an advisor); and 6 of thesis. Courses are offered at NJIT and UMDNJ.

CORE
18 credits:

BINF 600/BINF 5100	Introduction to Biomedical Informatics
BINF 601/BINF 5005	Health Care Information Systems
BINF 602/BINF 5020	Biomedical Modeling and Decision-Making Systems
BINF 603/BINF 5030	Visualization in Biomedical Sciences
BINF 621/BINF 5210	Research Methods in Health Sciences
CIS 610	Data Structures and Algorithms

THESIS (required)
6 credits:

BINF 700/BINF 6000	Directed Research/Project

AREAS OF EMPHASIS
6 credits:
Choose one of the four groups. Students should consider course prerequisites in determining course selection.

Group 1: Clinical Decision Support Systems

BINF 612/BINF 5125	Clinical Problem Solving and Decision Making
CIS 631	Data Management System Design

Group 2: Health Care Management Systems

BINF 613/BINF 5130	Health Care Decision Support Systems
CIS 631	Data Management System Design

Group 3: Health Sciences Education/Multimedia Systems

BINF 631/BINF 5311	Intelligent Instructional Systems *and*
BINF 632/BINF 5312	Interactive Learning Systems for the Health Sciences *or*
CIS 658	Multimedia Systems

Group 4: Bioinformatics/Biotechnology Systems

BINF 622/BINF 5220	Topics in Bioinformatics
BINF 623/BINF 5230	Advances in Molecular and Cellular Genetics

ELECTIVE
6 credits:
Choose two courses in consultation with advisor.

BINF 614/BINF 5135	Clinical Systems Interface Design
BME 669	Quantitative Physiology for Engineers
CIS 632	Advanced Database System Design
CIS 634	Information Retrieval
CIS 650	Computer Architecture
CIS 652	Computer Networks Architectures, Protocols and Standards
CIS 654	Telecommunication Networks Performance Analysis
CIS 656	Internetworking and Higher Layer Protocols
CIS 670	Artificial Intelligence
CIS 671	Knowledge-Based Systems
CIS 672	Expert System Methods and Design
* CIS 678	Medical Terminologies
CIS 688	Programming for Interactive Environments
MIS 648	Decision Support Systems

* pending

■ DOCTOR OF PHILOSOPHY IN BIOMEDICAL INFORMATICS

The Ph.D. degree program builds upon the M.S. in Biomedical Informatics and provides students with expertise in the development and application of biomedical computing solutions and systems. The Ph.D. program is intended for biomedical informatics professionals and scholars who desire to continue to explore the synergism between computer science and the nation's health care delivery system with faculty who are at the forefront of research and development in this field. Students will be able to develop and apply theories and techniques of biomedical informatics to design, testing and evaluation of data structures and algorithms for the conversion of scientific data into biomedical knowledge. They gain a thorough understanding of the processes of conversion and the properties of medical information.

Admission Requirements

Students admitted to the joint doctoral program in biomedical informatics must meet both NJIT and UMDNJ admission requirements. Students must hold an undergraduate or graduate degree in a health field or biomedical informatics, computer science, engineering or a related field from an accredited institution, with a minimum GPA of 3.5. Students must submit: official baccalaureate and master's degree transcripts, curriculum vitae, three letters of recommendation, and GRE/GMAT/MCAT/DAT or comparable graduate admission examination scores. International students must demonstrate proficiency in the English language by scoring a minimum of 550 on the TOEFL. In addition, applicants must demonstrate superior performance in a procedural programming language, database concepts and mathematics corresponding to the contents of CIS 431, CIS 505, Math 111, Math 121, and Math 211. See the NJIT undergraduate catalog for course descriptions. Students who fail to demonstrate performance in these areas will be required to take prerequisite courses. Applicants must have taken appropriate courses in biomedical informatics and demonstrate aptitude, interest and commitment to scholarly activities and research, documented by the quality of papers and projects completed by the applicant and letters of recommendation submitted by persons familiar with the applicant's academic work.

Degree Requirements

The Ph.D. in Biomedical Informatics requires completion of at least 61 credits beyond the master of science degree and maintenance of a cumulative graduate GPA of 3.0 or better with no more than two grades of C.

REQUIRED

24 credits of advanced courses at the 600 level (above 5000 level at UMDNJ) subject to advisor's approval and related to the expected research area of specialization are required. A minimum of 12 credits must be at the 700 level (7000 level at UMDNJ). For course descriptions of 7000-level courses, see the program director.

36 credits of dissertation research culminating in a dissertation, which meets the publication requirements of both UMDNJ and NJIT. A maximum of 6 credits of pre-doctoral research can be applied to the dissertation research requirement.

Qualifying Examination — Students must pass a qualifying examination of preparatory studies in the areas of biomedical informatics theory and systems as well as selected biomedical informatics courses related to the area of the student's interest.

Dissertation Proposal and Defense — After successfully completing the qualifying examination students must submit and give an oral defense of a dissertation proposal.

Research — Students who have passed the qualifying examination are permitted to register for doctoral dissertation research. The student's doctoral advisor and doctoral committee supervise the student's extensive research.

Dissertation and Defense — Students are required to write a dissertation summarizing the results of their research and give an oral defense in front of the student's doctoral committee.

Submission of a journal quality paper on the student's dissertation research to a peer-reviewed journal.

Participate in the graduate colloquium/seminars, BINF 7910 Biomedical Informatics Seminar or CIS 791 Graduate Seminar every semester.

Participate in the instruction of at least one course in biomedical informatics or a related area under the supervision of a faculty member.

Chemical Engineering

Administered by: Department of Chemical Engineering, Chemistry and Environmental Science

Chairperson: Gordon Lewandowski
Sponsored Chair: Kamalesh Sirkar (membrane separations and biotechnology)

Chemical Engineering Division
Distinguished Professors: Lewandowski, Pfeffer, Sirkar
Professors: Armenante, Baltzis, Greenstein, Hanesian, Huang, Magee, Perna, Sofer, Xanthos
Associate Professors: Barat, Knox, Loney
Assistant Professors: Bart, Luo
Research Professor: Shaw

Graduate Recruiter: Dana Knox (973) 596-3599, e-mail knoxd@admin.njit.edu

Graduate Advisor: Robert Barat (973) 596-5605 (Room 314 CEES), e-mail barat@admin.njit.edu

Degrees Offered: Master of Science in Chemical Engineering; Doctor of Philosophy in Chemical Engineering

Because the chemical engineering graduate programs are offered in an interdisciplinary department, there are strong ties to chemistry and environmental science. There are additional opportunities for interdisciplinary collaborations with the Federated Department of Biological Sciences. The strong research program in the department is supported by major grants from federal and state agencies, and industrial corporations. The department enjoys close ties to the pharmaceutical and petrochemical industries, and plastics manufacturers through the Polymer Processing Institute. Chemical engineering plays a major role in several NJIT research centers, including the Hazardous Substance Management Research Center, the Northeast Hazardous Substance Research Center, the Polymer Engineering Center, the Particle Technology Center, and the Center for Membrane Technology. These centers involve collaborations with other universities including MIT, Princeton, Rutgers, Stevens, Tufts, and UMDNJ.

■ MASTER OF SCIENCE IN CHEMICAL ENGINEERING

This program is intended for those interested in advancing their understanding of chemical engineering. It may be taken on a part-time or full-time basis, and can include a master's thesis as an option.

Admission Requirements

An undergraduate degree in chemical engineering is usually required. Students who have a degree in either chemistry or another engineering discipline may be considered for admission and required to take an individually designed program that includes undergraduate courses before beginning the graduate program. These courses are not counted toward degree credit.

A minimum undergraduate GPA of 3.0 on a 4.0 scale, or equivalent, is typically required for admission. GRE scores must be submitted by those seeking financial support and those whose last prior degree was from outside the United States. International students must achieve a minimum TOEFL score of 550.

Degree Requirements

A minimum of 30 degree credits is required. Students must attain a minimum GPA of 3.0 in core courses listed below, and a minimum overall GPA of 3.0.

Seminar — In addition to the minimum 30 degree credits required, all students who receive departmental or research-based awards must enroll each semester in ChE 791 Graduate Seminar.

CORE

12 credits:

ChE 611	Thermodynamics
ChE 612	Kinetics of Reactions and Reactor Design
ChE 624	Transport Phenomena I
ChE 626	Mathematical Methods in Chemical Engineering

THESIS

Required of those receiving departmental or research-based support; others may choose 6 credits of 600- or 700-level courses in chemical engineering or chemistry instead of thesis.
6 credits: ChE 701 Master's Thesis

ELECTIVE
12 credits for those completing a master's thesis
18 credits for those not completing a master's thesis
A maximum of 6 elective credits may be taken from outside chemical engineering or chemistry; a maximum of 3 credits may be at the 500 level.

DOCTOR OF PHILOSOPHY IN CHEMICAL ENGINEERING

This is a research-oriented degree intended for full-time students. Although courses may be taken on a part-time basis, a minimum of one year of full-time residency is typically required for completion of the doctoral dissertation.

Admission and Degree Requirements for Students Entering with a Master's Degree

A master's degree in chemical engineering is usually required. Highly qualified students with bachelor's degrees in chemical engineering may also be accepted directly into the doctoral program.

A minimum GPA of 3.5 on a 4.0 scale, or equivalent, is typically required for admission. GRE scores must be submitted. International students must also achieve a minimum TOEFL score of 550.

Specific degree requirements and dissertation topics are approved by the department on an individual basis. Students must attain a minimum overall GPA of 3.0. A minimum of 36 credits of ChE 790 Doctoral Dissertation, and registration every semester for ChE 791 Graduate Seminar, are required. Should the 36 credits of ChE 790 be completed before submission of the final dissertation document, students must register for a minimum of 3 credits of ChE 790 each semester until it has been submitted and accepted. In addition, at least 24 credits of course work beyond the master's degree are required, of which 12 credits must be at the 700-level.

For the required 700-level courses, 6 credits must be in chemical engineering or chemistry. No more than 6 credits may be in Independent Study (ChE 705 or Chem 705).

Qualifying Examination — All applicants are expected to pass a qualifying examination that tests general competence in chemical engineering, chemistry, and mathematics at the master's level. It must be taken within the first year following admission to the program, and passed within two years. A student will be allowed only two attempts to pass the examination.

Formation of Dissertation Committee — Within three months of passing the qualifying examination, doctoral students must form a dissertation committee that meets the approval of the graduate advisor (not the dissertation advisor) in chemical engineering. As a minimum, the committee must consist of the doctoral student's dissertation advisor, three additional faculty members from the department, and one member from outside the department.

Research Proposal — Within six months of forming the dissertation committee, doctoral students must make an oral presentation to their dissertation committee and other interested persons on the scope of their proposed research. The committee must formally approve the proposal within a maximum of three additional months. This ensures meeting the requirements that doctoral students must have an approved dissertation committee and an approved dissertation proposal within a year of passing the qualifying examination.

Dissertation Defense — An oral defense of the dissertation is required after submission of the final document to the dissertation committee for approval. Signatures of all members of the dissertation committee must be received for final approval to be granted.

Admission and Degree Requirements for Students Entering with a Bachelor's Degree

Exceptional students with undergraduate degrees in chemical engineering may apply directly for admission to the doctoral program. Applicants are evaluated on a case-by-case basis. A minimum undergraduate GPA of 3.5 on a 4.0 scale, or equivalent, is normally required for admission. GRE scores must be submitted. International students must achieve a minimum TOEFL score of 550.

Students must attain a minimum GPA of 3.0 in the required courses (ChE 611, ChE 612, ChE 624, and ChE 626), and a minimum overall GPA of 3.0.

REQUIRED
48 credits as follows:

ChE 611	Thermodynamics
ChE 612	Kinetics of Reactions and Reactor Design
ChE 624	Transport Phenomena I
ChE 626	Mathematical Methods in Chemical Engineering

In addition, a minimum of 36 credits of ChE 790 Doctoral Dissertation, and registration every semester for ChE 791 Graduate Seminar, are required. Should the 36 credits of ChE 790 be completed before submission of the final dissertation document, students must register for a minimum of 3 credits of ChE 790 every semester until it has been submitted and accepted.

ELECTIVE
30 credits as follows:
12 credits from 700-level courses. 6 credits must be in chemical engineering or chemistry. No more than 6 credits may be in Independent Study (ChE 705 or Chem 705).
6 credits from 600- or 700-level courses in chemical engineering or chemistry
12 credits from any 600- or 700-level courses (may be from outside the department)

Qualifying Examination — A qualifying exam must be taken within three semesters of admission to the program, and passed within two years. A student will be allowed only two attempts to pass the examination.

Formation of Dissertation Committee — Within three months of passing the qualifying examination, doctoral students must form a dissertation committee that meets the approval of the graduate advisor (not the dissertation advisor) in chemical engineering. As a minimum, the committee must consist of the doctoral student's dissertation advisor, three additional faculty members from the department, and one member from outside the department.

Research Proposal — Within six months of forming the dissertation committee, doctoral students must make an oral presentation to their committee and other interested persons on the scope of their proposed research. The committee must formally approve the proposal within a maximum of three additional months. This ensures meeting the requirements that doctoral students must have an approved dissertation committee, and an approved dissertation proposal, within a year of passing the qualifying examination.

Dissertation Defense — An oral defense of the dissertation is required after submission of the final document to the dissertation committee for approval. Signatures of all members of the dissertation committee must be received for final approval to be granted.

If students are unable to complete the requirements for the Ph.D. degree, they may become a candidate for the Master of Science in Chemical Engineering upon completion of requirements for that degree.

Chemistry

Administered by: Department of Chemical Engineering, Chemistry and Environmental Science

Chairperson: Gordon Lewandowski
Ada C. Fritz Professor of Environmental Engineering and Science: Joseph W. Bozzelli

Chemistry Division
Distinguished Professors: Bozzelli, Venanzi
Professors: Grow, Gund, Kebbekus, Kimmel, Krasnoperov, Kristol, Perlmutter, Trattner, Tomkins
Associate Professors: Dauerman, Getzin, Lambert, Lei, Mitra

Graduate Advisor: Lev Krasnoperov (973) 596-3592 (Room 366 TIE), e-mail krasnoperov@admin.njit.edu

Degrees Offered: Master of Science in Applied Chemistry

Because the chemistry graduate program is offered in an interdisciplinary department, there are strong ties to chemical engineering and environmental science. There are additional opportunities for interdisciplinary collaborations with the Federated Department of Biological Sciences. The strong research program in the department is supported by major grants from federal and state agencies, and industrial corporations.

Our department enjoys close ties to the pharmaceutical and petrochemical industries, and plastics manufacturers through the Polymer Processing Institute. Chemistry plays a major role in several NJIT research centers, including the Hazardous Substance Management Research Center, the Northeast Hazardous Substance Research Center, the Polymer Engineering Center, the Particle Technology Center, and the Center for Membrane Technology. These centers involve collaborations with other universities including MIT, Princeton, Rutgers, Stevens, Tufts, and UMDNJ.

■ MASTER OF SCIENCE IN APPLIED CHEMISTRY

This program is intended for those interested in advancing their understanding of chemistry. It may be taken on a part-time or full-time basis, and can include a master's thesis as an option.

Admission Requirements

An undergraduate degree in chemistry or chemical engineering is usually required. Students with baccalaureate degrees in other areas of science and engineering may be considered for admission and required to take an individually designed program that includes undergraduate courses before beginning the graduate program. These courses are not counted toward degree credit.

A minimum undergraduate GPA of 3.0 on a 4.0 scale, or equivalent, is typically required for admission. GRE scores must be submitted by those seeking financial support and those whose last prior degree was from outside the United States. International students must achieve a minimum TOEFL score of 550.

Degree Requirements

A minimum of 30 degree credits is required. Students must attain a cumulative GPA of 3.0 or better in the core courses listed below, and a minimum overall GPA of 3.0.

Seminar — In addition to the minimum 30 degree credits required, all students who receive departmental or research-based awards must enroll each semester in ChE 791 Graduate Seminar.

CORE

3 credits from:
Chem 602 Advanced Organic Chemistry II: Reactions
Chem 605 Advanced Organic Chemistry I: Structure
3 credits from:
Chem 661 Instrumental Analysis
Chem 664 Advanced Analytical Chemistry
6 credits:
Chem 610 Advanced Inorganic Chemistry
Chem 658 Advanced Physical Chemistry

THESIS

Required of those receiving departmental or research-based support; others may choose 6 credits of 600- or 700-level courses in chemical engineering or chemistry instead of thesis.
6 credits: Chem 701 Master's Thesis

ELECTIVE

12 credits for those completing a master's thesis
18 credits for those not completing a master's thesis
A maximum of 6 elective credits may be taken from outside chemistry or chemical engineering; a maximum of 3 credits may be at the 500 level.

Civil Engineering

Administered by: Department of Civil and Environmental Engineering

Acting Chairperson: John Schuring
Associate Chairperson: Hsin-Neng Hsieh
Distinguished Professor: Spillers
Professors: Bagheri, Chan, Cheng, Dauenheimer, Deutschman, Dresnack, Golub, Hsieh, Hsu, Khera, Konon, Raghu, Salek, Schuring, Wecharatana
Associate Professors: Greenfeld, Meegoda, Olenik, Saadeghvaziri
Assistant Professors: Axe, Chien, Ding, Marhaba, Mouskos

Graduate Advisor: Hsin-Neng Hsieh (973) 596-5859 (Room 219 COL), e-mail hsieh@admin.njit.edu

Degrees Offered: Master of Science in Civil Engineering; Doctor of Philosophy in Civil Engineering

In the information technology age, more resources are available for building new cities, repairing the infrastructure, cleaning up the environment: these are all tasks for the civil engineer. Major corporations, government agencies, private consulting and construction firms, and universities are just some of the organizations that employ civil engineers.

In-depth knowledge in one of the areas of civil engineering is essential for professional practice as well as for research. Courses are taught by full-time faculty members with a range of academic and professional experience as well as by adjunct instructors who are experts in their fields. Those students interested in research at the master's level or continuing their education at the doctoral level should consider working with faculty involved in one of the university's related research centers.

■ MASTER OF SCIENCE IN CIVIL ENGINEERING

The M.S. in Civil Engineering is designed for those who want both specialized course work and the flexibility to tailor their program to their needs.

Admission Requirements

Applicants are expected to have an undergraduate degree in civil engineering or its equivalent, and must have proficiency in basic sciences and mathematics. Students who lack an appropriate undergraduate background may be granted conditional admission in order to complete a bridge program or its equivalent. These courses are taken in addition to regular degree requirements; descriptions may be found in the undergraduate catalog.

Bridge Program — Students who do not have a bachelor's degree in civil engineering, but who want to obtain a master's degree in civil engineering must complete a bridge program for their chosen area of specialization. These courses are not counted for degree credit. See the areas of specialization in this section for specific bridge programs. Please note that prerequisites for bridge courses also must be met. See the undergraduate catalog for descriptions of 100- to 400-level courses. Some of the bridge courses may be waived depending on the student's background.

Master of Architecture (M.Arch.) and M.S. in Civil Engineering Dual Degree Program — This program permits students to obtain a Master of Architecture with a Master of Science in Civil Engineering. There is no reduction in the degree requirements for the Master of Architecture program. This dual degree program permits students to obtain the M.S. in Civil Engineering in substantially less time; in some cases, in only one more semester of full-time study. This dual degree program is described in the "Architecture" degree program section in this catalog.

Degree Requirements

The program as shown below offers numerous areas of specialization, each with its own list of required and elective courses and bridge program. Once the choice of specialization is made, the student consults his/her specialization advisor to plan and develop an individualized and cohesive sequence of courses that will meet the program requirements of at least 30 degree credits.

Seminar — In addition to the minimum 30 degree credits required, all students who receive departmental or research-based awards must enroll each semester in CE 791 Graduate Seminar.

AREAS OF SPECIALIZATION

Construction Engineering and Management

Bridge Program:
CE 200 Surveying
CE 200A Surveying Laboratory
CE 210 Construction Materials and Procedures
CE 341 Soil Mechanics
CE 341A Soil Mechanics Laboratory
CIS 101 Computer Programming and Problem Solving (or equivalent)
Math 105 Elementary Probability and Statistics
Math 112 Calculus II
Mech 237 Strength of Materials
Mech 237A Strength of Materials Laboratory
One design course, approved by program advisor

REQUIRED
12 credits:
CE 610 Construction Management
CE 611 Project Planning and Control
CE 616 Construction Cost Estimating
EM 632 Legal Aspects in Construction

THESIS
Required of those receiving departmental awards; elective for all others
6 credits: CE 701 Master's Thesis

ELECTIVE
Select 9 credits if completing a master's thesis; 15 credits if not completing a master's thesis, from:
Arch 647 Special Topics in Computer Applications
Arch 675 Elements of Infrastructure Planning
CE 545 Rock Mechanics I
CE 553 Design and Construction of Asphalt Pavements
CE 614 Underground Construction
CE 615 Infrastructure and Facilities Remediation
CE 631 Advanced Reinforced Concrete Design
CE 637 Short Span Bridge Design
CE 642 Foundation Engineering
CE 659 Flexible and Rigid Pavements
CE 700 Civil Engineering Project
CE 702 Special Topics in Civil Engineering
CE 710 Systems in Building Construction
CE 711 Methods Improvement in Construction
EM 602 Management Science
EM 655 Management Aspects of Information Systems
EM 660 Financing an Industrial Enterprise
EM 693 Managerial Economics
EnE 662 Site Remediation
EnE 671 Environmental Impact Analysis
HRM 693 Employment Relationships and the Law
IE 603 Behavioral Science in Engineering Organizations
3 credits from:
CE 602 Geographic Information System
Math 611 Numerical Methods for Computation
MIS 545 Management Information Systems
Other suitable electives may be taken subject to approval of program advisor.

Environmental Engineering

Bridge Program:
CE 320 Fluid Mechanics
CE 321 Water Resources Engineering
CE 322 Hydraulic Engineering
CE 501 Introduction to Soil Behavior
Chem 126 General Chemistry II
CIS 101 Computer Programming and Problem Solving (or equivalent)
Math 222 Differential Equations
Mech 234 Engineering Mechanics
Mech 236 Dynamics

REQUIRED
6 credits:
EnE 560 Chemistry for Environmental Engineers
EnE 661 Microbiology for Environmental Engineers

THESIS
Required of those receiving departmental awards; elective for all others
6 credits:
CE 701 Master's Thesis *or*
EnE 701 Master's Thesis

ELECTIVE
Select 15 credits if completing a master's thesis; 21 credits if not completing a master's thesis, from:
CE 602 Geographic Information System
CE 604 Environmental Modeling in Remote Sensing
CE 618 Applied Hydrogeology
CE 620 Open Channel Flow
CE 621 Hydrology
CE 623 Groundwater Hydrology
CE 647 Geotechnical Aspects of Solid Waste
CE 648 Flow Through Soils
CE 700 Civil Engineering Project *or*
EnE 700 Environmental Engineering Project
CE 702 Special Topics in Civil Engineering *or*
EnE 702 Special Topics in Environmental Engineering
EnE 610 Hazardous Site Operations
EnE 620 Environmental Chemodynamics
EnE 660 Introduction to Solid and Hazardous Waste Problems
EnE 662 Site Remediation
EnE 664 Physical and Chemical Treatment
EnE 665 Biological Treatment
EnE 666 Analysis of Receiving Waters
EnE 667 Solid Waste Disposal Systems
EnE 668 Air Pollution Control
EnE 669 Water and Wastewater Analysis
EnE 670 Advanced Processes in Water Pollution Control
EnE 671 Environmental Impact Analysis
Up to 6 credits may be selected from departments other than civil and environmental engineering subject to approval of program advisor.
3 credits from:
Math 611 Numerical Methods for Computation
Math 661 Applied Statistics
Math 687 Quantitative Analysis for Environmental Design Research
Other suitable electives may be taken subject to approval of program advisor.

Geoenvironmental Engineering

Bridge Program:
CE 320 Fluid Mechanics
CE 321 Water Resources Engineering
CE 501 Introduction to Soil Behavior
Chem 126 General Chemistry II
CIS 101 Computer Programming and Problem Solving (or equivalent)
Math 222 Differential Equations

REQUIRED
12 credits:
CE 618 Applied Hydrogeology
CE 647 Geotechnical Aspects of Solid Waste
EnE 560 Chemistry for Environmental Engineers
EnE 662 Site Remediation

THESIS
Required of those receiving departmental awards; elective for all others
6 credits: CE 701 Master's Thesis

ELECTIVE
Select 9 credits if completing a master's thesis; 15 credits if not completing a master's thesis, from:
CE 545 Rock Mechanics I
CE 602 Geographic Information System
CE 621 Hydrology
CE 623 Groundwater Hydrology
CE 641 Engineering Properties of Soils
CE 642 Foundation Engineering
CE 643 Advanced Foundation Engineering
CE 644 Geology in Engineering
CE 646 Geosynthetics and Soil Improvement
CE 700 Civil Engineering Project
CE 702 Special Topics in Civil Engineering
CE 743 Contaminant Transport in Soils
EM 631 Legal Aspects in Environmental Engineering
EM 633 Legal Aspects of Health and Safety
EnE 660 Introduction to Solid and Hazardous Waste Problems
EnE 661 Microbiology for Environmental Engineers
EnE 664 Physical and Chemical Treatment
EnE 665 Biological Treatment
EnE 667 Solid Waste Disposal Systems
EnE 669 Water and Wastewater Analysis
EnE 671 Environmental Impact Analysis
Other suitable electives may be taken subject to approval of program advisor.
3 credits from:
Math 611 Numerical Methods for Computation
Math 651 Applied Mathematics I
Math 661 Applied Statistics
Math 687 Quantitative Analysis for Environmental Design Research

Geotechnical Engineering

Bridge Program:

CE 320	Fluid Mechanics
CE 332	Structural Analysis
CE 341	Soil Mechanics
CE 341A	Soil Mechanics Laboratory
CE 443	Foundation Design
CIS 101	Computer Programming and Problem Solving (or equivalent)
Math 222	Differential Equations

REQUIRED

6 credits from:

CE 641	Engineering Properties of Soils
CE 642	Foundation Engineering

THESIS

Required of those receiving departmental awards; elective for all others
6 credits: CE 701 Master's Thesis

ELECTIVE

Select 12 credits if completing a master's thesis; 18 credits if not completing a master's thesis, from:

CE 545	Rock Mechanics I
CE 643	Advanced Foundation Engineering
CE 644	Geology in Engineering
CE 645	Rock Mechanics II
CE 646	Geosynthetics and Soil Improvement
CE 647	Geotechnical Aspects of Solid Waste
CE 648	Flow Through Soils
CE 700	Civil Engineering Project
CE 702	Special Topics in Civil Engineering
CE 741	Theoretical Soil Mechanics
CE 742	Geotechnology of Earthquake Engineering
CE 743	Contaminant Transport in Soils

3 credits from:

CE 553	Design and Construction of Asphalt Pavements
CE 610	Construction Management
CE 611	Project Planning and Control
CE 614	Underground Construction
CE 630	Matrix Analysis of Structures
CE 631	Advanced Reinforced Concrete Design
CE 659	Flexible and Rigid Pavements
Mech 630	Theory of Elasticity

3 credits from:

Math 611	Numerical Methods for Computation
Math 651	Applied Mathematics I
Math 661	Applied Statistics

Structural Engineering

Bridge Program:

CE 332	Structural Analysis
CE 333	Reinforced Concrete Design
CE 341	Soil Mechanics
CE 341A	Soil Mechanics Laboratory
CE 434	Structural Design
CIS 101	Computer Programming and Problem Solving (or equivalent)
Math 222	Differential Equations

REQUIRED

3 credits:

CE 630	Matrix Analysis of Structures

THESIS

Required of those receiving departmental awards; elective for all others
6 credits: CE 701 Master's Thesis

ELECTIVE

Select 18 credits if completing a master's thesis; 24 credits if not completing a master's thesis, from:

CE 530	Applied Finite Element Method
CE 531	Design of Masonry and Timber Structures
CE 545	Rock Mechanics I
CE 631	Advanced Reinforced Concrete Design
CE 632	Prestressed Concrete Design
CE 634	Structural Dynamics
CE 635	Fracture Mechanics of Engineering Materials
CE 636	Stability of Structures
CE 637	Short Span Bridge Design
CE 638	Nondestructive Testing Methods in Civil Engineering
CE 641	Engineering Properties of Soils
CE 642	Foundation Engineering
CE 661	Analysis and Design of Shell Structures
CE 700	Civil Engineering Project
CE 702	Special Topics in Civil Engineering
CE 730	Plastic Analysis and Design
CE 733	Design of Metal Structures
CE 734	Design of Tall Buildings and Space Structures
CE 736	Finite Element Methods in Structural and Continuum Mechanics
CE 737	Earthquake Engineering
CE 738	Advanced Matrix Analysis of Structures
CE 739	Structural Optimization
Mech 540	Advanced Strength of Materials
Mech 630	Theory of Elasticity

Other suitable electives may be taken subject to approval of program advisor.

3 credits from:

Math 611	Numerical Methods for Computation
Math 630	Linear Algebra and Applications
Math 651	Applied Mathematics I
Mgmt 580	Managerial Science

Urban and Transportation Engineering

REQUIRED

12 credits from:

CE 650	Urban Systems Engineering
CE 655	Land Use Planning
CE 660	Traffic Studies and Capacity
Math 661	Applied Statistics

THESIS

Required of those receiving departmental awards; elective for all others
6 credits: CE 701 Master's Thesis

ELECTIVE

Select 9 credits if completing a master's thesis; 15 credits if not completing a master's thesis, from:

CE 552	Geometric Design of Transportation Facilities
CE 553	Design and Construction of Asphalt Pavements
CE 603	Introduction to Urban Transportation Planning
CE 625	Public Transportation Operations and Technology
CE 653	Traffic Safety
CE 659	Flexible and Rigid Pavements
CE 700	Civil Engineering Project
CE 705	Mass Transportation Systems
CE 751	Transportation Design
CE 752	Traffic Control
CE 753	Airport Design and Planning
CE 754	Port Design and Planning
CE 765	Multi-modal Freight Transportation Systems Analysis
Tran 604	Public and Private Financing of Urban Areas
Tran 610	Transportation Economics
Tran 643	Transportation Finance

3 credits from:

CE 602	Geographic Information System
EnE 671	Environmental Impact Analysis
EPS 521	Urban Social Structure

Other suitable electives may be taken subject to approval of program advisor.

■ DOCTOR OF PHILOSOPHY IN CIVIL ENGINEERING

This is a program for superior students with master's degrees in civil engineering or allied fields who wish to do advanced research in an area of civil engineering. In exceptional circumstances, highly qualified students with bachelor's degrees in civil engineering may be accepted directly into the doctoral program.

Admission Requirements

A minimum master's GPA of 3.5 on a 4.0 scale, or equivalent, is normally required for admission. The GRE (general section) is required of all applicants. All international students must also achieve a minimum TOEFL score of 550.

Degree Requirements

The department approves specific degree requirements and dissertation topics on an individual basis. Students must attain a minimum

overall GPA of 3.0. Students must conduct independent original research in a specific area of civil engineering. Students must select an advisor willing to supervise dissertation work.

36 credits minimum of CE 790 Doctoral Dissertation is generally required. These 36 credits should be completed before submission of the final dissertation document. Students must register for a minimum of 3 credits of CE 790 until the dissertation has been submitted and accepted.

24 credits minimum of course work beyond the master's degree are required, of which at least 12 credits must be at the 700 level; the remaining credits may be at the 600 level.

Seminar — CE 791 Graduate Seminar is required of all doctoral students every semester.

Preliminary Qualifying Examination — Full-time students must take the preliminary qualifying exam for the first time within one year of beginning active study and must pass it completely by the next time the examination is offered. Part-time students must take the preliminary qualifying exam for the first time within three years of the beginning of active study and must pass it completely by the next time the examination is offered. Exceptional students having only bachelor's degrees who are admitted directly into the doctoral program must take the preliminary qualifying examination within one and one-half years of admission and must pass it within two years. All students are permitted to take the examination only twice.

Dissertation Committee — After passing the preliminary qualifying examination, each student in consultation with the major faculty member develops a list of five faculty members who have agreed to serve on an advisory committee as follows: two or three members of the graduate faculty in the student's major area of interest; a member of the graduate faculty in the student's major area appointed by the department chairperson; a member of the graduate faculty of the Department of Civil and Environmental Engineering from another field of interest; a member of the graduate faculty from the area of the student's minor field of interest.

Research Proposal — Doctoral students must prepare a written research proposal and make an oral presentation for approval by their dissertation committee. The proposal must be presented after formation of the committee but within six months after passing the qualifying examination. Research is expected to investigate or develop a unique contribution to science and technology.

Dissertation Defense — An oral defense of the dissertation is required after submission of the final document to the department for approval. Signatures of all members of the dissertation committee must be received for final approval to be granted.

Computer Engineering

Administered by: Department of Electrical and Computer Engineering

Chairperson: Richard A. Haddad
Associate Chairpersons: Kenneth Sohn, Nirwan Ansari (graduate), Gerald Whitman (graduate)
Director of Computer Engineering: Jacob Savir
Associate Director of Computer Engineering: Edwin Hou
Distinguished Professor: Savir
Professor: Rosenstark
Associate Professors: Carpinelli, Hou, Manikopoulos, Shih*, Stoyen*, Zhou, Ziavras
Assistant Professors: Fang*, Uzun

Graduate Advisors: Jacob Savir (973) 596-5681 (Room 209 ECE), e-mail savir@oak.njit.edu; Edwin Hou (973) 596-3521 (Room 331 ECE), e-mail hou@megahertz.njit.edu

* Joint appointee with the Department of Computer and Information Science

Degrees Offered: Master of Science in Computer Engineering; Doctor of Philosophy in Computer Engineering

Focus on interdisciplinary course work and research provides students enrolled in the M.S. and Ph.D. in Computer Engineering programs with an advanced background in both the hardware and software aspects of computing.

The master's program prepares computer engineers to successfully make the hardware-software design trade-offs inherent to computing today. The rapid development of computer hardware and software in the last decade has created a demand for engineers who are not only knowledgeable in both these areas, but who also understand their interaction. The fields of embedded computer system design and computer networks are based squarely on this knowledge.

The doctoral program is designed for superior students with a master's degree in computer engineering, computer science, electrical engineering, or other related fields, who wish to pursue advanced research in the area of computer engineering. The master's and doctoral programs emphasize microprocessor-based systems, computer networks, computer architecture, VLSI systems design, computer vision, and VLSI testing and fault tolerance.

■ MASTER OF SCIENCE IN COMPUTER ENGINEERING

This program prepares its graduates to successfully handle problems requiring in-depth knowledge of both computer hardware and software, and more important, their interaction. Students may concentrate in microprocessor-based systems, parallel computing systems, computer networking, VLSI system design, or machine vision systems.

Admission Requirements

Students are expected to have an undergraduate education in engineering or computer science. Students with baccalaureate degrees in areas other than computer engineering may be admitted and required to complete a bridge program. Those with undergraduate degrees in other fields should consult the director of computer engineering for bridge requirements. Bridge courses do not count toward degree requirements.

Bridge Program — Students with undergraduate degrees in computer science take courses from:

CoE 252	Computer Architecture
CoE 353	Advanced Computer Architecture
CoE 395	Microprocessor Lab
EE 231	Circuits and Systems I

Students with undergraduate degrees in electrical engineering take courses from:

CIS 105	Computer Programming
CIS 335	Data Structures and Algorithm Design
CoE 353	Advanced Computer Architecture
CoE 395	Microprocessor Lab

Graduate Certificate Program — A 12-credit graduate certificate in Computer Networking is available as a step toward this degree. See "Graduate Certificates" in this catalog. For further information, call the associate vice president of continuing and distance education, Division of Continuing Professional Education, 1 (800) 624-9850 or (973) 596-3060; e-mail cpe@njit.edu.

Degree Requirements

Students must complete 30 credits: two required core courses, a two-course sequence in at least one of five areas of specialization, and a master's project or thesis. As a requirement for graduation, students must achieve a 3.0 cumulative GPA, not including the master's thesis or project. The master's thesis or project grade must be B or higher.

Seminar — All students receiving departmental or research-based support are required to register every semester for ECE 791 Graduate Seminar.

CORE
Required for all specializations
6 credits:

CIS 610	Data Structures and Algorithms
ECE 651	Computer Systems Architecture

PROJECT OR THESIS (required) ← Bold?
3 credits: ECE 700 Master's Project *or*
6 credits: ECE 701 Master's Thesis

AREAS OF SPECIALIZATION

ELECTIVE
15 credits if completing master's thesis or 18 credits if completing master's project:
A list of suggested complementary elective courses is available for each area of concentration. Consult the director of computer engineer-

ing for a current list of these courses. Other courses may be used as electives with the permission of the director of computer engineering.

Microprocessor-Based Systems

REQUIRED
6 credits:
ECE 686 Instrumentation Systems and Microprocessors
ECE 688 Microcontrollers in Instrumentation

Parallel Computing Systems

REQUIRED
6 credits:
ECE 689 Digital System Design for Machine Arithmetic
ECE 785 Parallel Processing Systems

Computer Networking

REQUIRED
6 credits:
CIS 656 Internetworking and Higher Layer Protocols
ECE 683 Computer Network Design and Analysis

VLSI System Design

REQUIRED
6 credits:
ECE 658 VLSI Design I
ECE 758 VLSI Design II

Machine Vision Systems

REQUIRED
6 credits:
{ CIS 659 Image Processing and Analysis
{ CIS 780 Computer Vision
or
{ ECE 601 Linear Systems
{ ECE 643 Digital Image Processing I

DOCTOR OF PHILOSOPHY IN COMPUTER ENGINEERING

This program is intended for superior students with a master's degree in computer engineering, computer science, electrical engineering, or other related fields, who wish to pursue advanced research in computer engineering. The program emphasizes the following areas: microprocessor-based systems, computer networks, computer architecture, VLSI systems design, computer vision, and VLSI testing and fault tolerance.

Admission Requirements

Applicants are expected to have a master's degree in computer engineering, computer science, electrical engineering, or other related fields. Students who lack an appropriate background may be admitted and required to take bridge courses that cannot be applied as degree credits.

Students must demonstrate superior academic background in engineering, mathematics, and physical science; skills in programming; and proficiency in major areas of computer engineering and science. A minimum master's GPA of 3.5 on a 4.0 scale, or equivalent, is required for admission. GRE scores must be submitted. International students must also achieve a minimum TOEFL score of 550.

Superior undergraduate students may apply to be admitted directly into the Ph.D. program. Such an accelerated program requires a minimum entrance GPA of 3.5 and an interview with the electrical and computer engineering department graduate studies committee.

Degree Requirements

A minimum of 60 degree credits beyond the master's degree or 90 credits beyond the bachelor's degree is required; 24 credits of course work beyond the master's degree, with at least 12 at the 700 level; and 36 credits of doctoral dissertation. Doctoral students must register each semester for 1/2 credit of ECE 791 Graduate Seminar. Students must attain a minimum overall GPA of 3.0. Students admitted into the program at the baccalaureate level must complete a total of 87 credits, consisting of 51 course credits and 36 dissertation credits. At least 12 course credits must be at the 700 level. Courses will be selected in consultation with the graduate advisor. Dissertations should demonstrate original research that contributes to the knowledge in the field and should result in the submission of at least one paper for publication in a peer-reviewed journal. Students must provide the department with a written proposal showing that facilities are available and that there is a faculty member willing to supervise dissertation work.

Students who complete 36 credits of ECE 790 before research is finished must register for a minimum of 3 credits of ECE 790 each semester thereafter until the dissertation is accepted.

Residence — Degree-seeking students must spend at least one academic year in full-time residence.

Qualifying Examination — Contains material related to the student's intended area of specialization. See department for more details.

Dissertation Defense — An oral defense of the dissertation is required after submission of the final document to the department for approval.

Pre-Doctoral Research — With department approval, well-qualified students may register for up to a maximum of 9 credits of ECE 792 Pre-Doctoral Research before passing the qualifying examination. A maximum of 6 credits of ECE 792 may be applied toward ECE 790.

For further information, see Academic Policies and Procedures in this catalog and the department "Handbook for Graduate Students."

Computer Science

Administered by: Department of Computer and Information Science

Chairperson: Joseph Y. Leung
Vice Chairperson: Fadi P. Deek
Associate Chairpersons: Fadi P. Deek, James A.M. McHugh, Julian M. Scher, Frank Shih, Andrew Sohn
Distinguished Professors: Hiltz, Leung, Turoff**
Professors: McHugh, Perl, Shih, Verkhovsky
Associate Professors: Baltrush, Bieber, Carpinelli*, F. Deek, Featheringham, Geller, Hou*, Hung, Manikopoulos*, Nakayama, Nassimi, Recce†, Ryon, Sarian, Scher, A. Sohn, Stoyen, J. Wang, Ziavras*
Assistant Professors: Calvin, Fang*, Gerbessiotis, Kurfess, Liu, Rana, Scherl, P. Shi, Silberman
Special Lecturers: Aljallad, Basu, Chang, M. Deek, DuPre, Grasso, Lawler, Nicholson, Mohtashami, Morales

Graduate Advisors:
James A.M. McHugh (973) 596-3394 (Room 4409 GITC),
e-mail mchugh@cis.njit.edu (computer science master's, CIS doctorate)

Frank Shih (973) 596-5654 (Room 4305 GITC),
e-mail shih@cis.njit.edu (computer science master's)

Joseph Leung (973) 596-3387 (Room 4410 GITC),
e-mail leung@cis.njit.edu (CIS doctorate, computer science specialization)

Murray Turoff (973) 596-3399 (Room 4106 GITC),
e-mail turoff@vc.njit.edu (information systems master's; CIS doctorate, information systems specialization; Ph.D. in Management, computer information systems specialization)

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* Joint appointee with the Department of Electrical and Computer Engineering
** Joint appointee with the School of Management
† Joint appointee with the Federated Biological Sciences Department of NJIT and Rutgers-Newark and the Department of Mathematical Sciences

Degrees Offered: Master of Science in Computer Science; Master of Science in Information Systems; Doctor of Philosophy in Computer and Information Science. The Doctor of Philosophy in Management is offered by Rutgers, The State University of New Jersey.

The Department of Computer and Information Science is distinguished by prominent researchers who are actively investigating new applications in parallel processing and advanced computer architecture, systems integration, real-time computing, neuroscience and robotics, medical imaging, combinatorial computing, computer-mediated communication, group decision support systems, information systems evaluation, human computer interface design and visualization, and information processing and retrieval.

The department provides an environment that gives students the background and skills necessary for entry into today's workplace. This is achieved through team research in state-of-the-art facilities; a faculty that works steadily in the forefront of many research areas; interaction with industry and experts; and an administration focused on research and student services. As a result, the department attracts the largest student population for computer and information science in the greater New York/New Jersey area.

The computer and information science department maintains and offers computing facilities for its students, faculty, and staff. The computing facilities include research laboratories housing research in areas of computer science such as: networking, real-time systems, hypermedia, parallel processing, and collaborative systems. Users have access to the state-of-the-art software and hardware including Oracle database, UNIX-based workstations and Microsoft Windows PCs supported by several file and compute servers. Internet access, departmental intranets, and conferencing systems provide an integrated infrastructure for supporting teaching and research.

■ MASTER OF SCIENCE IN COMPUTER SCIENCE

Recognizing that a variety of academic backgrounds may be suited to this discipline, this program is for students who want advanced studies in computer science.

Admission Requirements

Applicants are expected to have backgrounds in computer science and mathematics equivalent to the bridge program courses listed below. Students who lack this background may be admitted and required to take these courses and attain a cumulative GPA of 3.0. At the discretion of the department, students who have completed courses equivalent to the bridge program will be granted a corresponding reduction in the bridge requirements. See the undergraduate catalog for descriptions of 100- to 300-level courses. These courses are not counted toward degree requirements although CIS 505 and CIS 510, as graduate courses, are included in the calculation of the cumulative graduate GPA. Also see the Admissions section in this catalog.

Bridge Program:

CIS 251	Computer Organization
CIS 332	Principles of Operating Systems
CIS 333	Introduction to UNIX Operating System
CIS 505	Programming, Data Structures, and Algorithms
CIS 510	Assembly Language Programming and Principles
Math 111	Calculus I
Math 112	Calculus II
Math 211	Calculus III
Math 226	Discrete Analysis
Math 333	Probability and Statistics

Off-Campus Programs — At the NJIT at Mount Laurel branch campus and at extension and corporate sites, NJIT offers sufficient courses to fulfill all degree requirements. NJIT faculty teach all courses. For locations, see "Extension Programs" in this catalog. The university's distance learning arm, ACCESS/NJIT, offers this program (as well as part of the bridge program described above) to qualified students who have access to the Internet and a VCR. In addition, distance-based, 12-credit graduate certificates in Object-Oriented Design, Programming Environment Tools, or Telecommunications Networking are available as a step toward this degree. See "Graduate Certificates" in this catalog. For further information about extension programs, ACCESS/NJIT programs, and graduate certificates, call the associate vice president of continuing and distance education, Division of Continuing Professional Education, 1 (800) 624-9850 or (973) 596-3060; e-mail cpe@njit.edu

Degree Requirements

Students are assigned an advisor to assist them in formulating a program of study and in selecting an area of specialization. A minimum of 30 credits must be taken, including a set of core courses, a thesis or project, and required and elective courses.

With the approval of the graduate advisor, students may take 700-level courses in computer science, or courses outside the department as electives.

Seminar — Those students who receive departmental or research-based support must enroll every semester in CIS 791 Graduate Seminar.

CORE

9 credits:

CIS 610	Data Structures and Algorithms
CIS 635	Computer Programming Languages
CIS 650	Computer Architecture

REQUIRED

3 credits from:

CIS 630	Operating System Design
CIS 631	Data Management System Design
CIS 636	Compiling System Design
CIS 651	Data Communications
CIS 673	Software Design and Production Methodology

PROJECT OR THESIS (required)
3 credits: CIS 700 Master's Project *or*
6 credits: CIS 701 Master's Thesis

AREAS OF SPECIALIZATION

The student may take other electives or develop an area of specialization with the approval of the graduate advisor.

Artificial Intelligence

ELECTIVE

Select 12 credits if completing a master's thesis; 15 credits if completing a master's project, from:

CIS 630	Operating System Design
CIS 631	Data Management System Design
CIS 665	Algorithmic Graph Theory
CIS 667	Design Techniques for Algorithms
CIS 670	Artificial Intelligence
CIS 671	Knowledge-Based Systems
CIS 672	Expert System Methods and Design
CIS 674	Natural Language Processing
CIS 780	Computer Vision

Other 600/700-level courses as approved by graduate advisor.

Computer Algorithms and Theory of Computing

ELECTIVE

Select 12 credits if completing a master's thesis; 15 credits if completing a master's project, from:

CIS 540	Fundamentals of Logic and Automata
CIS 605	Discrete Event Dynamic Systems
CIS 611	Introduction to Computability and Complexity
CIS 630	Operating System Design
CIS 631	Data Management System Design
CIS 640	Recursive Function Theory
CIS 641	Formal Languages and Automata
CIS 665	Algorithmic Graph Theory
CIS 667	Design Techniques for Algorithms
CIS 668	Parallel Algorithms
CIS 669	Computational Geometry

Other 600/700-level courses as approved by graduate advisor.

Computer Communications and Networking

ELECTIVE

Select 12 credits if completing a master's thesis; 15 credits if completing a master's project, from:

CIS 604	Client/Server Computing
CIS 630	Operating System Design
CIS 651	Data Communications
CIS 652	Computer Networks – Architectures, Protocols and Standards
CIS 654	Telecommunication Networks Performance Analysis
CIS 656	Internetworking and Higher Layer Protocols
CIS 735	Computer Mediated Communication Systems
CIS 741	Communication Network Design

Other 600/700-level courses as approved by graduate advisor.

Computer Systems, and Parallel and Distributed Processing

ELECTIVE

Select 12 credits if completing a master's thesis; 15 credits if completing a master's project, from:

CIS 630	Operating System Design
CIS 633	Distributed Systems
CIS 636	Compiling System Design
CIS 637	Real-Time Systems
CIS 651	Data Communications
CIS 653	Microcomputers and Applications
CIS 654	Telecommunication Networks Performance Analysis
CIS 656	Internetworking and Higher Layer Protocols
CIS 665	Algorithmic Graph Theory
CIS 668	Parallel Algorithms
CIS 750	High Peformance Computing
ECE 658	VLSI Design I
ECE 758	VLSI Design II
ECE 689	Digital System Design for Machine Arithmetic
ECE 784	Digital Systems Architecture

Other 600/700-level courses as approved by graduate advisor.

Database and Knowledge-Based Engineering

ELECTIVE

Select 12 credits if completing a master's thesis; 15 credits if completing a master's project, from:

CIS 630 Operating System Design
CIS 631 Data Management System Design
CIS 632 Advanced Database System Design
CIS 651 Data Communications
CIS 658 Multimedia Systems
CIS 670 Artificial Intelligence
CIS 671 Knowledge-Based Systems
CIS 672 Expert System Methods and Design
Other 600/700-level courses as approved by graduate advisor.

Image Processing and Computer Graphics

ELECTIVE

Select 12 credits if completing a master's thesis; 15 credits if completing a master's project, from:

CIS 630 Operating System Design
CIS 632 Advanced Database System Design
CIS 657 Principles of Interactive Computer Graphics
CIS 659 Image Processing and Analysis
CIS 665 Algorithmic Graph Theory
CIS 667 Design Techniques for Algorithms
CIS 682 Geometric Modeling
CIS 759 Advanced Image Processing and Analysis
CIS 780 Computer Vision
ECE 601 Linear Systems
ECE 643 Digital Image Processing I
ME 635 Computer-Aided Design
Other 600/700-level courses as approved by graduate advisor.

Information Systems Applications and Management

ELECTIVE

Select 12 credits if completing a master's thesis; 15 credits if completing a master's project, from:

CIS 601 Object-Oriented Programming
† CIS 602 WWW: Applications development and Java
CIS 603 Advanced Programming Environments and Tools
CIS 604 Client/Server Computing
CIS 631 Data Management System Design
CIS 658 Multimedia Systems
CIS 660 Systems Analysis Methodology
CIS 661 Systems Simulation
CIS 662 Model Analysis and Simulation
CIS 673 Software Design and Production Methodology
CIS 675 Information System Evaluation
CIS 676 Requirements Engineering
CIS 677 Information System Principles
CIS 679 Management of Computer and Information Systems
CIS 684 Business Process Innovation
CIS 688 Programming for Interactive Environments
CIS 731 Applications of Database Systems
CIS 732 Design of Interactive Systems
CIS 735 Computer Mediated Communication Systems
CIS 767 Decision Support Systems
Other 600/700-level courses as approved by graduate advisor.

Numerical Computation

ELECTIVE

Select 12 credits if completing a master's thesis; 15 credits if completing a master's project, from:

CIS 621 Numerical Analysis I
CIS 622 Numerical Analysis II
CIS 657 Principles of Interactive Computer Graphics
CIS 667 Design Techniques for Algorithms
Math 614 Numerical Methods I
Math 630 Linear Algebra and Applications
Math 690 Advanced Applied Mathematics III: PDEs
Math 712 Numerical Methods II
Other 600/700-level courses as approved by graduate advisor.

† pending

Software Engineering

ELECTIVE

Select 12 credits if completing a master's thesis; 15 credits if completing a master's project, from:

CIS 601 Object-Oriented Programming
CIS 630 Operating System Design
CIS 631 Data Management System Design
CIS 636 Compiling System Design
CIS 657 Principles of Interactive Computer Graphics
CIS 667 Design Techniques for Algorithms
CIS 670 Artificial Intelligence
CIS 673 Software Design and Production Methodology
CIS 676 Requirements Engineering
CIS 683 Object-Oriented Software Development
CIS 688 Programming for Interactive Environments
Other 600/700-level courses as approved by graduate advisor.

Systems Analysis, Simulation and Modeling

ELECTIVE

Select 12 credits if completing a master's thesis; 15 credits if completing a master's project, from:

CIS 630 Operating System Design
CIS 631 Data Management System Design
CIS 661 Systems Simulation
CIS 662 Model Analysis and Simulation
CIS 673 Software Design and Production Methodology
CIS 675 Information System Evaluation
CIS 676 Requirements Engineering
CIS 684 Business Process Innovation
CIS 732 Design of Interactive Systems
Other 600/700-level courses as approved by graduate advisor.

■ MASTER OF SCIENCE IN INFORMATION SYSTEMS

The master's program in information systems emphasizes the planning, investigation, design, development, application, and evaluation of information systems. This program is designed to accommodate students interested in the application of information systems to areas including but not limited to business, physical sciences, social sciences, biological sciences, the arts, humanities, and engineering.

Admission Requirements

Applicants with degrees in information systems (or management information systems), computer science, computer engineering and others which develop a high degree of computer skills and knowledge are usually sufficiently prepared for entry into this program. The student is expected to have a working knowledge of the C programming language as this is assumed for many technical courses in the department. It is expected that students will have at least a year of calculus, a probability and statistics course requiring calculus as a prerequisite, and an additional advanced math course such as discrete analysis. Students must submit the GRE, GMAT or MCAT scores for admission and are expected to have a GPA of 3.0 or higher in their prior academic work. Applicants with degrees in other fields may be considered on an individual basis. These students may be required to make up deficiencies by completing appropriate courses from the following bridge program. Applicants with work experience in the field of computer or information systems may have work experience applicable to satisfying part of the bridge program.

Final determination of the bridge requirements can only be made from the examination of a completed formal application folder. Applicants with applicable work experience should include a detailed statement of specific job experiences and computer technology skills acquired.

Bridge Program —

Computer and Information Systems Technology

CIS 505	Programming, Data Structures, and Algorithms (teaches C language programming; required for remaining bridge courses)
CIS 332	Principles of Operating Systems
CIS 431	Database System Design and Management
CIS 451	Data Communications and Networks
CIS 465	Advanced Information Systems

Mathematics

Math 111	Calculus I
Math 112	Calculus II
Math 226	Discrete Analysis
Math 333	Probability and Statistics

Off-Campus Programs — At the NJIT at Mount Laurel branch campus and at extension and corporate sites, NJIT offers sufficient courses to fulfill all degree requirements. All courses are taught by NJIT faculty. For locations, see "Extension Programs" in this catalog. The university's distance learning arm, ACCESS/NJIT, offers this program (as well as part of the bridge program described below) to qualified students who have access to the Internet and a VCR. In addition, distance-based, 12-credit graduate certificates in Electronic Media Design, Information Systems Design and Development, Internet Applications Development, Object-Oriented Design, or Programming Environment Tools are available as a step toward this degree. See "Graduate Certificates" in this catalog. For further information about extension programs, ACCESS/NJIT programs, and graduate certificates, call the associate vice president of continuing and distance education, Division of Continuing Professional Education, 1 (800) 624-9850 or (973) 596-3060; e-mail cpe@njit.edu

Degree Requirements

The student is required to take 36 credits: 9 credits of core courses, another 3 credits of required courses, 6 credits in an area of specialization, and 18 credits of electives. Students should check the department or program director's home page for any recent updates to the program.

Seminar — Those students who receive departmental or research-based support must enroll every semester in CIS 791 Graduate Seminar.

CORE

9 credits:

CIS 673	Software Design and Production Methodology
CIS 675	Information System Evaluation
CIS 677	Information System Principles

REQUIRED

3 credits from:

CIS 601	Object-Oriented Programming
† CIS 602	WWW: Applications Development and Java
CIS 610	Data Structures and Algorithms
CIS 631	Database Management System Design
CIS 635	Computer Programming Languages
CIS 652	Computer Networks
CIS 661	Systems Simulation

AREAS OF SPECIALIZATION

Select one of the following areas and choose two of the courses listed in that area. The student is responsible for checking with the program director to determine if the necessary course prerequisites have been met.

Interdisciplinary Information Systems

The application of information systems in fields such as the physical or social sciences, engineering, the arts, humanities, and public administration.

6 credits from:

HRM 601	Organizational Behavior *or*
HRM 655	Theory and Research in Organizational Behavior
Mgmt 691	Legal, Ethical and Privacy Issues in Computing *or*
Eng 603	Cultural and Technological Change
IE 661	Human Design Factors in Engineering

† pending

Management Information Systems

Traditional business and commercial applications of information systems.

6 credits from:

Acct 610	Internal Auditing Concepts and Procedures *or*
Acct 615	Concepts of Strategic Cost Analysis
Fin 624	Financial Management
HRM 601	Organizational Behavior *or*
HRM 655	Theory and Research in Organizational Behavior
Mrkt 631	Market Planning and Analysis *or*
Mrkt 632	Marketing Strategy for Technology-Based Organizations

Electronic Enterprise Design

The use of information systems methodologies and methods for redesigning organizations employing modern information technology and concepts.

6 credits from:

CIS 676	Requirements Engineering
CIS 634	Information Retrieval
CIS 684	Business Process Innovation *or*
CIS 762	Computerized Information Systems for Planning and Forecasting Information Systems

Multimedia Communication

Use of multimedia data with regard to development, presentation, utilization and understanding by individuals and organizations.

6 credits from:

Eng 604	Communication Theory
Eng 605	Document Design and Electronic Publishing
† Eng 610	Creating Hypertext Projects: A Task-Oriented Approach
Eng 613	Multimedia Presentations

Biomedical Informatics

Application of information systems in the biomedical and health areas. Biomedical informatics is also available as a master's and a doctoral degree. See "Biomedical Informatics" in the Degree Programs section of this catalog.

6 credits from:

BINF 602/BINF 5020	Biomedical Modeling and Decision-Making Systems
BINF 603/BINF 5030	Visualization in Biomedical Sciences
BINF 621/BINF 5210	Research Methods in Health Sciences

Students considering earning a doctorate or who are already enrolled in the Ph.D. in Computer and Information Science program in the information systems specialization should consider the following Rutgers-Newark courses for the area of specialization.

Interdisciplinary Information Systems

26:620:555	Seminar in Organizational Behavior
26:620:556	Seminar in Organizational Theory
26:620:671	Management of Innovation and Technology
26:620:677	Culture and Organizations

Evaluation Methods and Tools

26:630:660	Qualitative Research Methods
26:630:668	Causal Modeling
26:960:577	Introduction to Statistical Linear Models

Data Analysis and Modeling Tools

26:630:576	Quantitative Methods in Marketing
26:630:625	Clustering Analysis
26:711:585	Control Models

ELECTIVES

18 credits chosen from one or more elective areas. A minimum of two courses is required from any single area selected. The following are some representative specialty areas available in the computer and information science department. The student may propose any specialty set of courses desired including up to two additional courses in other departments. There are many possible specialty areas possible. Choices should be approved by the program director.

† pending

Advanced Information Systems Design

CIS 634	Information Retrieval and Data Mining
CIS 658	Multimedia Systems
CIS 676	Requirements Engineering
CIS 684	Business Process Innovation
CIS 731	Applications of Database Systems
CIS 732	Design of Interactive Systems
CIS 735	Computer Mediated Communication Systems
CIS 762	Computerized Information Systems for Planning and Forecasting
CIS 767	Decision Support Systems

Information Systems Supporting Technology

CIS 601	Object-Oriented Programming
† CIS 602	WWW: Applications Development and Java
CIS 610	Data Structures and Algorithms
CIS 631	Database Management System Design
CIS 635	Programming Languages
CIS 652	Computer Networks
CIS 661	Simulation

Communications and Networking

CIS 651	Data Communications
CIS 652	Networks — Architectures, Protocols, and Standards
CIS 654	Telecommunication Networks Performance Analysis
CIS 656	Internetworking and Higher Layer Protocols

Artificial Intelligence, Expert Systems, and/or Knowledge-Based Systems

CIS 670	Artificial Intelligence
CIS 671	Knowledge-Based Systems
CIS 672	Expert System Methods and Design
CIS 674	Natural Language Processing

DOCTOR OF PHILOSOPHY IN COMPUTER AND INFORMATION SCIENCE

There are two specializations in the Ph.D. in Computer and Information Science: the computer science specialization and the information systems specialization, which are described below.

COMPUTER SCIENCE SPECIALIZATION

This specialization is intended for the superior student in computer science or a related field who has an interest in and commitment to scholarly research.

Admission Requirements

Applicants are expected to have a superior background in mathematics, computer science theory and practice, and the basic sciences. They must have a bachelor's degree from an accredited institution and a demonstrated proficiency in English. Students who do not meet these requirements must strengthen their background before becoming eligible for admission. The GRE is required for applicants to this program.

Degree Requirements

Students must complete all required courses, spend one academic year in full-time residency, participate in the instruction of a computer science course under the supervision of a faculty member, and submit an acceptable final draft of the dissertation with a successful dissertation defense.

REQUIRED

24 credits of advanced courses beyond the master's degree or its equivalent in an area of concentration selected by the student with the approval of the advisor. At least 12 credits must be at the 700 level.

CIS 791 Graduate Seminar every semester.

30 credits of CIS 790 Doctoral Dissertation. A maximum of 6 credits of CIS 792 Pre-Doctoral Research may be used toward the CIS 790 requirement.

Qualifying Examination — The qualifying examination tests general academic preparation and competence in the theory and practice of computing. Students should apply for permission to take the test through the doctoral program director. Students without master's degrees in computer science are expected to complete 30 credits of course work, as specified by the doctoral program advisor, before they may apply for permission to take the qualifying examination.

If a student fails to pass any part of the qualifying examination, the individual must submit a plan to rectify deficiencies to the doctoral program committee in order to receive permission to retake the examination. Students who do not receive permission to retake the examination, or those who fail to pass on the second attempt, will be dismissed from the program.

Pre-Doctoral Research — Students who pass the qualifying examination are permitted to register for a maximum of 6 credits of pre-doctoral dissertation research, to prepare a proposal for their dissertation research. This is subject to advisor approval. The proposal must be defended before the dissertation committee before it is accepted.

Dissertation and Defense — An oral defense of the dissertation is required after submitting the final document to the department for approval.

AREAS OF RESEARCH

In general, areas of specialization reflect faculty research and interests and are periodically reviewed by the department for timeliness. Samples of areas of research within both specializations are:

- Collaborative Systems
- Combinatorial Computing
- Computer Algorithms and Computational Complexity
- Computer and Information Systems in Management
- Computer Graphics
- Computer Networks
- Computer Performance Evaluation
- Database/Artificial Intelligence
- Data Communications and Networking
- Data and Knowledge Management
- Decision-Support Systems
- Distributed Processing
- Expert Systems
- Human-Computer Interaction
- Image Processing/Computer Vision
- Information Processing and Retrieval
- Knowledge-Based Systems
- Medical Imaging
- Neural Computation
- Neuroscience and Robotics
- Natural Language Processing
- Operating Systems
- Parallel Processing
- Pattern Recognition
- Programming Languages
- Real-Time Computing
- System Architectures
- System Development Technologies
- Systems Integration
- System Simulation and Modeling
- Theory of Computing

INFORMATION SYSTEMS SPECIALIZATION

The program in information systems is designed to produce scholars who possess a commanding knowledge of the nature of information systems, its applications, research and supporting technology. Graduates will be prepared for research, teaching, and practice.

The program seeks to develop individuals from different disciplinary backgrounds who can expand both the practice and theory of information systems for complex applications and organizational environments in any field of application: management, business, engineering and manufacturing, health and medicine, education, the social sciences, and the arts and humanities.

Admission Requirements

Applicants are expected to have successfully completed a baccalaureate program from an accredited institution. They must submit a resume of experience and background, transcripts of academic record, three letters of recommendation by persons familiar with the student's academic work and/or related work experience, and GRE, GMAT or MCAT scores.

International students must present a TOEFL score of 550 to be eligible for admission. However, those seeking support must demonstrate a level of spoken English proficiency sufficient for teaching activities (600 or higher on the TOEFL and a reasonably high GRE verbal).

Applicants must have demonstrated superior performance in prior academic programs. The following is the minimum set of necessary courses in the fields of mathematics and computer technology. Applicants who have not met all these course requirements prior to admission, may be accepted and required to complete these requirements while in the program. Those seeking support must have satisfied this knowledge requirement in advance of admission.

An outstanding student with a bachelor's or master's degree in any field may apply and be accepted into the degree program, conditional on accomplishing an appropriate set of bridge courses to make up necessary prerequisites or knowledge deficiencies in such areas as computers and mathematics. Students should have the following course background: two semesters of calculus; a post calculus probability and statistics course; a discrete math methods course; and four undergraduate courses in computer science in areas such as programming, data structures, databases, software engineering, and

† pending

communications. Appropriate work experience may be applicable to satisfying part or all of these requirements. A working knowledge of one development-oriented computer language such as C or Pascal is also expected.

Applicants without the above background might consider applying for the M.S. in Information Systems and completing the specific bridge requirements for the master's, as described earlier in this section.

Degree Requirements

Those entering with a bachelor's degree must complete a total of 90 credits consisting of:

36 credits of core courses

24 credits of advanced courses

30 credits of CIS 790 Doctoral Dissertation. A maximum of 6 credits of CIS 792 Pre-Doctoral Research may be used toward the CIS 790 requirement. Prepare and defend the dissertation.

For those entering with an appropriate master's degree, the master's degree can be considered an equivalent to the 36 credits of core courses. Master's-prepared students complete 54 credits including the additional requirements as described below.

Passing a qualifying exam on the core courses

24 credits of advanced courses beyond the master's degree or its equivalent in a concentration selected by the student with the approval of the advisor. At least 12 credits must be at the 700 level.

30 credits of CIS 790 Doctoral Dissertation. A maximum of *6 credits* of CIS 792 Pre-Doctoral Research may be used toward the CIS 790 requirement. Prepare and defend the dissertation.

CIS 791 Graduate Seminar every semester

Participate in the instruction of an information systems course under the supervision of a faculty member.

Submission of at least one research paper for publication in a peer-reviewed conference or journal.

Develop a state-of-the-art paper on that specialty area for presentation at NJIT.

Take a field exam based upon the state-of-the-art paper.

While pursuing the Ph.D. in Computer and Information Science information systems specialization, the student may obtain the Master of Science in Information Systems.

The department encourages part-time students to take part in this program, however most thesis advisors will require some full-time effort after successful completion of the comprehensive exam.

Part-Time Students and Distance Learning The program welcomes part-time students. A great many of the required courses are being offered in a distance learning mode as well as the normal class room offerings. However, after completing the courses and exams and entering the initial phase of dissertation work, most successful doctoral students need to invest a full-time effort for six months to a year to assure success.

CONCENTRATIONS

The student must select a concentration and take 12 credits (four courses) within the concentration. The concentrations and their course choices are listed in the Master of Science in Information Systems program description under "Areas of Specialization." Those who already have a background, such as a master's degree, covering one of these concentrations might decide to take more advanced courses selected in consultation with the program director.

Qualifying Exam — The student must take a qualifying exam that will cover the content of the supporting technology and information systems required courses.

Advanced Courses — Upon successful completion of the qualifying exam the student must select a concentration with the approval of an advisor. These courses must constitute a coherent body of knowledge in support of the student's expected area of concentration and research. They may include courses eligible for transfer credit from an academic program beyond the bachelor's. The area of concentration must include at least four additional information systems or computer science courses (refer to the Areas of Specialization described earlier in the M.S. in Information Systems program). These courses must be approved by the student's advisor and the program director.

State-of-the-Art Paper and Comprehensive Exam — The state-of-the-art paper is a product the student works on with an advisor during the period when he or she is taking the 24 credits of advanced study. It focuses on summarizing the student's command and understanding of the current research issues and activity in the concentration area and important related findings from all of the coherent set of courses in the advanced study. The student may include in the advanced study independent study course (CIS 776) with the advisor to allow for the completion of the state-of-the-art paper under the advisor's guidance.

The state-of-the-art paper will usually form the basis for the student's subsequent dissertation proposal. It will summarize literature in the specialty area, carefully exposing related research areas from relevant topics making up the specialty area. Faculty research areas are listed earlier in the computer science specialization program description under "Areas of Research." The objective of this requirement is to insure the student has obtained a solid understanding of the research issues in the chosen area of study before specializing on a specific issue for their dissertation work.

The state-of-the-art paper, once approved by the advisor, will be submitted to a dissertation committee, which will determine the nature of the comprehensive exam after careful review of the state-of-the-art paper.

Dissertation Proposal, Work and Defense — After acceptance of the state-of-the-art paper and the passage of the comprehensive exam the student prepares a dissertation proposal and works on the dissertation. The student must then successfully defend the dissertation.

■ DOCTOR OF PHILOSOPHY IN MANAGEMENT

Administered by: Department of Computer and Information Science

Computer Information Systems Specialization Program Coordinator and Advisor: Murray Turoff (973) 596-3366 (Room 4106 GITC), e-mail turoff@vc.njit.edu
Faculty: appropriate faculty from the Department of Computer and Information Science and the School of Management

The computer information systems concentration in the Ph.D. in Management program is dedicated to the study and investigation of computer applications. This entails the areas of planning, conception, design, development, implementation, testing, validation, evaluations, management and relationships of, and strategies for applications, communications and other computer technologies. The context of computer applications and technologies includes the relationships of impacts, consequences and implications of these systems on individuals, groups, organizations and society. This area may also include theory and internal implementation topics when there is a clear perceived relationship or consequence for an application or technology. Thesis work includes the assessment of such relationships.

Admission Requirements

Applicants must have a thorough working knowledge of computer technology as that gained in a bachelor's or master's program in information systems or computer science. Knowledge should include the ability to program in a systems development language such as C, knowledge of basic database models and structures, knowledge of object-oriented concepts and programming in an object-oriented language such as C++ and/or Java, and the knowledge of concepts underlying an operating system. The above knowledge may be obtained from work experience as well as from course work.

The following is a set of NJIT courses that would provide a minimum core of knowledge as indicated above. Undergraduate courses are described in the NJIT undergraduate catalog.
Knowledge of C: CIS 505 Programming, Data Structures, and Algorithms, or CIS 113 Introduction to Computer Science I and CIS 114 Introduction to Computer Science II.

Knowledge of operating systems: CIS 332 Principles of Operating Systems, CIS 601 Object-Oriented Programming in C++, CIS 631 Data Management System Design.

Applicants are normally expected to hold a master's degree or an M.B.A. in any field that may be considered an application area for information systems or directly in information systems, management, engineering, or science.

Students who wish to earn an M.S. in Information Systems at NJIT first may satisfy a number of the following courses as part of that program. It is possible, depending on the student's background, to take some of the doctoral degree requirements as part of the master's degree requirements.

Applications for the computer information systems specialization for the Ph.D. in Management are made through the Office of Admission, Graduate School of Management, Rutgers-Newark, University Heights, 92 New St., Newark, N.J. 07102. Additional information may be ordered from the Ph.D. office at Rutgers-Newark at the same address, c/o Narda Acevedo, assistant director, by calling (973) 648-1002, or by e-mail to nacevedo@andromeda.rutgers.edu

The NJIT M.S. in Information Systems and the Ph.D. in Computer Science, information systems specialization, programs are found under Computer and Information Science" in the Degree Programs section of this catalog.

Degree Requirements

The following is a concise summary of the course of study for those interested in the area of specialization in computer information systems. All students in this area should contact the advisor. Initial study plans for the first year must be approved by the area coordinator.

CORE

These courses provide the student with fundamental principles of information systems and with the methods by which information systems may be studied and understood in the context of their role in organizations.

Methodology

6 credits:

26:630:660 Qualitative Research Methods
26:960:577 Introduction to Statistical Linear Models

Choose two courses from one of the following sets.

Information Systems Management and Impacts

6 credits from:

26:620:555 Seminar in Organizational Behavior
26:620:556 Seminar in Organizational Theory
26:620:671 Management of Innovation and Technology
26:620:677 Culture and Organizations

Data Analysis and Modeling Tools

6 credits from:

26:630:668 Causal Modeling
26:630:576 Quantitative Methods in Marketing
26:630:625 Clustering Analysis
26:771:585 Control Models

REQUIRED

Foundation

6 credits:

CIS 677 Information System Principles
CIS 679 Management of Computer and Information Systems

Research

6 credits:

CIS 675 Evaluation of Information Systems (to be taken immediately after CIS 677)
CIS 776 Independent Study in Information Systems (to be taken after or simultaneously with completing the four elective courses below)

ELECTIVE

Students choose four courses in a major and minor with the guidance of the advisor. At least four elective courses must be taken and before enrolling in CIS 776 with the advisor's approval.

Specific areas of interest in which one may choose major and minor electives should be determined with the faculty advisor. The following areas are examples only: simulation and modeling, data base systems, decision support systems, computer mediated communications, hypermedia and hypertext, interface design, software engineering, social impacts of IS, communications, evaluation methodology for IS, expert systems, information management, collaborative systems, standards, distributed processing, computer integrated manufacturing, computer system management, AI and expert systems.

All of the above topics have a focus on applications in organizations, management and development of those applications, and/or the implications of the technology for management and the organization.

Reading Lists — There are standard reading lists for CIS 677, CIS 675, and CIS 679.

These will be held constant for up to one academic year preceding the field examination. All majors are responsible for the material in the current reading lists for the general part of the field exam.

Offerings — All required courses will be offered at least once a year. Currently there are Distance Learning versions offered by NJIT for many of its graduate courses.

Faculty Advisor — Once the student has successfully completed most of the required courses, the individual should determine a specific area of interest and discuss this with various faculty in that area as well as read some of the publications of the faculty with whom the student is interested in working. Faculty research appears in the "NJIT Faculty Research" section of this catalog. Some faculty post home pages describing their research and publications. The citation index in the Rutgers-Newark Dana Library can provide useful information on various publications of faculty members. In addition, the program director can guide the student to appropriate faculty.

Until a faculty advisor has been chosen, the student should seek approval for any elective courses from the computer information systems program coordinator at NJIT.

General Qualifying Exam — The general exam is based upon the material in CIS 677, CIS 675 and CIS 679. It is a four-hour written exam given every March, and if there are sufficient students to warrant an exam, in October.

State-of-the-Art-Paper — As part of completing CIS 776, the student, with an advisor, must produce a state-of-the-art review paper focusing on the student's desired research area. The review paper for a major must meet the standards of scholarly work and should be written as a review on the "state of the art" for fellow researchers in this topic area. This review paper will emphasize the current findings in the field and the identification of a range of researchable issues, not just the one issue the student will work on for the thesis. This paper is expected to be the basis for the literature review included in the student's dissertation proposal. A faculty committee will review the state-of-the-art paper. The student may be required to undergo an exam (oral or written) on the state-of-the-art paper.

Advisement — New students should see the computer information systems specialization program coordinator upon entering the program. If potential waivers or transfers need to be discussed, the student should have a transcript copy and material on prior computer science and information systems area courses such as catalog descriptions or lists of books or material covered. Other subject area course waivers or transfers are handled in the Rutgers-Newark Ph.D. in Management program office.

Course Registration — Because the registration process for Rutgers-Newark students may cause delays, doctoral students may seek, and usually will be given, entry to closed sections. Contact Michael Tress, department administrator, (973) 596-3385.

The NJIT Department of Computer and Information Science is on the fourth floor of the Guttenberg Information Technologies Building located at Central Avenue and Lock Street. Faculty office hours can be obtained by calling the department, (973) 596-3366.

Electrical Engineering

Administered by: Department of Electrical and Computer Engineering

Chairperson: Richard A. Haddad
Associate Chairpersons: Kenneth Sohn, Nirwan Ansari (graduate studies), Gerald Whitman (graduate studies)
Assistant Chairperson: Mohammed Feknous (Mount Laurel campus)
Distinguished Professors: Bar-Ness, Friedland, Savir
Professors: Akansu, Ansari, Carr, Cohen, Cornely, Grebel, Haddad, Klapper, Kuo, Meyer, S. Reisman, Rosenstark, K. Sohn, Strano, Thomas, Whitman
Associate Professors: Carpinelli, T. Chang, Clements, Engler, Frank, Haimovich, Hou, Hubbi, Manikopoulos, Misra, Niver, Y. Shi, Sosnowski, Zhou, Ziavras
Assistant Professors: Fang, Ge, Tekinay, Uzun
Visiting Professor: Malik
Professional/Instructional Staff: Feknous

Graduate Advisors: Nirwan Ansari (973) 596-3670 (Room 343 ECE), e-mail ansarin@admin.njit.edu; Gerald Whitman (973) 596-3232 (Room 223 ECE), e-mail whitman@megahertz.njit.edu

Doctoral Programs Coordinator: Stanley Reisman (973) 596-3527 (Room 347 ECE), e-mail reisman@admin.njit.edu

Degrees Offered: Master of Science in Electrical Engineering; Doctor of Philosophy in Electrical Engineering

The Department of Electrical and Computer Engineering serves the community, the state and the nation by educating engineers, expanding knowledge and developing new tools for solving complex technological problems. The department's graduate program offers students with backgrounds in electrical engineering or related areas unusual opportunities to specialize in advanced phases of electrical engineering. In addition to more than 30 full-time faculty members devoted to teaching and research, students are taught by adjunct professors from industry who offer specialty courses in their area of expertise and serve on thesis and dissertation committees.

The master's degree programs provide state-of-the-art training at advanced levels in areas of technical specialization, including faculty-supervised research. Students in the doctoral program conduct significant original research in areas of interest to department members. Students also have opportunities to conduct thesis research at industrial sites, hospitals, biomedical engineering facilities, and university centers and departments.

■ MASTER OF SCIENCE IN ELECTRICAL ENGINEERING

A program for students with an undergraduate degree in engineering who wish either to specialize in an advanced phase of electrical engineering or prepare for a more advanced degree.

Admission Requirements

Applicants are expected to have undergraduate backgrounds in physics, mathematics (through differential equations and vector analysis), electrical networks and devices, electronics, analysis and design methods, transients, electromagnetic fields, and appropriate laboratory work in some of these areas. For further information, see the Admissions section in this catalog.

Bridge Program — Students who have earned a Bachelor of Science in Engineering Technology (B.S.E.T.) degree, or who lack an appropriate background may be admitted and be required to take selected courses such as the ones listed below in addition to the degree requirements in order to make up deficiencies. They must attain a grade of B or better in each course. At the discretion of the department, students who have taken courses equivalent to these may have their bridge programs reduced accordingly.

EE 232	Circuits and Systems II
EE 333	Circuits and Systems III
EE 361	Electromagnetic Fields I
EE 362	Electromagnetic Fields II
EE 372	Electronic Circuits II
EE 373	Electronic Circuits III

Graduate Record Examinations — See the Admissions section of this catalog for details.

Graduate Certificate Program — A 12-credit graduate certificate in Telecommunications Networking is available as a step toward this degree. See "Graduate Certificates" in the Degree Programs section of this catalog. For further information, call the associate vice president of continuing and distance education, Division of Continuing Professional Education, 1 (800) 624-9850 or (973) 596-3060; e-mail cpe@njit.edu

Degree Requirements

Upon entering the program, students select an area of specialization supervised by an area coordinator. The master's program consists of 30 credits. Students who enter the program but who do not receive departmental or research-based awards have three program options: 24 course credits and 6 credits of master's thesis; or 27 course credits and 3 credits of master's project; or 30 course credits not to include either a master's project or thesis. Students should consult with the area coordinator or designee of their area of specialization before registering for courses to make sure they are meeting department requirements. As a requirement for graduation, students must achieve a 3.0 cumulative GPA in graduate-level courses, not including the master's thesis or project. The thesis or project grade must be B or better.

ECE courses at the 500 level are not acceptable for credit toward a graduate degree in electrical engineering. Only one 500 level course outside the department may be applied for credit toward a graduate degree in electrical engineering.

Seminar — All students receiving departmental or research-based support are required to register every semester for ECE 791 Graduate Seminar.

PROJECT, THESIS

Thesis is required for all those receiving departmental or research-based support. For all others, a project or thesis is optional.
3 credits: ECE 700 Master's Project
6 credits: ECE 701 Master's Thesis

AREAS OF SPECIALIZATION

Entering students must select an area of specialization during their first semester. Special topics courses and electives are chosen with the approval of the area coordinator or designee. Two non-ECE graduate courses may be chosen. Students should contact the appropriate associate chairperson for graduate studies for guidance.

Area Coordinators

Biomedical Systems: S. Reisman
Communication and Signal Processing: A. Haimovich
Computer Systems: J. Savir
Control Systems: A. Meyer
Energy Conversion and Power: E. Cohen
Microwave and Lightwave Engineering: G. Whitman
Solid State Materials, Devices and Circuits: R. Cornely

Biomedical Systems

This area of specialization is available only to electrical engineering doctoral students.

CORE
6 credits:

ECE 601	Linear Systems
ECE 673	Random Signal Analysis I

REQUIRED
9 credits:

BME 669	Quantitative Physiology for Engineers
ECE 667	Systems Studies in Bioengineering
ECE 687	Design of Medical Instrumentation

ELECTIVE
15 credits:
See the department "Handbook for Graduate Students" for suggestions. Course selection is determined in consultation with the area faculty.

Communication and Signal Processing

Choose communications or digital signal processing.

CORE
Applies to both communications and digital signal processing
6 credits:

ECE 601	Linear Systems
ECE 673	Random Signal Analysis I

REQUIRED
Communications
6 credits:

ECE 642	Communication Systems I
ECE 742	Communication Systems II

Digital Signal Processing
6 credits:

ECE 640	Digital Signal Processing
ECE 740	Advanced Digital Signal Processing

ELECTIVE
Applies to both communications and digital signal processing. Select 12 credits if completing a master's thesis; 15 credits if completing a master's project; or 18 credits if not completing either a master's project or thesis. See the department "Handbook for Graduate Students" for suggestions. Course selection must be approved by the associate chairperson for graduate studies, the area coordinator or the thesis advisor.

Computer Systems

Choose either computer networking, VLSI systems design, microprocessor systems or parallel computing systems.

Computer Networking

CORE
6 credits:
ECE 673 Random Signal Analysis I
ECE 684 Advanced Microprocessor Systems

REQUIRED
6 credits:
ECE 683 Computer Network Design and Analysis
ECE 783 Computer Communication Networks

VLSI Systems Design

CORE
6 credits:
ECE 673 Random Signal Analysis I
ECE 684 Advanced Microprocessor Systems

REQUIRED
6 credit:
ECE 658 VLSI Design I
ECE 758 VLSI Design II

Microprocessor Systems

CORE
6 credits:
{ ECE 601 Linear Systems *or*
{ ECE 673 Random Signal Analysis I
ECE 684 Advanced Microprocessor Systems

REQUIRED
6 credits:
ECE 686 Instrumentation Systems and Microprocessors
ECE 688 Microcontrollers in Instrumentation

Parallel Computing Systems

CORE
6 credits:
{ ECE 601 Linear Systems *or*
{ ECE 673 Random Signal Analysis I
ECE 684 Advanced Microprocessor Systems

REQUIRED
6 credits:
ECE 689 Digital System Design for Machine Arithmetic
ECE 690 Computer Systems Architecture

ELECTIVE
Applies to computer networking, VLSI system design, microprocessor systems and parallel computing systems. Select 12 credits if completing a master's thesis; 15 credits if completing a master's project; or 18 credits if not completing either a master's project or thesis. See the department "Handbook for Graduate Students" for suggestions. Course selection must be approved by the associate chairperson for graduate studies, the area coordinator or the thesis advisor.

Control Systems

CORE
6 credits:
ECE 601 Linear Systems
ECE 673 Random Signal Analysis I

REQUIRED
9 credits:
ECE 660 Control Systems I
ECE 664 Real-Time Computer Control Systems
ECE 666 Control Systems II

ELECTIVE
Select 9 credits if completing a master's thesis; 12 credits if completing a master's project; or 15 credits if not completing either a master's project or thesis. See the department "Handbook for Graduate Students" for suggestions. Course selection must be approved by the associate chairperson for graduate studies, the area coordinator or the thesis advisor.

Energy Conversion and Power

CORE
6 credits:
ECE 601 Linear Systems
{ ECE 620 Electromagnetic Field Theory *or*
{ ECE 673 Random Signal Analysis I *or*
{ ECE 684 Advanced Microprocessor Systems

REQUIRED
6 credits:
ECE 610 Power System Steady-State Analysis
ECE 611 Transients in Power Systems

ELECTIVE
Select 12 credits if completing a master's thesis; 15 credits if completing a master's project; or 18 credits if not completing either a master's project or thesis. See the department "Handbook for Graduate Students" for suggestions. Course selection must be approved by the associate chairperson for graduate studies, the area coordinator or the thesis advisor.

Microwave and Lightwave Engineering
Choose microwave engineering or lightwave engineering.

CORE
Applies to both microwave and lightwave engineering
6 credits:
{ ECE 601 Linear Systems *or*
{ ECE 673 Random Signal Analysis I
ECE 620 Electromagnetic Field Theory

REQUIRED

Microwave Engineering
9 credits:
ECE 622 Wave Propagation
ECE 630 Microwave Engineering
ECE 632 Antenna Theory

Lightwave Engineering
9 credits:
ECE 622 Wave Propagation
ECE 626 Optoelectronics
ECE 739 Laser Systems

ELECTIVE
Applies to both microwave and lightwave engineering. Select 6 credits if completing a master's thesis; 9 credits if completing a master's project; or 12 credits if not completing either a master's project or thesis. See the department "Handbook for Graduate Students" for suggestions. Course selection must be approved by the associate chairperson for graduate studies, the area coordinator or the thesis advisor.

Solid State Materials, Devices, and Circuits
Choose either solid state circuits or solid state devices.

Solid State Circuits

CORE
6 credits:
ECE 601 Linear Systems
ECE 684 Advanced Microprocessor Systems

REQUIRED
12 credits:
ECE 648 Digital Microelectronics
ECE 657 Semiconductor Devices
ECE 658 VLSI Design I
ECE 660 Control Systems I

ELECTIVE
Select 6 credits if completing a master's thesis; 9 credits if completing a master's project; or 12 credits if not completing either a master's project or thesis. See the department "Handbook for Graduate Students" for suggestions. Course selection must be approved by the associate chairperson for graduate studies, the area coordinator or the thesis advisor.

Solid State Devices

CORE
6 credits:
ECE 601 Linear Systems
ECE 620 Electromagnetic Field Theory

REQUIRED
9 credits:

ECE 657	Semiconductor Devices
ECE 658	VLSI Design I
ECE 659	Fabrication Principles of Electronic and Optoelectronic Devices

ELECTIVE
Select 9 credits if completing a master's thesis; 12 credits if completing a master's project; or 15 credits if not completing either a master's project or thesis. See the department "Handbook for Graduate Students" for suggestions. Course selection must be approved by the associate chairperson for graduate studies, the area coordinator or the thesis advisor.

■ DOCTOR OF PHILOSOPHY IN ELECTRICAL ENGINEERNG

This is a program for superior students with master's degrees in electrical engineering or allied fields who wish to conduct advanced research in an area of electrical engineering.

Exceptional Candidates with a Bachelor of Science in Electrical Engineering

Highly qualified students with bachelor's degrees in electrical engineering may be accepted directly into the doctoral program. Contact the doctoral program coordinator for further information.

Admission Requirements

Applicants are expected to have a broad background in engineering, mathematics, physics, and computer science. At least half of undergraduate course work should have been in the physical sciences or similar fields. Doctoral students should have majored in electrical engineering or related field, with course work at the master's level in mathematics, physics and/or computer science. In addition, students are expected to be proficient in computer programming.

Students who lack an appropriate background will be required to take additional courses that cannot be applied as degree credits.

Degree Requirements

Course selection is determined in consultation with the area faculty.

24 credits minimum of course work beyond the master's degree

12 credits of 700-level courses (normally associated with the area of specialization as listed in the master's degree description). For details, see the department "Handbook for Graduate Students."

36 credits of ECE 790 Doctoral Dissertation

Registration for 1/2 credit of ECE 791 Graduate Seminar is required of all doctoral students every semester. Waivers of the seminar requirement may occur with the approval of the dean of graduate studies.

Dissertation and Defense — The dissertation should demonstrate original research that contributes to the knowledge in the field and should result in the submission of at least one paper for publication in a peer-reviewed journal. Students must provide the department a written proposal showing that facilities are available and that there is a faculty member willing to supervise dissertation work. Students who complete 36 credits of ECE 790 before their research is finished, must register for a minimum of 3 credits of ECE 790 every semester thereafter until the dissertation has been accepted. An oral defense of the dissertation is required after submission of the final document to the dissertation committee for approval.

Residency — Degree-seeking students must spend at least one academic year in full-time residence.

Qualifying Examination — The examination contains material related to the student's fundamental knowledge, which includes the area of specialization. Contact the doctoral programs coordinator for more information.

Pre-Doctoral Research — With department approval, well-qualified students may register for up to a maximum of 9 credits of ECE 792 Pre-Doctoral Research prior to passing the qualifying examination. A maximum of 6 credits of ECE 792 may be applied toward the ECE 790 requirement.

Engineering Management

Administered by: Department of Industrial and Manufacturing Engineering

Chairperson: Athanassios K. Bladikas
Associate Chairperson: George Abdou

Program Director and Graduate Advisor: Carl Wolf (973) 596-3657 (Room 2511 GITC), e-mail wolf@admin.njit.edu

Professors: Abdel-Malek, Caudill, Chao, Hatch, Ranky, Sebastian, Tricamo, Wolf
Associate Professors: Abdou, Bengu, Bladikas, Das, McDermott
Assistant Professors: Jeng, Sengupta

Degrees Offered: Master of Science in Engineering Management

By drawing on the diverse resources available through the university and surrounding industry, the M.S. in Engineering Management program develops engineers and other technically trained individuals for leadership roles in a technologically-based, project-oriented enterprise.

Focus on interdisciplinary course work and research provides students with an advanced background in both the theoretical and practical aspects of managing technical/engineering projects and programs via case studies, role playing, and course work. The engineering management program faculty bring to the classroom a critical blend of practical and academic experience.

■ MASTER OF SCIENCE IN ENGINEERING MANAGEMENT

The program is particularly valuable to individuals who have a number of years of experience in industry, government, and service organizations, or those who have been entrepreneurs. It provides these professionals with broad-based knowledge and skills to succeed as organizational managers and project managers, from conceptualization through implementation.

Admission Requirements

Eligibility for admission requires completion of an undergraduate degree in engineering, the sciences or a closely related area. Students are expected to have achieved an undergraduate GPA of at least 2.8 on a 4.0 scale. Students not satisfying the above requirement will be considered for conditional admission on a case-by-case basis. In some cases, a bridge program will be required to qualify for matriculation.

Bridge Program — Students who lack appropriate academic preparation may be required to take one or more of the following courses before being admitted to the program. These courses are taken in addition to degree requirements:

EM 501	Industrial Management
EM 502	Engineering Cost Analysis
EM 503	Methods and Applications of Industrial Statistics and Probability

Off-Campus Programs — At the NJIT at Mount Laurel branch campus and at extension sites, NJIT offers sufficient courses to fulfill all degree requirements. NJIT faculty teach all courses. For locations, see "Extension Programs" in this catalog. The university's distance learning arm, ACCESS/NJIT, offers this program (as well as part of the bridge program described above) to qualified students who have access to the Internet and a VCR. In addition, a distance-based, 12-credit graduate certificate in Project Management is available as a step toward this degree. See "Graduate Certificates" in this catalog. For further information about extension programs and graduate certificates call the associate vice president for continuing and distance education, Division of Continuing Professional Education, 1 (800) 624-9850 or (973) 596-3060; e-mail cpe@njit.edu

Degree Requirements

The program requires 30 credits, 18 of which are taken in a required core. A purpose of the core is to provide knowledge in the functional areas that are the cornerstones of the discipline: organization and people management, cost management, and systems management. The remaining 12 credits are elective courses, which may be within an area of specialization to meet the individual's specific professional and personal objectives. A 3-credit project or a 6-credit thesis is optional. In some cases, students may select courses to enhance their technical competency. In other cases, individuals may select courses to prepare

for a change in responsibilities or job function. At least half of the elective courses must be selected from those offered by the Department of Industrial and Manufacturing Engineering.

Seminar — In addition to the minimum 30 degree credits required, all students who receive departmental or research-based awards must enroll each semester in IE 791 Graduate Seminar.

CORE
18 credits:

Acct 615	Concepts of Strategic Cost Analysis
EM 602	Management Science
EM 636	Project Management
HRM 601	Organizational Behavior
IE 673	Total Quality Management
MIS 648	Decision Support Systems

PROJECT OR THESIS (optional)
3 credits: IE 700 Master's Project *or*
6 credits: IE 701 Master's Thesis

AREAS OF SPECIALIZATION
For all areas of specialization, select 6 credits if completing a master's thesis; 9 credits if completing a master's project; 12 credits if not completing either a master's project or thesis.

Project Management

EM 634	Legal, Ethical and Intellectual Property Issues for Engineering Managers
EM 637	Project Control
EM 691	Cost Estimating for Capital Projects
IE 651	Industrial Simulation

Cost Engineering

EM 632	Legal Aspects in Construction
EM 637	Project Control *or*
IE 618	Engineering Cost and Production Economics
EM 691	Cost Estimating for Capital Projects
Fin 624	Financial Management

Technical Marketing

EM 640	Distribution Logistics
EM 641	Engineering Procurement and Materials Management
Mrkt 631	Market Planning and Analysis
Mrkt 636	Design and Development of High Technology Products

Technological Entrepreneurship

EM 634	Legal, Ethical and Intellectual Property Issues for Engineering Managers
Mgmt 620	Management of Technology
MnE 655	Concurrent Engineering
Mrkt 636	Design and Development of High Technology Products

Quality

EM 674	Benchmarking and Quality Function Deployment
IE 605	Engineering Reliability
IE 672	Industrial Quality Control
MnE 654	Design for Manufacturability

Facility Management

Arch 650	Economy of Building
EM 632	Legal Aspects in Construction
Fin 624	Financial Management
IE 653	Facility Maintenance

Manufacturing Systems Management

MnE 601	Manufacturing Systems
MnE 602	Flexible and Computer Integrated Manufacturing
MnE 603	Management of Manufacturing Systems
MnE 655	Concurrent Engineering

Management Information Systems

EM 655	Management Aspects of Information
IE 651	Industrial Simulation
IE 661	Man-Machine Systems
MIS 690	Executive Information Systems

Engineering Management

EM 635	Management of Engineering Research and Development
EM 714	Multicriteria Decision Making
HRM 606	Human Resource Management
IE 618	Engineering Cost and Production Economics
MIS 645	Operations Management, Planning and Control
MnE 655	Concurrent Engineering

Engineering Science

Administered by: Office of the Dean, Newark College of Engineering and College of Science and Liberal Arts

Program Director and Graduate Advisor: David Kristol (973) 596-3584 (Room 363 TIE), e-mail kristol@njit.edu

Faculty: from Newark College of Engineering and College of Science and Liberal Arts, as appropriate

Degree Offered: Master of Science in Engineering Science

The M.S. in Engineering Science allows students to study areas not covered by traditional engineering or science discipline graduate programs. For those already in the work force, the program provides the opportunity to develop expertise relevant to their work.

■ MASTER OF SCIENCE IN ENGINEERING SCIENCE

This is a very flexible program that permits advanced study from numerous disciplines in engineering and the sciences.

Admission Requirements

Applicants are expected to have an accredited undergraduate degree in science or engineering. Candidates with other appropriate backgrounds may be considered.

Bridge Program — To ensure academic success in their graduate studies, students may be required to take additional undergraduate or graduate courses before beginning graduate curricula. This program of courses will be individually-designed in consultation with the student's graduate advisor. Such courses are not counted toward degree requirements.

Degree Requirements

A minimum of 30 credits is required. A thesis or project may be included.

Seminar — In addition to the minimum 30 degree credits, all students who receive departmental or research-based awards must enroll each semester in a graduate seminar. The seminar is selected in consultation with the graduate advisor.

REQUIRED
15 credits, selected in consultation with graduate advisor:
6 credits of 600-level mathematics
3 credits of 600-level physics, chemistry, or biology
6 credits of 600-level engineering courses

PROJECT OR THESIS (optional)
3 or 6 credits: selected in consultation with graduate advisor

ELECTIVE
15 credits selected in consultation with graduate advisor
The elective credits must form a meaningful and coherent program integrated with the specialization in science or engineering.

Environmental Engineering

Administered by: Department of Civil and Environmental Engineering

Acting Chairperson: John Schuring
Professors: Chan, Cheng, Dresnack, Golub, Hsieh
Associate Professor: Olenik
Assistant Professors: Axe, Ding, Marhaba

Graduate Advisor: Hsin-Neng Hsieh (973) 596-5859 (Room 219 COL), e-mail hsieh@admin.njit.edu

Degrees Offered: Master of Science in Environmental Engineering; Doctor of Philosophy in Environmental Engineering

Environmental engineers are essential participants in the planning, design and construction of waste water and potable water treatment plants, solid waste disposal systems, site remediation and emission control measures, and other similar projects. Major corporations, government agencies, private consulting and construction firms, and universities are just some of the organizations that employ environmental engineers.

In-depth knowledge in environmental engineering is essential for professional practice as well as for research. Full-time faculty members with a range of academic and professional practice experience as well

as by adjunct instructors who are experts in their field teach the courses. Those students interested in research at the master's level or continuing their education at the doctoral level should consider working with faculty involved in one of the university's related major research centers.

MASTER OF SCIENCE IN ENVIRONMENTAL ENGINEERING

The M.S. in Environmental Engineering is designed for those who want both specialized course work and the flexibility to tailor their program to their needs.

Admission Requirements

Applicants are expected to have an undergraduate degree in engineering or its equivalent. Students who lack an appropriate undergraduate background may be granted conditional admission in order to complete a bridge program or its equivalent. These courses are taken in addition to regular degree requirements; descriptions may be found in the undergraduate catalog.

Bridge Program — Students who lack appropriate background are asked to make up deficiencies by taking a program of courses, including any prerequisites, that is designed in consultation with graduate advisors. See the undergraduate catalog for description of bridge courses. These courses are taken in addition to the degree requirements:

CE 320	Fluid Mechanics
CE 321	Water Resources Engineering
CE 322	Hydraulic Engineering
CE 501	Introduction to Soil Behavior
Chem 126	General Chemistry II
CIS 101	Computer Programming and Problem Solving (or equivalent)
Math 222	Differential Equations
Mech 234	Engineering Mechanics
Mech 236	Dynamics

Degree Requirements

The program comprises 30 credits of required and elective courses. The student consults the graduate advisor to plan and maintain an individualized and cohesive sequence of courses.

Seminar — In addition to the minimum 30 degree credits required, all students who receive departmental or research-based awards must enroll each semester in EnE 791 Graduate Seminar.

REQUIRED

12 credits as follows:

EnE 560	Chemistry for Environmental Engineers
EnE 660	Introduction to Solid and Hazardous Waste Problems
EnE 661	Microbiology for Environmental Engineers

Graduate mathematics or computer science course approved by graduate advisor.

THESIS

Required of those receiving departmental awards; elective for all others.
6 credits: EnE 701 Master's Thesis

ELECTIVE

Select 12 credits if completing a master's thesis; 18 credits if not completing a master's thesis, from:

CE 601	Advanced Remote Sensing
CE 602	Geographic Information System
CE 604	Environmental Modeling in Remote Sensing
CE 605	Research Methods in Remote Sensing
CE 618	Applied Hydrogeology
CE 620	Open Channel Flow
CE 621	Hydrology
CE 623	Groundwater Hydrology
CE 647	Geotechnical Aspects of Solid Waste
CE 702	Special Topics in Civil Engineering
EnE 610	Hazardous Site Operations
EnE 620	Environmental Chemodynamics
EnE 662	Site Remediation
EnE 664	Physical and Chemical Treatment
EnE 665	Biological Treatment
EnE 666	Analysis of Receiving Waters
EnE 667	Solid Waste Disposal Systems
EnE 668	Air Pollution Control
EnE 669	Water and Wastewater Analysis
EnE 670	Advanced Processes in Water Pollution
EnE 671	Environmental Impact Analysis
EnE 700	Environmental Engineering Master's Project
EnE 702	Special Topics in Environmental Engineering

Other suitable electives may be taken subject to approval of graduate advisor.

DOCTOR OF PHILOSOPHY IN ENVIRONMENTAL ENGINEERING

This is a program for superior students with master's degrees in environmental engineering, civil engineering, or allied fields who wish to conduct advanced research in an area of environmental engineering. In exceptional circumstances, highly qualified students with bachelor's degrees in civil engineering or environmental engineering may be accepted directly into the doctoral program.

Admission Requirements

A minimum master's GPA of 3.5 on a 4.0 scale, or equivalent, is normally required for admission. The GRE (general section) is required of all applicants. All international students must also achieve a minimum TOEFL score of 550.

Degree Requirements

The department approves specific degree requirements and dissertation topics on an individual basis. Students must attain a minimum overall GPA of 3.0. Students must conduct independent original research in a specific area of environmental engineering. Students must select an advisor willing to supervise dissertation work.

36 credits minimum of EnE 790 Doctoral Dissertation is generally required. These 36 credits should be completed before submission of the final dissertation document. Students must register for a minimum of 3 credits of EnE 790 until the dissertation has been submitted and accepted.

24 credits minimum of course work beyond the master's degree is required, of which at least 12 credits must be at the 700 level; the remaining credits may be at the 600 level.

Seminar — EnE 791 Graduate Seminar is required for all doctoral students every semester.

Preliminary Qualifying Examination — Full-time students must take the preliminary qualifying examination for the first time within one year of beginning active study and must pass it completely by the next time the examination is offered. Part-time students must take the preliminary qualifying examination for the first time within three years of the beginning of active study and must pass it completely by the next time it is offered. Exceptional students having only bachelor's degrees who are admitted directly into the doctoral program must take the preliminary qualifying examination within one and one-half years of admission and must pass it within two years. All students are permitted to take the examination only twice.

Dissertation Committee — After passing the preliminary qualifying examination, each student in consultation with the major faculty member develops a list of five faculty members who have agreed to serve on an advisory committee as follows: two or three members of the graduate faculty in the student's major area of interest; a member of the graduate faculty in the student's major area appointed by the department chairperson; a member of the graduate faculty of the Department of Civil and Environmental Engineering from another field of interest; a member of the graduate faculty from the area of the student's minor field of interest.

Research Proposal — Doctoral students must prepare a written research proposal and make an oral presentation for approval by their dissertation committee. The proposal must be presented after formation of the committee but within six months after passing the qualifying examination. Research is expected to investigate or develop a unique contribution to science and technology.

Dissertation Defense — An oral defense of the dissertation is required after submission of the final document to the department for approval. Signatures of all members of the dissertation committee must be received for final approval to be granted.

Environmental Policy Studies

Administered by: Department of Humanities and Social Sciences

Chairperson: Norbert Elliot
Associate Chairperson: Richard Quinn

Program Director and Graduate Advisor: Robert Friedman
(973) 596-3371 (Room 428 CUL), e-mail friedman@adm.njit.edu

Professors: Beaton, Bordman, Elliot, Geithman, Schweizer
Associate Professors: N. Jackson, Katz, Rothenberg
Assistant Professors: Linton, Markowitz
Adjunct Faculty: Lederman

Degree Offered: Master of Science in Environmental Policy Studies

This program presents a multidisciplinary course of study that emphasizes empirical and analytical methodologies, together with environmental problem solving within a broader social, historical, and ethical framework. In the core courses, students acquire skills in quantitative research methods and analysis as well as tools to design and assess environmental policy from the perspectives of economics, geography, social psychology, political science, history, rhetoric and philosophy.

After completing the core, students have the option of developing independent research seminars with faculty mentors or selecting from more than twenty courses offered by NJIT and Rutgers-Newark that cover scientific, technological, economic, ethical, historical, and political dimensions of environmental policy studies. Students with a solid background in mathematics and science can also enroll in NJIT graduate courses in environmental science, civil engineering, and environmental engineering.

NJIT is home to a number of research centers where students can participate in major environmental research, including the Hazardous Substance Management Research Center, the Emissions Reduction Research Center, the Center for Policy Studies, and the Institute for Transportation.

■ MASTER OF SCIENCE IN ENVIRONMENTAL POLICY STUDIES

This degree is intended for graduates and professionals interested in government, industry, public advocacy and consulting, with specializations such as environmental research, resource management, environmental planning and regulatory oversight.

Admission Requirements

Individuals may have an undergraduate degree in natural or physical science, social science, engineering, technology, humanities, or interdisciplinary majors. Applicants must have an undergraduate degree from an accredited institution with an undergraduate GPA of at least 3.0 on a 4.0 scale. GRE (verbal, analytical and quantitative aptitude) scores of at least 550 are expected. International students must submit a TOEFL score of at least 575. A writing sample of no more than five pages of recent work also is required. Letters of recommendation from recent instructors or advisors may be requested.

Graduate Certificate Program — A 12-credit graduate certificate in Environmental Infrastructure and Management is available as a step toward this degree. See "Graduate Certificates" in this catalog. For further information, call the associate vice president of continuing and distance education, Division of Continuing Professional Education, 1 (800) 624-9850 or (973) 596-3060; e-mail cpe@njit.edu

Degree Requirements

Students must complete a minimum of 30 degree credits: 18 credits in a series of six, 3-credit core courses followed by 6 elective credits in an area of specialization, and a 6-credit thesis of publishable quality. Students should develop a thesis topic early in the graduate program in consultation with a faculty advisor. Full-time students normally complete the program in less than two years.

Seminar — All students who receive departmental or research-based awards must enroll in an NJIT graduate seminar that is relevant to students' courses of study once during the academic year.

CORE
18 credits:

EPS 601	Research Methods
EPS 602	Research Analysis for the Social and Policy Sciences
EPS 612	Introduction to Environmental Policy Studies
EPS 613	Environmental History and Policy
EPS 614	Environmental Economics
EPS 660	Ethics and Environmental Policy

THESIS (required)
6 credits: EPS 701 Master's Thesis

AREAS OF SPECIALIZATION
6 credits:
In consultation with the graduate advisor, choose two courses from one area of specialization or select two independent study courses. Suggested areas and courses:

Humanities and Social Sciences

EPS 606	Technology Forecasting and Management Planning
EPS 609	Environmental Risk Assessment
EPS 615	The Politics of Science
EPS 616	Global Problem Solving in Science, Technology, and the Environment
EPS 634	Professional Ethics
EPS 644	The Rhetoric of Environmental Policy
EPS 725	Independent Study I
EPS 726	Independent Study II

History

Hist 622	Culture and Science in the History of American Medicine
Hist 624	Technology, Environment and Medicine in World History, 1500-1900
Hist 634	Environmental History of North America
Hist 636	Environmental History: Theory of Method

Environmental Management

HRM 601	Organizational Behavior
Mgmt 620	Management of Technology
Mgmt 695	Business Strategy for Environmental Management

Transportation

Tran 602	Geographic Transportation Systems
Tran 608	Behavioral Issues in Transportation
Tran 610	Transportation Economics

Political Science

26:790:504	Comparative Public Policy
26:790:510	Public Policy Analysis
26:790:537	Recent International Relations: Global Governance
26:790:538	Recent International Relations: Global Environmental Issues
26:790:571	American Politics and Public Policy

For students prepared in mathematics and science:

Environmental Science

EM 631	Legal Aspects in Environmental Engineering
EvSc 602	Special Topics in Environmental Science
EvSc 611	Hazardous Waste Management
EvSc 613	Environmental Problem Solving

Environmental Engineering

EnE 560	Chemistry for Environmental Engineers
EnE 660	Introduction to Solid and Hazardous Waste Problems
EnE 661	Microbiology for Environmental Engineers
EnE 662	Site Remediation
EnE 668	Air Pollution Control

Environmental Science

Administered by: Department of Chemical Engineering, Chemistry and Environmental Science

Chairperson: Gordon Lewandowski

Associate Chairperson and Graduate Advisor: Richard Trattner
(973) 596-3595 (Room 385 TIE), e-mail trattner@admin.njit.edu

Sponsored Chair: Kamalesh Sirkar (membrane separations and biotechnology)

Ada C. Fritz Professor of Environmental Engineering and Science: Joseph W. Bozzelli

Environmental Science Division
Distinguished Professors: Bozzelli, Lewandowski, Pfeffer, Sirkar
Professors: Armenante, Baltzis, Kebbekus, Krasnoperov, Magee, Perna, Perlmutter, Schuring, Sofer, Trattner
Associate Professors: Barat, Knox, Mitra
Assistant Professors: Axe, Hahn*
Research Professor: Shaw

Rutgers-Newark Faculty
Professors: Kafkewitz, Weis
Associate Professor: Gates
Assistant Professors: Hammerlynck, Henebry, Hover, Peavy

* Joint appointee with the Federated Biological Sciences Department of NJIT and Rutgers-Newark

Degrees Offered: Master of Science in Environmental Science; Doctor of Philosophy in Environmental Science. Both degrees are offered jointly by NJIT and Rutgers-Newark.

Because the environmental science graduate programs are offered in an interdisciplinary department, there are strong ties to chemistry, chemical engineering, and the program in occupational safety and industrial hygiene. There are additional opportunities for interdisciplinary collaborations with the Department of Civil and Environmental Engineering, the Federated Department of Biological Sciences, and the Rutgers-Newark Department of Geology. The strong research program in the department is supported by major grants from federal and state agencies, and industrial corporations. Environmental science plays a major role in several NJIT research centers, including the Hazardous Substance Management Research Center, the Northeast Hazardous Substance Research Center, the Particle Technology Center, and the Center for Membrane Technologies. These centers involve collaborations with other universities including MIT, Princeton, Rutgers, Stevens, Tufts, and UMDNJ.

■ MASTER OF SCIENCE IN ENVIRONMENTAL SCIENCE

This is an interdisciplinary program intended for individuals with backgrounds in science or engineering who want advanced education in the identification, management, treatment and effects of hazardous and toxic materials in the environment. It may be taken on a part-time or full-time basis.

Admission Requirements

Applicants should have undergraduate degrees in chemistry, biology, chemical engineering, environmental engineering, environmental science, or related fields who have taken a minimum of one year of college chemistry and mathematics through calculus. Students who lack an appropriate background may be considered for admission and required to take a program of courses that is designed in consultation with the graduate advisor. These may include undergraduate courses which are not counted toward degree credit.

A minimum undergraduate GPA of 3.0 on a 4.0 scale, or equivalent, is typically required for admission. Those applying for financial support and those whose last prior degree was from outside the United States must submit GRE scores. International students must achieve a minimum TOEFL score of 550.

Degree Requirements

A minimum of 30 degree credits is required. Candidates must consult with the graduate advisor (not thesis advisor) in designing appropriate programs of study.

Students must attain a minimum GPA of 3.0 in the core courses listed below, and a minimum overall GPA of 3.0.

Seminar — In addition to the minimum 30 degree credits required, all students who receive departmental or research-based awards must enroll each semester in EvSc 600 Environmental Science Seminar.

CORE
15 credits:

EM 631	Legal Aspects in Environmental Engineering
EvSc 610	Environmental Chemical Science
EvSc 612	Environmental Analysis
EvSc 616	Toxicology for Engineers and Scientists
26:120:604	Microbiology: Principles and Applications

THESIS
Required of those receiving departmental or research-based support; others may choose 6 credits of course work instead of thesis.

6 credits: EvSc 701 Master's Thesis

ELECTIVE
Courses are offered at NJIT and Rutgers-Newark and selected with the graduate advisor's (not thesis advisor's) approval.

9 credits if completing a master's thesis; *15 credits* if not completing a master's thesis from:

26:120:551	Biology of Pollution
26:120:536	Multivariate Biostatistics
26:120:616	Topics in Biology
26:460:577	Seminar in Environmental Geology
CE 618	Applied Hydrogeology
ChE 685	Industrial Waste Control I
ChE 686	Industrial Waste Control II
ChE 687	Industrial Gas Cleaning
ChE 740	Biological Treatment of Hazardous Chemical Wastes
Chem 662	Air Pollution Analysis
Chem 664	Advanced Analytical Chemistry
EnE 660	Introduction to Solid Waste Problems
EnE 662	Site Remediation
EnE 664	Physical and Chemical Treatment
EnE 665	Solid Waste Disposal Systems
EnE 668	Air Pollution Control
EnE 671	Environmental Impact Analysis
EPS 613	Environmental Politics and Policy
EPS 614	Environmental Economics
EPS 660	Ethics and Environmental Policy
EvSc 602	Special Topics in Environmental Science I
EvSc 611	Hazardous Waste Management
EvSc 613	Environmental Problem Solving
EvSc 614	Quantitative Environmental Risk Assessment
EvSc 615	Global Environmental Problems
EvSc 700	Master's Project
EvSc 702	Special Topics in Environmental Science II
EvSc 711	Advanced Environmental Analysis
EvSc 725	Independent Study I
EvSc 726	Independent Study II
IE 615	Industrial Hygiene and Occupational Health
ME 660	Noise Control
ME 661	Thermal Pollution of Water and Air
ME 662	Air Pollution Control and Design

■ DOCTOR OF PHILOSOPHY IN ENVIRONMENTAL SCIENCE

This is a research-oriented degree intended for full-time students. Although courses may be taken on a part-time basis, a minimum of one year of full-time residency is typically required for completion of the doctoral dissertation.

Admission and Degree Requirements for Students Entering with a Master's Degree

A master's degree in chemistry, biology, chemical engineering, environmental engineering, environmental science, or related fields is usually required. Highly qualified students with bachelor's degrees in these fields may also be accepted directly into the doctoral program.

A minimum master's GPA of 3.5 on a 4.0 scale, or equivalent, is typically required for admission. GRE scores must be submitted. International students must achieve a minimum TOEFL score of 550.

Specific degree requirements and dissertation topics are approved by the department on an individual basis. Students must attain a minimum overall GPA of 3.0. A minimum of 36 credits of EvSc 790 Doctoral Dissertation, and registration every semester for EvSc 600 Environmental Science Seminar, are required. Should the 36 credits of EvSc 790 be completed before submission of the final dissertation document, students must register for a minimum of 3 credits of EvSc 790 per semester until it has been submitted and accepted. In addition, at least 24 credits of course work beyond the master's degree are required, of which 12 credits must be at the 700-level and chosen in consultation with the graduate advisor. No more than 6 credits may be in Independent Study (EvSc 725 or EvSc 726).

Qualifying Examination — All applicants are expected to pass a qualifying examination that tests general competence in environmental sciences at the master's level. It must be taken within the first year fol-

lowing admission to the program, and passed within two years. A student will be allowed only two attempts to pass the examination.

Formation of Dissertation Committee — Within three months of passing the qualifying examination, doctoral students must form a dissertation committee that meets the approval of the graduate advisor (not the dissertation advisor) in environmental science. As a minimum, the committee must consist of the doctoral student's dissertation advisor, three additional faculty members from the program, and one member from outside the program and the Department of Chemical Engineering, Chemistry and Environmental Science.

Research Proposal — Within six months of forming the dissertation committee, doctoral students must make a formal oral presentation to their dissertation committee and other interested persons on the scope of their proposed research. The committee must formally approve the proposal within a maximum of three additional months. This ensures meeting the requirements that doctoral students must have an approved dissertation committee and an approved dissertation proposal within a year of passing the qualifying examination.

Dissertation Defense — An oral defense of the dissertation is required after submission of the final document to the dissertation committee for approval. Signatures of all members of the dissertation committee must be received for final approval to be granted.

Admission and Degree Requirements for Students Entering with a Bachelor's Degree

Exceptional students with appropriate undergraduate degrees may apply directly for admission to the doctoral program. Applicants are evaluated on a case-by-case basis. A minimum undergraduate GPA of 3.5 on a 4.0 scale, or equivalent, is typically required for admission. GRE scores must be submitted. International students must achieve a minimum TOEFL score of 550.

Students must attain a minimum GPA of 3.0 in the required courses (EvSc 610, EvSc 612, EvSc 616, EM 631, and 26:120:604), and a minimum overall GPA of 3.0.

REQUIRED

51 credits as follows:

26:120:604	Microbiology: Principles and Applications
EM 631	Legal Aspects in Environmental Engineering
EvSc 610	Environmental Chemical Science
EvSc 612	Environmental Analysis
EvSc 616	Toxicology for Engineers and Scientists

In addition, a minimum of 36 credits of EvSc 790 Doctoral Dissertation, and registration every semester for EvSc 600 Environmental Science Seminar, are required. Should the 36 credits of EvSc 790 be completed before submission of the final dissertation document, students must register for a minimum of 3 credits of EvSc 790 per semester until it has been submitted and accepted.

ELECTIVE

27 credits as follows:

12 credits from 700-level courses chosen in consultation with the graduate advisor. No more than 6 credits may be in Independent Study (EvSc 725 or EvSc 726).

15 credits from any 600- or 700-level courses (may be from outside the department)

Qualifying Examination — A qualifying examination must be taken within three semesters of admission to the program, and passed within two years. A student will only be allowed two attempts to pass the examination.

Formation of Dissertation Committee — Within three months of passing the qualifying examination, doctoral students must form a dissertation committee that meets the approval of the graduate advisor (not the dissertation advisor) in environmental science. As a minimum, the committee must consist of the doctoral student's dissertation advisor, three additional faculty members from the program, and one member from outside the program and the Department of Chemical Engineering, Chemistry and Environmental Science.

Research Proposal — Within six months of forming the dissertation committee, doctoral students must make an oral presentation to their dissertation committee and other interested persons on the scope of their proposed research. The committee must formally approve the proposal within a maximum of three additional months. This ensures meeting requirements that doctoral students must have an approved dissertation committee and an approved dissertation proposal within a year of passing the qualifying examination.

Dissertation Defense — An oral defense of the dissertation is required after submission of the final document to the dissertation committee for approval. Signatures of all members of the dissertation committee must be received for final approval to be granted.

If students are unable to complete the requirements for the Ph.D. degree, they may become a candidate for the Master of Science in Environmental Science upon completion of requirements for that degree.

History

Administered by: Federated History Department of Rutgers-Newark and NJIT

Chairpersons: Richard Sher (NJIT), James Goodman (Rutgers-Newark)

Director, Graduate Programs (NJIT): Lisa Herschbach (973) 596-5634 (Room 4032 CAB), e-mail herschbach@admin.njit.edu

Director, Graduate Programs (Rutgers-Newark): Jan E. Lewis (973) 353-5411 (Room 317 Conklin Hall), e-mail janlewis@andromeda.rutgers.edu

NJIT Faculty

Professors: O'Connor, Schweizer, R. Sher
Associate Professor: Benton
Assistant Professors: Herschbach, Summers, Stradling

Rutgers-Newark Faculty

Robert Treat Professor: Kimball
Professors: Basch, Golden, Hosford, Hunczak, Lewis, Lurie, Price, Samatar, Wou
Associate Professors: Goodman, Merker, Russell, Satter, Vermes, Wagenheim
Assistant Professor: Cowans

Degrees Offered: Master of Arts in History, Master of Arts in Teaching (History). Both degrees are offered by NJIT and Rutgers-Newark.

Students interested in history of technology, environment and medicine should contact the graduate coordinator and apply to NJIT; students interested in American history, world history or the master's in teaching for history should contact the graduate programs director and apply to Rutgers-Newark.

The Federated History Department offers the master of arts for generalists and for students interested in preparing for further graduate study in history, and the Master of Arts in Teaching for current and prospective secondary school teachers of history and social studies. The objective of the graduate history program is to furnish a broad yet rigorous course of study in preparation for careers in teaching, business, law, government, administration, and other fields related to history, as well as to enhance the professional experience and increase the opportunities for advancement of students who are already working as professionals in these fields.

Program administration and teaching are shared by faculty from both campuses, and the full resources of both universities are available to all history graduate students and faculty. Resources include access to the Rutgers University library system of more than three million volumes, to the outstanding collection in the history of medicine at UMDNJ, and to excellent history collections in the region. The program emphasizes hands-on learning and archival research in association with local institutions, such as the Thomas Edison National Historic Site in nearby West Orange and the Newark Museum and the New Jersey Historical Society in Newark.

The joint Rutgers-Newark/NJIT graduate history program is the largest and most diverse master's-level history program in New Jersey. Many of the graduate faculty have national or international reputations as scholars, representing a wide variety of time periods and fields of study. The program is particularly noted for its strengths in environ-

mental history and the history of science, technology and medicine; the history of film, broadcasting, and print culture; cultural and intellectual history; diplomatic history; history of women; pre-Civil War and contemporary America; African and African-American history; legal history; and global and comparative history.

■ MASTER OF ARTS IN HISTORY

The M.A. in History furnishes a broad yet rigorous training in history in preparation for a wide variety of careers in education, law, business, medicine, and administration.

Admission Requirements

Applicants must have an undergraduate degree from an accredited institution and favorable letters of recommendation from professors familiar with their work. An undergraduate GPA of at least 3.0 is normally required. Students must provide GRE scores.

Bridge Program — Students who lack appropriate undergraduate preparation for the program are required to make up deficiencies by taking a program of courses designed in consultation with the graduate advisor. Bridge courses are not counted toward degree credit.

Note: Students interested in history of technology, environment and medicine major field should apply to NJIT. Students interested in the American history or world history major field should contact the graduate programs director and apply to Rutgers-Newark.

Degree Requirements

A minimum of 30 credits is required: 18 in a major field and 6 in a minor field chosen in consultation with a faculty advisor. The remaining 6 credits may be completed through additional course work or a thesis. A comprehensive examination is also required. Students must have reading ability in a foreign language.

Seminar — In addition to the minimum 30 degree credits required, all students who receive departmental or research-based awards must enroll every semester in Hist 791 Seminar in History of Technology, Environment and Medicine.

Although faculty from NJIT and Rutgers-Newark teach in all three of the major fields offered, NJIT has primary administrative responsibility for history of technology, environment and medicine. Rutgers-Newark has primary administrative responsibility for the major fields in American history and world history.

History of Technology, Environment and Medicine is unique in its integration of three relatively new and increasingly important historical sub-disciplines. Their rapid growth in recent years reflects greater awareness among professional historians and the general public of the significance of broader issues concerning technology, the environment, and medicine in contemporary life. As these issues loom larger in the consciousness of society, so does the need to learn more about their historical origins, causes, and patterns of development. The department has a distinguished concentration of faculty in these areas, with particular strengths in American environmental history; urban environmental history; the social and cultural history of medicine and technology (including gender issues); military medicine; history of mental health; history of printing and communication; and technology and warfare.

American History Contact the graduate programs director for more information.

World History Contact the graduate programs director for more information.

The following is a sample curriculum for a student completing a major field of study in history of technology, environment and medicine. Those interested in completing a major in world history or American history should contact Rutgers-Newark for information.

MAJOR FIELD

History of Technology, Environment and Medicine
18 credits:

Hist 622	Culture and Science in the History of American Medicine
Hist 628	Gender, Science, and Technology in the Modern World
Hist 632	Technology, Culture and History
Hist 634	Environmental History of North America
Hist 635	History of Technology, Environment and Medicine: Theory and Method
Hist 638	Social History of Communication

MINOR FIELD
6 credits of course work selected in consultation with a faculty advisor

THESIS (optional)
6 credits: Hist 701 Master's Thesis

ELECTIVE
6 credits of course work if not completing a master's thesis; selected in consultation with a faculty advisor

■ MASTER OF ARTS IN TEACHING (History)

The Master of Arts in Teaching is a terminal degree for students who are preparing for, or are already engaged in, careers in secondary school teaching in history and social studies. See the Rutgers Graduate School-Newark catalog for more information.

Industrial Engineering

Administered by: Department of Industrial and Manufacturing Engineering

Chairperson: Athanassios K. Bladikas
Associate Chairperson: George Abdou
Program Director: George Abdou
Professors: Abdel-Malek, Caudill, Chao, Hatch, Ranky, Sebastian, Tricamo, Wolf
Associate Professors: Abdou, Bengu, Bladikas, Das, McDermott
Assistant Professor: Jeng

Graduate Advisor: George Abdou (973) 596-3651 (Room 2508 GITC), e-mail abdou@admin.njit.edu

Degrees Offered: Master of Science in Industrial Engineering; Doctor of Philosophy in Industrial Engineering

The field of industrial engineering brings together the various sciences concerned with technology, the production of goods, performance of services and the way in which people work. Industrial engineers address the efficient utilization of resources to produce quality, as well as cost competitive goods and services in a healthy and efficient work environment. Industrial engineering covers a broad spectrum including production planning and control, manufacturing systems and processes, facilities design, human factors, occupational safety, quality control, systems reliability, and systems analysis and design with a strong emphasis on advanced computing.

■ MASTER OF SCIENCE IN INDUSTRIAL ENGINEERING

A program for individuals who seek professional advancement in the industrial engineering field.

Admission Requirements

Applicants are expected to have an accredited undergraduate degree in industrial engineering or related fields. For further information, see Admissions in this catalog.

Bridge Program — Students who do not have a bachelor of science degree in industrial engineering may be admitted and required to complete the following bridge program. These courses do not count toward degree requirements:

EM 502	Engineering Cost Analysis
EM 602	Management Science
IE 501	Fundamentals of Industrial Engineering

Degree Requirements

A minimum of 30 credits beyond a baccalaureate degree is required. A master's thesis or independent research is optional. Students select an area of specialization and individually design their programs in consultation with the graduate advisor. Faculty advisor approval must be obtained by students before they are permitted to register for IE 701 Master's Thesis.

Seminar — In addition to the minimum 30 degree credits required, all students who receive departmental or research-based awards must enroll each semester in IE 791 Graduate Seminar.

CORE

12 credits:

IE 604	Advanced Engineering Statistics
IE 618	Engineering Cost and Production Economics
IE 621	Systems Analysis and Simulation
IE 650	Advanced Topics in Operations Research

THESIS OR INDEPENDENT RESEARCH (optional)

The following optional courses are appropriate for all areas of specialization:

6 credits: IE 701 Master's Thesis *or*
3 credits: IE 725 Independent Research

AREAS OF SPECIALIZATION

The range of possible specializations is broad. Students should consult the graduate advisor in designing specializations and related degree requirements. The following is a list of possible specializations and suggested electives.

Courses are selected from an area of specialization with the approval of the graduate advisor as follows: 12 credits if completing a master's thesis, 15 credits if completing independent research, or 18 credits if not completing either a master's thesis or independent research.

Quality and Reliability Engineering

EM 635	Management of Engineering Research and Development
EM 640	Distribution Logistics
IE 605	Engineering Reliability
IE 606	Maintainability Engineering
IE 608	Product Liability Control
IE 672	Industrial Quality Control
IE 674	Quality Maintenance and Support Systems
MnE 655	Concurrent Engineering

Cost Engineering

EM 636	Project Management
EM 691	Cost Estimating for Capital Projects
EM 693	Managerial Economics
EM 771	Operations Cost and Management Control
IE 605	Engineering Reliability
IE 606	Maintainability Engineering
IE 618	Engineering Cost and Production Economics
IE 641	Operations Analysis
IE 651	Industrial Simulation
IE 653	Facility Maintenance
IE 672	Industrial Quality Control

Operations Research and Decision Sciences

EM 714	Multicriteria Decision Making
IE 605	Engineering Reliability
IE 623	Linear Programming
IE 624	Heuristic Methods
IE 651	Industrial Simulation
IE 652	Facilities Location and Plant Layout
IE 672	Industrial Quality Control
IE 704	Sequencing and Scheduling
IE 705	Mathematical Programming in Management Science
IE 706	A Queuing Approach to Performance Evaluation

Human Factors/Ergonomics

IE 605	Engineering Reliability
IE 614	Safety Engineering Methods
IE 615	Industrial Hygiene and Occupational Health
IE 665	Applied Industrial Ergonomics
IE 670	Industrial Work Physiology
IE 672	Industrial Quality Control
IE 675	Safety in Facility and Product Design
IE 760	Quantitative Methods in Human Factors Engineering
ME 660	Noise Control
ME 670	Introduction to Biomechanical Engineering
ME 671	Biomechanics of Human Structure and Motion
MnE 601	Manufacturing Systems
MnE 612	Robotic Manufacturing Systems

Production and Manufacturing Systems

CIS 610	Data Structures and Algorithms
CIS 651	Data Communications
EM 655	Management Aspects of Information Systems
IE 618	Engineering Cost and Production Economics
IE 654	Design for Manufacturability
IE 655	Concurrent Engineering
ME 635	Computer-Aided Design
MnE 601	Manufacturing Systems
MnE 602	Flexible and Computer Integrated Manufacturing
MnE 603	Management of Manufacturing Systems
MnE 612	Robotic Manufacturing Systems

Service Systems

CIS 632	Advanced Data Base System Design
EM 636	Project Management
HRM 606	Human Resource Management
IE 622	Simulation and Risk Analysis in Operations Management
IE 624	Heuristic Methods
IE 641	Operations Analysis
IE 651	Industrial Simulation
IE 652	Facilities Location and Plant Layout
IE 673	Total Quality Management
IE 674	Quality Maintenance and Support Systems
MIS 545	Management Information Systems

Systems Analysis

CIS 505	Programming, Data Structures, and Algorithms
CIS 631	Data Management System Design
CIS 673	Software Design and Production Methodology
CIS 676	Requirements Engineering
EM 636	Project Management
EM 691	Cost Estimating for Capital Projects
IE 622	Simulation and Risk Analysis in Operations Management
IE 624	Heuristic Methods
IE 651	Industrial Simulation
IE 673	Total Quality Management
MnE 655	Concurrent Engineering

■ DOCTOR OF PHILOSOPHY IN INDUSTRIAL ENGINEERING

The objectives of the Ph.D. in Industrial Engineering program are to provide the knowledge and develop the skills that students need to become leaders of research in academia, industry and government.

This program is intended for highly qualified students who wish to pursue advanced research in industrial engineering and related areas. The program emphasizes two areas: manufacturing systems and assurance sciences, and human factors and occupational safety.

Admission Requirements

Applicants should have a master's degree in industrial engineering or a related field. In certain circumstances, a qualified student with a bachelor's degree in industrial engineering or related field may be admitted into the program.

Degree Requirements

For students entering with an appropriate master's degree, a minimum of 60 degree credits is required as follows: 36 credits of dissertation and 24 credits of course work beyond the master's degree in an area of specialization, 12 credits of which must be at the 700 level and none at the 500 level. Of the 24 credits of course work, 12 credits are core courses and the other 12 credits are technical electives.

Registration for IE 791 Graduate Seminar is required each semester for all students.

If the 36 credits of dissertation are completed before the dissertation is finished, students must register each semester for at least 3 credits of dissertation until the dissertation is accepted.

For students entering with bachelor's degrees, a minimum of 42 credits of course work and at least 36 credits of dissertation research is required.

Specific degree requirements and dissertation topics are approved by the department on an individual basis. Before being permitted to register for dissertation, students must complete course requirements, pass qualifying examinations, both written and oral, and demonstrate that there are facilities and a faculty member available to supervise the research.

Qualifying Examinations — All doctoral students are expected to pass both a written and oral qualifying examination. Passing the written qualifying examination is a prerequisite for the oral examination. Students are urged to take these examinations as soon as possible after being admitted into the program.

Students must take a two-part written examination within the first year following admission to the program, and pass within two years. The examination is offered every October. A student will be allowed only two attempts to pass the examination. Both parts must be taken at the same time. It consists of two sections:

Section I General competence in mathematics including calculus, probability and statistics, differential equations, and linear algebra.

Section II Proficiency in fundamentals of industrial engineering including: operations research (deterministic and probabilistic), quality control, reliability, engineering economy, production planning and control, and human factors.

The oral examination should be taken and passed in the semester after the written examination is passed. The dissertation committee assigns a topic for the oral examination from the student's area of specialization. The examination is offered by the dissertation committee. Thorough study and understanding of theoretical, technical and practical aspects of the assigned topic should be demonstrated in the oral examination.

Formation of a Dissertation Committee — With the approval of the graduate advisor, within two months after passing the written examination, students must form a dissertation committee. The committee should consist of at least four faculty members from the department including the student's advisor. In addition, one member of the committee must be chosen from outside the department.

Dissertation Proposal — Within three months of passing the oral examination, students must submit, for the approval of their dissertation committee, both in writing and orally, a doctoral proposal on the scope of their proposed research.

The dissertation must represent original research leading to meaningful advances in the industrial engineering profession. The work must be worthy of publication in refereed journals on industrial engineering or related fields. Doctoral students must complete the dissertation in the five years subsequent to passing their written and oral qualifying examinations.

Dissertation Defense — Each doctoral student must submit to their committee a written dissertation for their approval. After the dissertation committee approves the document, the student must successfully defend the dissertation in front of the committee and other interested faculty and students.

AREAS OF SPECIALIZATION

Manufacturing Systems and Assurance Sciences

CORE

12 credits:

IE 704	Sequencing and Scheduling
IE 705	Mathematical Programming in Management Science
IE 706	A Queuing Approach to Performance Analysis
MnE 654	Design for Manufacturability

ELECTIVE

12 credits, 3 credits of which must be at the 700 level and none at the 500 level:

Courses selected from IE, ME, MnE, CIS, and Math.

Human Factors and Occupational Safety

CORE

12 credits:

IE 604	Advanced Engineering Statistics
IE 760	Quantitative Methods in Human Factors Engineering
IE 761	Advanced Studies in Human Factors
IE 762	Psychophysical Methods for Human Factors

ELECTIVE

12 credits, 3 credits of which must be at the 700 level and none at the 500 level:

Courses selected from IE, ME, MnE, CIS, and Math.

Infrastructure Planning

Administered by: School of Architecture

Program Director and Graduate Advisor: Antonio de Souza Santos (973) 596-3078 (Room 349 WES), e-mail: mip@admin.njit.edu

Associate Program Director: Darius Sollohub
Graduate Program and Admissions Coordinator: Fred Little
Distinguished Professor: Mostoller
Professors: Celik, Dresnack, Ehrenkrantz, Elliot, Franck, Gauchat, Goldman, Hawk, Papademetriou, Santos
Associate Professors: Greenfeld, Schuman
Assistant Professors: Anyanwu, Mouskos

Degree Offered: Master in Infrastructure Planning

Through interdisciplinary teaching, research and practice made possible by NJIT's resources in architecture, civil and environmental engineering, transportation, management, and environmental policy studies, the program addresses the global need to train planning and design professionals capable of acting across the spectrum of disciplines involved in infrastructure development.

Infrastructure is defined as the whole built fabric of public spaces, institutions, facilities and services that shapes and sustains daily life. Collaboration between the disciplines concerned with different infrastructure components is necessary to develop holistic strategies for building more livable and efficient urban environments. The goal of the M.I.P. program is to gain a coherent understanding of the interrelationships between those components and to develop the potential of integrally planned and designed infrastructure systems to deal more effectively with the critical problems confronting our cities.

Using a variety of project settings, the program focuses on the natural environment and on public space, roads, transportation, services and utilities as interacting physical and spatial systems, as well as on parks, schools, housing and civic institutions. The purpose is to develop operational strategies that integrate the broadest possible range of planning and design policies, methods and actions for improving human settlements; and to resolve in environmental terms the larger social and political issues that affect the quality of life in our communities.

Capitalizing on NJIT's multidisciplinary resources and location at the center of the nation's greatest regional concentration of urban infrastructure, the M.I.P. program incorporates applied research and realistic problem solving in its curriculum and also offers internships and research assistantships. M.I.P. faculty, drawn from the university's four academic divisions, is supplemented by eminent infrastructure planning practitioners. Collaborative relationships have been established with complementary academic programs at Rutgers University and with regional, national and international institutions concerned with infrastructure. At NJIT, a number of notable research facilities are engaged in specialized work related to infrastructure planning and design.

■ MASTER IN INFRASTRUCTURE PLANNING

A unique interdisciplinary program in infrastructure planning and design directed at students with previous degrees in architecture, landscape architecture, urban planning or civil engineering.

Dual Degree Programs — Dual M.Arch./M.I.P. or M.S. in Civil Engineering/ M.I.P. degree options that reduce the number of credits required to obtain the two degrees separately are available to students with superior academic records who hold bachelor's degrees in architecture or engineering from NJIT or equivalent degrees from other universities; or who are prospective graduates of the professional M.Arch. program at NJIT. See "Architecture" for the M.Arch./M.I.P dual degree program description. See the graduate advisor for the M.S. in Civil Engineering/ M.I.P. dual degree program description.

Admission Requirements

Applicants must have a bachelor's or a master's degree in architecture, landscape architecture, urban planning, or engineering. A GPA of at least 3.0 is expected and evidence of potential for graduate study is to be demonstrated by a portfolio, letters of recommendation, GRE scores, and TOEFL scores in the case of international students.

Bridge Course — Students not sufficiently experienced in design will be required to take an intensive bridge course in design prior to entering the program. This course does not count toward degree credit.

Degree Requirements

Students must complete 36 course credits through full- or part-time study. Up to 6 credits toward the degree may be waived based on previous academic study. Additional elective courses may be taken in disciplines related to infrastructure planning, but do not count toward degree credit.

REQUIRED

The following courses are required, subject to those waived in individual cases; however, no waivers will be given for studio courses. A typical full-time study plan over two semesters is shown below; degree credits are in parentheses.

Semester 1

MIP 601	Interdisciplinary Infrastructure Studio I (6)
MIP 612	Introduction to Environmental Policy Studies (3)
MIP 615	Introduction to Transportation Studies (3)
MIP 631	History and Theory of Infrastructure (3)
MIP 675	Elements of Infrastructure Planning (3)

Semester 2

MIP 602	Interdisciplinary Infrastructure Studio II (6)
MIP 618	Public and Private Financing of Urban Areas (3)
MIP 652	Geographic Information Systems (3)
MIP 655	Land Use Planning (3)
MIP 673	Infrastructure Planning in Practice (3) *or*
MIP 674	Infrastructure and Architecture (3)

Interdisciplinary Studies

Administered by: Department of Humanities and Social Sciences

Program Director: Robert Friedman
Faculty: from NJIT's graduate degree-offering colleges, as appropriate

Graduate Advisors: faculty from NJIT's graduate degree-offering colleges, as appropriate

Degree Offered: Master of Science in Interdisciplinary Studies

This program is designed for students seeking graduate work at NJIT that involves one or more departments and/or colleges and those seeking proficiency in a subject not specified by an existing degree program. Emphasis is placed upon the relationship between a technological field and the social sciences. Examples include environmental law or journalism, urban land use policy, economic forecasting, and sports management. Students can take courses at Rutgers-Newark in related areas.

■ MASTER OF SCIENCE IN INTERDISCIPLINARY STUDIES

This program is designed for professionals whose careers require proficiency across several technical and non-technical disciplines. It also provides opportunities for graduate students with non-traditional preparation.

Admission Requirements

Applicants must have an undergraduate degree from an accredited institution with preparation in a technological or social science field. Applicants are expected to have an undergraduate GPA of at least 3.0. GRE scores are required.

Bridge Program — Students who lack appropriate undergraduate preparation for interdisciplinary studies are required to make up deficiencies by taking a course or program of courses designed in consultation with the graduate advisor. Bridge courses are not counted toward degree credit.

Degree Requirements

A minimum of 30 degree credits is required, including 9 credits in a core, 15 elective credits in an area of specialization, and 6 credits of thesis, project, or directed field work or internship. A series of core courses, designed for each student depending upon their concentration, introduces essential methodologies, disciplines and fields. Programs will be designed individually in consultation with the program director and graduate advisors.

Seminar — In addition to the minimum 30 degree credits required, all students who received departmental or research-based awards must enroll each semester in an appropriate seminar that will be determined in consultation with the graduate advisor.

AREAS OF SPECIALIZATION

The three sample programs described below are not formalized curricula, but represent how a graduate student and faculty advisor in interdisciplinary studies might develop a series of courses.

Environmental Law

CORE

9 credits:

EM 631	Legal Aspects in Environmental Engineering
EPS 612	Introduction to Environmental Policy Studies
Mgmt 695	Business Strategy for Environmental Management

DIRECTED FIELDWORK (required)
6 credits:
Internship in a law firm, government agency, or industrial operation

ELECTIVE

15 credits:

EPS 614	Environmental Economics
EPS 660	Ethics and Environmental Policy
EvSc 613	Environmental Problem Solving
26:790:510	Public Policy Analysis
26:790:571	American Politics and Public Policy

Economic Forecasting

CORE

9 credits:

EnE 671	Environmental Impact Analysis
EPS 601	Research Methods
EPS 606	Technology Forecasting and Management Planning

THESIS, PROJECT OR INTERNSHIP (required)
6 credits:
Selected in consultation with a graduate advisor

ELECTIVE

15 credits:

Arch 650	Economy of Building
EM 660	Financing an Industrial Enterprise
EM 691	Cost Estimating for Capital Projects
EPS 614	Environmental Economics
Fin 618	Public and Private Financing of Urban Areas

Sports Management

CORE

9 credits:

BINF 5005	Health Care Information Systems
Fin 624	Financial Management
HRM 601	Organizational Behavior

DIRECTED FIELDWORK (required)
6 credits
Selected in consultation with a graduate advisor

ELECTIVE

15 credits:

BINF 612/BINF 5125	Clinical Problem Solving and Decision Making
Eng 642	Professional Writing
HRM 606	Human Resource Management
IE 615	Industrial Hygiene and Occupational Health
IE 670	Industrial Work Physiology

Management

Administered by: School of Management

Dean: Alok Chakrabarti
Associate Dean: Barbara Tedesco
Assistant Dean for Graduate Programs: Malcolm L. Worrell
Sponsored Chair: Alok Chakrabarti (management of technology)
Director, Executive Program: Paul J. Dine (973) 596-6378 (Room 3008 CAB), e-mail dine@admin.njit.edu
Distinguished Professors: Chakrabarti, Kirchhoff, Turoff†
Professors: Hasan, Hawk‡ , Lawrence, Rotter, Schachter
Associate Professors: Bonitsis, Cordero, Fjermestad, Havlena, Somers, Spasovic, Sylla, Wen

Assistant Professors: Anandarajan, Anyanwu, Heller, Kleinman, Mathis
Visiting Professors: Haley, Sau
Special Lecturers: Dine, Neuman, Rauth, Roy, Walsh
Professional/Instructional Staff: Wachspress, Worrell

Graduate Advisor: Malcolm Worrell (973) 596-3262 (Room 3011 CAB), e-mail worrell@admin.njit.edu

† Joint appointee with the Department of Computer and Information Science
‡ Joint appointee with the School of Architecture

Degree Offered: Master of Science in Management; Master of Business Administration in Management of Technology

MASTER OF SCIENCE IN MANAGEMENT

A specialized degree program for individuals who desire a career in managing an industrial or technology-based organization. This is a focused degree and students are required to concentrate in a specific area of management. In addition to the traditional degree, there are two variations.

Executive Program — An intensive, accelerated course of study for carefully selected candidates. Course work is completed on alternate weekends for approximately 14 months. Students in this program will focus on global competitiveness, use of technology, management of information, total quality, environmental and ethical issues in business.

Bachelor of Architecture (B.Arch.) and M.S. in Management Dual Degree Program — This program permits students to obtain a Bachelor of Architecture with a Master of Science in Management. There is no reduction in the degree requirements for the professional degree in architecture. This dual degree program permits students to obtain the M.S. in Management in substantially less time; in some cases, in only one more semester of full-time study. This dual degree program is described under the "Architecture" academic major in the undergraduate catalog.

Master of Architecture (M.Arch.) and M.S. in Management Dual Degree Program — This program permits students to obtain a Master of Architecture with a Master of Science in Management. There is no reduction in the degree requirements for the Master of Architecture program. This dual degree program permits students to obtain the M.S. in Management in substantially less time; in some cases, in only one more semester of full-time study. This dual degree program is described in the "Architecture" degree program description in this catalog.

Admission Requirements

Applicants must have a bachelor's degree from an accredited institution with some undergraduate background in economics, finance, probability and statistics, and management information systems.

Bridge Program — Students are expected to have knowledge of the primary management disciplines: managerial economics, finance, management information systems, and marketing. Students who have made a satisfactory grade in undergraduate courses in these areas are not required to take them again. Students who are deficient in these areas are required to take the following courses unless they receive approval for a waiver from the assistant dean for graduate studies. Unless they are stated as a requirement in a specific program, such as Fin 516 in the dual degree program with architecture, these courses will not count toward degree requirements.

Econ 565	Managerial Economics
Fin 516	Principles of Financial Management
MIS 545	Management Information Systems
Mrkt 530	Principles of Marketing

Off-Campus Programs — At extension sites, NJIT offers many courses required to fulfill degree requirements. NJIT faculty teach all courses. For locations, see "Extension Programs" in this catalog. The university's distance learning arm, ACCESS/NJIT, offers a part of the bridge program described above to qualified students who have access to the Internet and a VCR. In addition, 12-credit graduate certificates in Health Care Information Systems or in Managing Human Resources are available as a step toward this degree. See "Graduate Certificates" in this catalog. For further information about extension programs and graduate certificates call the associate vice president of continuing and distance education, Division of Continuing Professional Education, 1 (800) 624-9850 or (973) 596-3060; e-mail cpe@njit.edu

Degree Requirements

A minimum of 36 credits is required for all areas of specialization: 18 in core courses and 18 in an area of specialization, of which 6 to 9 are in required courses and 9 to 12 are in elective courses.

At the discretion of the graduate advisor and with the approval of the assistant dean for graduate studies students may take appropriate courses at Rutgers-Newark or UMDNJ within the limits of the NJIT transfer policy.

Students must exercise one of two options in completing the degree program:

Option I — 30 credits of course work, plus 6 credits of thesis. This option is not available for the management accounting and auditing areas of specialization.

Option II — 36 credits of course work.

Seminar — In addition to the minimum degree credits required, all students who receive school or research-based support must enroll each semester in Mgmt 791 Graduate Seminar.

CORE

For all specializations
18 credits:

Fin 600	Financial and Economic Environment
HRM 601	Organizational Behavior
MIS 620	Computing Concepts for Managers
Mgmt 630	Decision Analysis
Mgmt 692	Business Strategy
Mrkt 620	Competing in Global Markets

AREAS OF SPECIALIZATION

Financial Management

CORE
18 credits: As described

REQUIRED
6 credits:

Fin 624	Financial Management
Fin 626	Financial and Investment Institutions

ELECTIVE
6 credits if exercising Option I; 9 credits if exercising Option II, from:

Acct 615	Concepts of Strategic Cost Analysis
Acct 690	Seminar in Taxation
Fin 618	Public and Private Financing of Urban Areas
Fin 627	International Finance
Fin 630	Applied Business Econometrics
Fin 631	Working Capital Management and Credit Analysis
Fin 632	Financial Valuation of Technology-Based Companies
Fin 634	Mergers, Acquisitions, and Restructuring
Fin 660	Financial Planning and Decision Making
Fin 700	Seminar in Theory and Research in Financial Management
MIS 654	Design of Accounting Information Systems

3 credits selected in consultation with assistant dean graduate programs (not available with Option I)

THESIS
Required if exercising Option I; elective for all others
6 credits: Fin 701 Thesis in Financial Management

Human Resource Management

CORE
18 credits: As described

REQUIRED
6 credits:

HRM 606	Human Resource Management
HRM 607	Personnel and Evaluation Research

ELECTIVE
6 credits if exercising Option I; 9 credits if exercising Option II, from:

HRM 608	Behavioral Issues in Transportation Studies
HRM 609	Employee Development and Training
HRM 616	Job Analysis and Design
HRM 630	Managing Technological and Organizational Change
HRM 640	Seminar on Cultures in Organizations
HRM 650	Human Resource Information Systems
HRM 655	Theory and Research in Organizational Behavior
HRM 660	Human Resource Management Issues in Technology-Based Organizations
HRM 662	Organizational Diagnosis and Development

HRM 685 Cross Cultural Management Studies
HRM 693 Employment Relationships and the Law
3 credits selected in consultation with assistant dean for graduate programs (not available with Option I)

THESIS
Required if exercising Option I; elective for all others.
6 credits: HRM 701 Thesis in Human Resources Management

Management Information Systems

CORE
18 credits: As described

REQUIRED
6 credits:
MIS 645 Operations, Management, Planning and Control
MIS 648 Decision Support Systems

ELECTIVE
6 credits if exercising Option I; 9 credits if exercising Option II, from:
CIS 631 Data Management System Design
CIS 635 Computer Programming Languages
CIS 661 System Simulation
CIS 671 Knowledge-Based Systems
CIS 675 Information Systems Evaluation
CIS 679 Management of Computer and Information Systems
EM 636 Project Management
HRM 650 Human Resource Information Systems
MIS 620 Computing Concepts for Managers
MIS 635 Management of Telecommunications
MIS 654 Design of Accounting Information Systems
MIS 655 Informational Systems Audit, Control and Security
MIS 680 PC Tools for Managers
MIS 690 Executive Information Systems
3 credits selected in consultation with assistant dean for graduate programs (not available with Option I)

THESIS
Required if exercising Option I; elective for all others
6 credits: MIS 701 Thesis in Information Systems Management

International Business

CORE
18 credits: As described

REQUIRED
6 credits:
Mgmt 655 Global Competiveness
Mgmt 670 International Business

ELECTIVE
6 credits if exercising Option I; 9 credits if exercising Option II, from:
Fin 627 International Finance
HRM 685 Cross Cultural Management Studies
Mgmt 657 Import/Export Processes
Mgmt 660 Global Communications
Mgmt 665 International Product Development
Mgmt 675 Legal Environment of International Business
Mrkt 642 International Marketing Management
3 credits selected in consultation with assistant dean for graduate programs (not available with Option I)

THESIS
Required if exercising Option I; elective for all others
6 credits: Mgmt 701 Thesis in Management

Marketing Management

CORE
18 credits: As described

REQUIRED
6 credits:
Mrkt 630 Models of Consumer Behavior
Mrkt 631 Market Planning and Analysis

ELECTIVE
6 credits if exercising Option I; 9 credits if exercising Option II, from:
EM 714 Multicriteria Decision Making
Mgmt 710 Business Forecasting Methods
Mgmt 731 Advanced Market Planning and Analysis
Mrkt 632 Marketing Strategy for Technology-Based Organizations
Mrkt 636 Design and Development of High-Technology Products
Mrkt 637 Marketing Communications and Promotions
Mrkt 638 Sales Management for Technical Professionals
Mrkt 640 Industrial Marketing Management
Mrkt 642 International Marketing Management
Mrkt 753 Marketing Science
3 credits selected in consultation with assistant dean for graduate programs (not available with Option I)

THESIS
Required if exercising Option I; elective for all others
6 credits: Mrkt 701 Thesis in Marketing Management

Management Accounting and Auditing

CORE
18 credits: As described

REQUIRED
9 credits:
Acct 615 Concepts of Strategic Cost Analysis
MIS 654 Design of Accounting Information Systems
MIS 655 Information Systems Audit, Control and Security

ELECTIVE
9 credits from:
Acct 610 Concepts of Internal Auditing Concepts and Procedures
Acct 630 Concepts and Applications of Control
Acct 650 Operational Auditing
Acct 670 Seminar in Accounting Theory
Acct 680 Seminar in Auditing
Acct 690 Seminar in Taxation
Fin 634 Mergers, Acquisitions, and Restructuring
MIS 620 Computing Concepts for Managers

THESIS
Not offered in this area of specialization

MASTER OF BUSINESS ADMINISTRATION IN MANAGEMENT OF TECHNOLOGY

The M.B.A. in Management of Technology serves the needs of students who need a more generalized advanced degree to progress into management positions in technology-based firms. This program takes advantage of NJIT's considerable strength in the technology area. This degree presents a broader, more generalized base for students than the M.S. in Management with its intensive focus in a given area.

Admission Requirements
Applicants should have a bachelor's degree with a GPA of at least 3. 0 on a 4.0 scale from a recognized/accredited institution and with some background in economics, finance, probability and statistics, and information systems. Students are expected to have a GMAT score of 550 or higher. In addition to meeting the university requirements for course credit transfer, students must have the approval of the assistant dean for graduate programs with the concurrence of the registrar and the dean of graduate studies. A course used to obtain a degree at the other academic institution cannot be transferred. For the M.B.A., only those courses taken at an AACSB accredited institution are acceptable for transfer.

Bridge Program — Students are expected to have knowledge of the primary management disciplines: managerial economics, finance, management information systems, and marketing. Students who have made a satisfactory grade in undergraduate courses in these areas are not required to take them again. Students who are deficient in these areas are required to take the following courses unless they receive approval for a waiver from the assistant dean for graduate studies. Unless they are stated as a requirement in a specific program, such as Fin 516 in the dual degree program with architecture, these courses will not count toward degree requirements. This bridge program is identical to that used for the M.S. in Management:
Econ 565 Managerial Economics
Fin 516 Principles of Financial Management
MIS 545 Management Information Systems
Mrkt 530 Principles of Marketing

Degree Requirements

A minimum of 48 credits is required for all areas of specialization: 39 credits in core courses and 9 credits in elective courses. At the discretion of the graduate advisor and with the approval of the assistant dean for graduate programs, students may take appropriate courses at Rutgers-Newark or UMDNJ.

Seminar — In addition to the minimum degree credits required, all students who receive school or research-based support must enroll each semester in Mgmt 791 Graduate Seminar.

CORE
For all areas of specialization

Technology Module
21 credits:

Mgmt 620	Management of Technology
Mgmt 625	Distribution Logistics
Mgmt 630	Decision Analysis
Mgmt 635	Management Research Methods
Mgmt 685	Operations Research and Decision Making
MIS 620	Computing Concepts for Managers
MIS 645	Operations Management, Planning and Control
Tran 640	Distribution Logistics

Essential Business Processes
18 credits:

Acct 615	Concepts of Strategic Cost Analysis
Fin 600	Financial and Economic Environment
Fin 624	Financial Management
HRM 601	Organizational Behavior
Mgmt 692	Business Strategy
Mrkt 620	Competing in Global Markets

AREAS OF SPECIALIZATION

Management Information Systems

CORE
39 credits: as described

ELECTIVE
9 credits from:

CIS 671	Knowledge-Based Systems
CIS 675	Information System Evaluation
CIS 679	Management of Computer and Information Systems
MIS 625	Internet for Managers
MIS 635	Management of Telecommunications
MIS 648	Decision Support Systems
MIS 690	Executive Information Systems

Transportation/Logistics

CORE
39 credits: as described

ELECTIVE
9 credits from:

Mgmt 710	Business Forecasting Methods
Mrkt 632	Marketing Strategy for Technology-Based Organizations
Tran 603	Introduction to Urban Transportation Planning
Tran 740	Management of Transportation Carriers
Tran 765	Multi-modal Freight Transportation System Analysis

Manufacturing

CORE
39 credits: as described

ELECTIVE
9 credits from:

IE 674	Quality Maintenance and Support Systems
MnE 601	Manufacturing Systems
MnE 602	Flexible and Computer Integrated Manufacturing
MnE 603	Management of Manufacturing Systems

* pending

COLLABORATIVE PH.D. IN MANAGEMENT PROGRAM

The School of Management participates with Rutgers-Newark in a Ph.D. in Management program. The degree is offered by Rutgers-Newark. NJIT's School of Management faculty teach courses, participate in the development of curriculum, advise dissertations, and serve on planning committees.

The Ph.D. in Management program offers specializations in these areas:
Accounting
Accounting Information Systems
Computer Information Systems
Finance
Information Technology
Management Science
Marketing
Organization Management
Individualized areas of specialization are also possible.

For further information about the Ph.D. in Management program contact: Ph.D. in Management Program, 200F Ackerson Hall, 180 University Avenue, Newark, N.J. 07102. Phone (973) 353-5371; fax (973) 353-5691.

For further information about the computer information systems specialization, contact Murray Turoff, computer information systems specialization program coordinator and advisor, turoff@vc.njit.edu or (973) 596-3366. Also see Doctor of Philosophy in Management under "Computer Science" in this catalog.

Manufacturing Systems Engineering

Administered by: Department of Industrial and Manufacturing Engineering

Chairperson: Athanassios K. Bladikas
Associate Chairperson: George Abdou
Program Director: George Abdou
Professors: Abdel-Malek, Caudill, Chao, Hatch, Ranky, Sebastian, Tricamo, Wolf
Associate Professors: Abdou, Bengu, Bladikas, Das, McDermott
Assistant Professor: Jeng

Graduate Advisor: George Abdou (973) 596-3651 (Room 2508 GITC), e-mail abdou@admin.njit.edu

Degree Offered: Master of Science in Manufacturing Systems Engineering

The manufacturing engineering discipline addresses problems and methods of manufacturing systems integration. The M.S. in Manufacturing Systems Engineering program emphasizes the interrelationships between manufacturing equipment, processes and controls, and their integration into production factories.

The curriculum is computer and multimedia intensive and includes the use and understanding of new technologies such as robotics, programmable logic controllers, microprocessors and computer-integrated manufacturing and their application in automated production, assembly, automated inspection, and automated packaging. Focus is on computer-aided design and computer-aided manufacturing. Automation laboratories are used that contain many state-of-the-art devices including several industrial robots, CNC millers, CNC lathes, computer vision systems, and a fully automated flexible manufacturing system.

MASTER OF SCIENCE IN MANUFACTURING SYSTEMS ENGINEERING

This is an interdisciplinary program of advanced study for individuals with backgrounds in engineering, focusing on efficient production in technology-intensive manufacturing industries.

Admission Requirements

Applicants should be graduates of an accredited undergraduate engineering program. Students with degrees in science may also be considered.

Bridge Program — Students who lack appropriate undergraduate preparation for the program are required to make up deficiencies by taking a program of courses that are designed in consultation with graduate advisors. These courses are taken in addition to the degree requirements and may include undergraduate courses.

Degree Requirements

A minimum of 30 credits is required: 12 credits of core courses and 18 in an area of specialization. A master's project or thesis is optional. Students select an area of specialization in consultation with the graduate advisor and must take a set of core, required and elective courses.

Seminar — All students who receive departmental or research-based awards must register each semester for MnE 791 Manufacturing Engineer Seminar.

CORE
12 credits:

MnE 601	Manufacturing Systems
MnE 602	Flexible and Computer Integrated Manufacturing
MnE 603	Management of Manufacturing Systems
MnE 654	Design for Manufacturability

PROJECT, THESIS, INDEPENDENT STUDY (optional)
The following optional courses are appropriate for all areas of specialization:
3 credits: MnE 700 Master's Project
6 credits: MnE 701 Master's Thesis
3 credits: MnE 725 Independent Study in Manufacturing

AREAS OF SPECIALIZATION
The range of possible specializations is broad. Students should consult the program director in designing specializations and related degree requirements. Some examples follow.

Design for Manufacturability
18 credits from:

CE 736	Finite Element Methods in Structural and Continuum Mechanics
IE 675	Safety in Facility and Product Design
ME 620	Stress Methods in Mechanical Design
ME 621	Energy Methods in Mechanical Design
ME 622	Finite Element Methods in Mechanical Engineering
ME 635	Computer-Aided Design
ME 636	Mechanism Design: Analysis and Synthesis
MnE 655	Concurrent Engineering

System Automation
18 credits:

CIS 651	Data Communications
CIS 652	Computer Networks — Architecture, Protocols and Standards
ECE 686	Instrumentation Systems and Microprocessors
ME 638	Computer-Aided Machining
ME 735	Advanced Topics in Robotics
MnE 612	Robotic Manufacturing System

Computer Control of Manufacturing Systems
18 credits from:

ECE 601	Linear Systems
ECE 660	Control Systems I
ECE 664	Discrete-Time Control Systems
ECE 666	Control Systems II
IE 624	Heuristics Methods
ME 655	Introduction to Modern Control Methods
ME 755	Adaptive Control Systems

Manufacturing Systems Analysis and Design
18 credits from:

CIS 631	Data Management System Design
CIS 651	Data Communications
ECE 683	Computer Network Design and Analysis
IE 616	Planning and Control of Products and Processes
IE 621	Systems Analysis and Simulation
IE 622	Simulation and Risk Analysis in Operations Management
IE 651	Industrial Simulation
IE 652	Facilities Location and Plant Layout
MnE 655	Concurrent Engineering

Management of Manufacturing Systems
18 credits from:

EM 602	Management Sciences
EM 635	Management of Engineering Research and Development
EM 636	Project Management
EM 640	Distribution Logistics
EM 653	Facility Maintenance
EM 660	Financing an Industrial Enterprise
EM 691	Cost Estimating of Capital Projects
EM 771	Operations Cost and Management Control
IE 618	Engineering Cost and Production Economics
IE 673	Total Quality Management
IE 674	Quality Maintenance and Support Systems

Materials Science and Engineering

Administered by: Committee for the Interdisciplinary Program in Materials Science and Engineering

Acting Program Director and Graduate Advisor: Ken K. Chin (973) 596-3297 (Room 466 TIE), e-mail chin@admin.njit.edu

Degrees Offered: Master of Science in Materials Science and Engineering; Doctor of Philosophy in Materials Science and Engineering

The interdisciplinary M.S. and Ph.D. in Materials Science and Engineering programs focus on the properties and applications of modern engineering materials, bridge academic research and industrial development, and serve New Jersey's technology-intensive economy. Three areas of specialization are emphasized: electronic and photonic materials, polymer and biomaterials, and composite and structural materials.

MASTER OF SCIENCE IN MATERIALS SCIENCE AND ENGINEERING

This degree program is intended for individuals with a strong background in science and/or engineering.

Admission Requirements

Applicants are expected to have an undergraduate degree from an accredited institution. A minimum undergraduate GPA of 3.0 on a 4.0 scale, or equivalent, is normally required for admission. An undergraduate major in physics, chemistry, materials science, or a related engineering discipline is preferred. GRE quantitative scores of 700 or higher are highly desirable. Students from countries where English is not the native language should demonstrate TOEFL scores higher than 550.

Bridge Program — Students who lack appropriate undergraduate preparation for the program may be admitted and required to make up deficiencies by taking a program of courses which is designed in consultation with the graduate advisor. These courses are taken in addition to the degree requirements and may include undergraduate courses.

Degree Requirements

Candidates must complete a minimum of 30 credits, including 12 credits of required materials science courses and 18 credits in an area of specialization, which are selected in consultation with the graduate advisor.

Seminar — In addition to the minimum 30 degree credits required, all students who receive program or research-based awards must enroll each semester in MtSE 791 Graduate Seminar.

REQUIRED
9 credits:

MtSE 605	Fundamentals of Engineering Materials
MtSE 610	Mechanical Properties of Materials
MtSE 630	Thermodynamics of Materials

3 credits from:

CE 635	Fracture Mechanics of Engineering Materials
Chem 640	Polymer Chemistry
ME 675	Mechanics of Fiber Composites
Phys 687/26:755:687	Physics of Materials

PROJECT OR THESIS
Required of all students receiving program or research-based awards; optional for all others.

3 credits: MtSE 700	Master's Project *or*
6 credits: MtSE 701	Master's Thesis

AREAS OF SPECIALIZATION
The range of possible specialization is broad. Students should consult the graduate advisor in designing the area of specialization and related degree requirements. Three areas and suggested courses are listed below.

Electronic and Photonic Materials
Select 12 credits if completing a master's thesis; 15 credits if completing a master's project; 18 credits if not completing either a master's project or thesis, from:

Chem 611	Solid-State Inorganic Chemistry
Chem 626	Chemistry of Contemporary Materials
ECE 623	Fourier Optics
ECE 625	Fiber and Integrated Optics
ECE 626	Optoelectronics
ECE 657	Semiconductor Devices
ECE 658	VLSI Design I

ECE 659	Fabrication Principles of Electronic and Optoelectronic Devices
ECE 739	Laser Systems
ECE 760	Solid-State Image Sensors
MtSE 615	Composite Materials
MtSE 625	Introduction to Ceramics
MtSE 627	Glass Science and Engineering
MtSE 702	Characterization of Solids
MtSE 737	Transport of Electrons and Phonons in Solids
MtSE 757	Defects in Solids
MtSE 765	Science and Technology of Thin Films
Phys 661/26:755:661	Solid-State Physics
Phys 667/26:755:667	Modern Experimental Techniques for Materials Processing and Characterization
Phys 762/26:755:762	Electronic Structure of Solids
Phys 763/26:755:763	Surface and Interface Physics
Phys 771/26:755:771	Quantum Electronics
Phys 781/26:755:781	Physics of Advanced Semiconductor Devices
Phys 789/26:755:789	Physics of Advanced Semiconductor Device Processing

Polymer and Biomaterials

Select 12 credits if completing a master's thesis; 15 credits if completing a master's project; 18 credits if not completing either a master's project or thesis, from:

BME 669	Quantitative Physiology for Engineers
BME 672	Biomaterials
ChE 627	Introduction to Biomedical Engineering
Chem 640	Polymer Chemistry
Chem 643	Polymer Laboratory I
Chem 645	Polymer Laboratory II
Chem 661	Instrumental Analysis
Chem 673	Biochemistry
ECE 667	Systems Studies in Bioengineering
Math 661	Applied Statistics
ME 670	Introduction to Biomechanical Engineering
ME 671	Biomechanics of Human Structure and Motion
ME 675	Mechanics of Fiber Composites
ME 676	Applied Plasticity
ME 678	Engineering Design of Plastic Products
ME 679	Polymer Processing Techniques
ME 680	Polymer Processing Equipment
MtSE 615	Composite Materials
MtSE 625	Introduction to Ceramics
MtSE 702	Characterization of Solids
MtSE 737	Transport of Electrons and Phonons in Solids
MtSE 757	Defects in Solids
MtSE 765	Science and Technology of Thin Films

Courses in metallic biomaterials and polymeric biomaterials offered at UMDNJ and courses in biosciences offered at Rutgers-Newark may be taken as electives. See the graduate advisor for information about these courses and registration.

Composite and Structural Materials

Select 12 credits if completing a master's thesis; 15 credits if completing a master's project; 18 credits if not completing either a master's project or thesis, from:

CE 631	Advanced Reinforced Concrete Design
CE 632	Prestressed Concrete Design
CE 634	Structural Dynamics
CE 635	Fracture Mechanics of Engineering Materials
CE 636	Stability of Structures
Chem 611	Solid-State Inorganic Chemistry
Chem 654	Corrosion
Chem 655	Electrochemistry: Principles and Applications
Chem 661	Instrumental Analysis
Math 661	Applied Statistics
Mech 540	Advanced Strength of Materials
Mech 630	Theory of Elasticity
ME 675	Mechanics of Fiber Composites
ME 676	Applied Plasticity
ME 678	Engineering Design of Plastic Products
ME 679	Polymer Processing Techniques
ME 680	Polymer Processing Equipment
ME 776	Dynamics of Polymeric Liquids
ME 785	Theory of Deformable Solids in Mechanical Engineering I
ME 786	Theory of Deformable Solids in Mechanical Engineering II
MtSE 615	Composite Materials
MtSE 625	Introduction to Ceramics
MtSE 627	Glass Science and Engineering
MtSE 650	Physical Metallurgy
MtSE 655	Diffusion and Solid State Kinetics
MtSE 702	Characterization of Solids
MtSE 725	Crystallography and Diffraction
MtSE 757	Defects in Solids
Phys 667/26:755:667	Modern Experimental Techniques for Materials Processing and Characterization

■ DOCTOR OF PHILOSOPHY IN MATERIALS SCIENCE AND ENGINEERING

This is a degree program for superior students who wish to do advanced research in an area of materials science and engineering. Current areas of research include electronic and photonic materials, polymer and biomaterials, and composite and structural materials.

Admission Requirements

Applicants are expected to have an appropriate master's degree in materials science or related field, physics, chemistry, or engineering from an accredited institution. Students entering with a master's degree must have at least a 3.5 GPA on a 4.0 scale in previous graduate study. Highly qualified students with bachelor's degrees may be accepted directly into the doctoral program. These students must have at least a 3.5 GPA in undergraduate work.

Degree Requirements

Students with an appropriate master's degree in materials science or related field, physics, chemistry or engineering, are required to complete a minimum of 60 credits beyond the master's degree: 24 credits of course work, 12 of which must be at the 700 level and none at the 500 level, and no less than 12 are materials science and engineering or related courses. A minimum of 36 credits of doctoral dissertation research is required. Specific course selection, the area of specialization and dissertation topics are approved by the program advisor on an individual basis.

Students entering with bachelor's degrees are required to complete a minimum of 78 credits: 42 credits of course work and 36 credits of doctoral dissertation research. For the course work, the required courses for the M.S. in Materials Science and Engineering are mandatory; no less than 24 credits must be materials science and engineering or related courses, and no less than 12 credits must be at the 700 level and none at the 500 level. Specific course selection, the area of specialization, and dissertation topics are approved by the program advisor on an individual basis.

REQUIRED

For those entering with a master's degree:

24 credits of course work beyond the master's degree

36 credits of MtSE 790 Doctoral Dissertation

MtSE 791 Graduate Seminar, every semester

For those entering with a bachelor's degree:

9 credits:

MtSE 605	Fundamentals of Engineering Materials
MtSE 610	Mechanical Properties of Materials
MtSE 630	Thermodynamics of Solids

3 credits from:

CE 635	Fracture Mechanics of Engineering Materials
Chem 640	Polymer Chemistry
ME 675	Mechanics of Fiber Composites
Phys 687/26:755:687	Physics of Materials

30 credits of course work beyond the master's degree core requirements listed above

36 credits of MtSE 790 Doctoral Dissertation

MtSE 791 Graduate Seminar, every semester

Qualifying Examination — The student must pass a written and an oral qualifying examination. The written qualifying exam is administered to test general academic preparation and competence in the research of materials science and engineering. Within one year after passing the written qualifying exam, the student is required to pass the oral qualifying exam to achieve Ph.D. candidacy, in which the potential Ph.D. candidate presents a preliminary research proposal for approval by the

dissertation committee. The student will be allowed two attempts to pass the written or oral qualifying exam.

Formation of Dissertation Committee — Within six months of passing the written qualifying examination, doctoral students must form a five-member dissertation committee that meets the approval of the graduate program director for materials science and engineering. The committee must include the dissertation advisor, three additional faculty members from the program, and at least one member from outside the program or NJIT.

Dissertation and Defense — An oral presentation and public defense of the doctoral dissertation is required.

Mathematics

Administered by: Department of Mathematical Sciences

Chairperson: Daljit S. Ahluwalia
Foundation Chair in Applied Mathematics: Gregory A. Kriegsmann
Distinguished Professors: Goldberg, Kriegsmann
Professors: Ahluwalia, Andrushkiw, Aubry†, Bhattacharjee, Blackmore, Lacker, D. Levy, Milojevic, Perez, Porter, Stickler, Tavantzis, Voronka
Associate Professors: Bechtold, Booty, Bukiet, Chase, Dhar, Dios, Garfield, Hile, Kappraff, Katzen, Lieb, Luke, Michalopoulou, Papageorgiou, Petropoulos, Plastock, Ray, Recce‡*, Siegel, Sran
Assistant Professors: Berliner, Booth, Bose, Crato, Lott-Crumpler, Nadim‡, Tilley

Graduate Advisor (NJIT): Demetrius Papageorgiou (973) 596-5837 (Room 623 CUL), e-mail depapa@aphrodite.njit.edu

† Joint appointee with the Department of Mechanical Engineering
‡ Joint appointee with the Federated Biological Sciences Department of NJIT and Rutgers-Newark
* Joint appointee with the Department of Computer and Information Science

Degrees Offered: Master of Science in Applied Mathematics; Master of Science in Applied Statistics; Doctor of Philosophy in Mathematical Sciences offered jointly with Rutgers-Newark.

Applied mathematics is the application of classical and modern mathematical techniques to the solution of practical problems in the natural sciences and engineering. The applied mathematician develops and analyzes mathematical models of physical phenomena, then collects and interprets data in order to identify relationships, patterns, and the impact of altering one or more variables or modeling assumptions. Many of the courses in the program illustrate how mathematics can be used to predict the behavior of physical phenomena.

The master's in applied mathematics with its areas of specialization in analysis, applied mathematics, computational methods and the master's in applied statistics are designed to serve the needs of students who are interested in later pursuing a doctoral degree in the mathematical or physical sciences. The program also serves students with a bachelor's degree who are planning to strengthen their quantitative and analytical skills in preparation for work in industry, commerce, or education as well as practicing engineers and others already employed in industry and commerce who wish to improve their quantitative and analytical skills.

■ MASTER OF SCIENCE IN APPLIED MATHEMATICS

The program is intended for students with a strong interest in applied mathematics.

Admission Requirements

It is expected that students applying for admission will have an undergraduate education in mathematics, engineering or the sciences. For additional information, see the Admissions section of this catalog.

Bridge Program — Students with baccalaureate degrees in other areas may be admitted and required by the department to take an individually-designed program of courses that may include undergraduate courses before proceeding to the graduate curriculum. Such courses do not count towards a graduate degree.

Degree Requirements

Candidates select an area of specialization and must complete 30 credits: 15 in core courses, 15 in an area of specialization, 6 of which are required and 9 are elective. Students must successfully complete at least 24 credits at the 600-level and no more than 6 credits at the 500-level. Specific course requirements depend on the area of specialization. A project or thesis is optional.

The choice of electives is made in consultation with a department graduate advisor, and consists of advanced courses in mathematics or advanced courses offered by other programs such as physics, computer and information science, or one of the engineering programs.

Seminar — In addition to the minimum 30 degree credits required, all students who receive departmental or research-based awards must enroll every semester in Math 791 Graduate Seminar.

CORE

Required for all areas of specialization
15 credits:

Math 613	Advanced Applied Mathematics I: Modeling
Math 631	Linear Algebra
** Math 645	Analysis I
Math 656	Complex Variables I
Math 689	Advanced Applied Mathematics II: ODEs

** Students specializing in applied mathematics or computational mathematics may take Math 545 Advanced Calculus I and Math 546 Advanced Calculus II instead of Math 645 and 3 credits of elective.

PROJECT, THESIS (optional)

3 credits: Math 700 Master's Project
6 credits: Math 701 Master's Thesis

AREAS OF SPECIALIZATION

Applied Mathematics

REQUIRED
6 credits:

Math 614	Numerical Methods I
Math 690	Advanced Applied Mathematics III: PDEs

ELECTIVE
Selected with approval of graduate advisor: 3 credits if completing a master's thesis, 6 credits if completing a master's project, or 9 credits if not completing either a master's project or thesis.

Computational Mathematics

REQUIRED
6 credits:

Math 614	Numerical Methods I
Math 712	Numerical Methods II

ELECTIVE
Selected with approval of graduate advisor: 3 credits if completing a master's thesis, 6 credits if completing a master's project, or 9 credits if not completing either a master's project or thesis.

Analysis

REQUIRED
6 credits:

Math 745	Analysis II
Math 756	Complex Variables II

ELECTIVE
Selected with approval of graduate advisor: 3 credits if completing a master's thesis, 6 credits if completing a master's project, or 9 credits if not completing either a master's project or thesis.

■ MASTER OF SCIENCE IN APPLIED STATISTICS

This degree is for students who intend to pursue a career as a statistician.

Admission Requirements

Applicants must have a degree from an accredited institution with at least 12 credits in mathematics including calculus. Students who do not meet these requirements but meet the university's requirements for admission will be admitted and required to take a bridge program of

6 credits in appropriate mathematics courses. An undergraduate GPA of at least 3.0 on a 4.0 scale or equivalent is normally required. Submission of GRE scores is encouraged but not required. However, GRE scores are required for those applying for financial support. Applications are considered on a case-by-case basis.

Degree Requirements

The M.S. in Applied Statistics requires 30 credits: 21 credits of required courses and 9 credits of elective courses. A master's thesis or a master's project is optional.

Seminar — In addition to the minimum 30 degree credits required, all students who receive departmental or research-based awards must enroll every semester in Math 791 Graduate Seminar.

REQUIRED

21 credits:

{ Math 611 Numerical Methods for Computation *or*
{ Math 630 Linear Algebra and Applications
Math 644 Regression Analysis Methods
Math 646 Time Series Analysis
Math 661 Applied Statistics
Math 662 Probability Distributions
Math 664 Methods for Statistical Consulting
Math 762 Statistical Inference

ELECTIVE

Select 3 credits if completing a master's thesis; 6 credits if completing a master's project; 9 credits if not completing either a master's project or master's thesis.

Students are encouraged to choose courses in an application area such as biostatistics, industrial statistics, or marketing analysis. Courses offered by appropriate departments at NJIT, UMDNJ and Rutgers-Newark can be used as electives within the limits of the NJIT transfer policy. All elective courses must be approved by the graduate advisor.

PROJECT, THESIS (optional)

Enrollment in master's project or master's thesis requires approval of the graduate advisor. These courses are completed under the supervision of a faculty member.

3 credits: Math 700 Master's Project
6 credits: Math 701 Master's Thesis

■ DOCTOR OF PHILOSOPHY IN MATHEMATICAL SCIENCES

NJIT Faculty

See listing at the beginning of the "Mathematics" degree programs section.

Rutgers-Newark Faculty

Professors: Feighn, Gilman, Mosher, Oertel, Shelstad
Associate Professors: Keigher, Keys, Randall, Sczech, Sturm
Assistant Professors: Guo, Mao, Sageev

Graduate Program Director: Lee Mosher (973) 353-5156 ext. 19 (Room 319 Smith Hall), e-mail mosher@andromeda.rutgers.edu

The degree of Doctor of Philosophy in Mathematical Sciences is offered jointly by the Department of Mathematical Sciences at NJIT and the Department of Mathematics and Computer Science at Rutgers-Newark. The program has two broadly defined options: applied mathematics, offered by NJIT, and pure mathematics, offered by Rutgers-Newark.

The applied mathematics option emphasizes the applications of mathematical methods to the natural sciences and engineering, including acoustics, electromagnetics, fluid dynamics, manufacturing, biology and medicine. Mathematical modeling, asymptotic analysis, and scientific computing are emphasized. Students are expected to develop a broad range of capabilities both in mathematics and in an area of application. The applied mathematics option is intended to provide preparation for those seeking careers as applied mathematicians in either academia or industry.

The pure mathematics option offers research opportunities in many fields of specialization, including representation theory, number theory, low-dimensional topology, Riemann surfaces and Kleinian groups, geometric group theory, and 4-manifolds.

Students in either option will be able to and are encouraged to select a program of study that includes several courses in the other option. In this way students can develop the kind of mathematical versatility needed to solve mathematical problems in a world where the line between applied and pure mathematics is becoming increasingly indistinct.

Admission Requirements

Admission to the program is based on a review of the applicant's credentials and interests as expressed in academic transcripts, GRE scores, letters of recommendation, statement of interests, and TOEFL scores (for students whose native language is not English). Applicants with strong academic records whose abilities and interests complement the research of the faculty are sought. In general, applicants should have a bachelor's or master's degree in mathematics, an engineering discipline, or a branch of the natural sciences. Students choosing the applied mathematics option must fulfill the admissions requirements specified in the Admissions section of this catalog.

Those interested primarily in the applied mathematics option should apply to NJIT, while students interested in the pure mathematics option should apply to Rutgers-Newark.

Degree Requirements

APPLIED MATHEMATICS OPTION (NJIT)

Students choosing the applied mathematics option must fulfill the requirements for the doctor of philosophy as specified in this catalog. Specific courses of study are planned in consultation with a faculty advisor and are subject to approval. In general, students are encouraged to take courses both in mathematics and in areas of application.

Seminar — In addition to the minimum degree credits required, all doctoral students must enroll each semester in Math 791 Graduate Seminar.

Qualifying Examination — The qualifying examination for the applied mathematics option consists of three components: analysis, linear algebra/numerical methods, and applied mathematics. Students must achieve a grade of A in each component to pass the qualifying examination. Components may be passed at different times. However, a student may attempt each component at most twice and must pass all three components by the end of the second year in the program. Typically, two opportunities to take each component are provided each year: analysis and linear algebra/numerical methods (September and January), applied mathematics (January and May).

Dissertation Committee — The dissertation committee is an important resource for the doctoral student in the conduct of research for their dissertation. Within six months of passing the qualifying examination a dissertation committee must be formed according to the regulations specified in this catalog.

Dissertation Proposal — Doctoral students must prepare a research proposal for approval by their dissertation committee. The student must offer an oral defense of this proposal before the dissertation committee. The committee determines if the proposal has an appropriate objective, if there is a reasonable plan to reach that objective, and if the student possesses the knowledge and skills needed to carry out the plan. The dissertation proposal can only be approved by unanimous consent of the committee members. Approval of the dissertation proposal must precede the defense of the dissertation by no less than six months.

Dissertation Defense — A public oral defense of the dissertation before the dissertation committee is required. All members of the committee must be present for the defense. Success of the defense is determined by a majority vote of the dissertation committee.

PURE MATHEMATICS OPTION (Rutgers-Newark)

Students interested in the pure mathematics option complete four core courses, a series of four required courses within the option and 24 credits of advanced elective courses. The advanced electives are chosen in consultation with the advisor, advisory committee, and the graduate program director. For further information, contact the Rutgers-Newark Department of Mathematics and Computer Science.

Qualifying Examination — The qualifying examination for the pure mathematics option consists of three parts, each covering the basic topics in a particular subdiscipline.

Part A Real and Complex Analysis
Part B Algebra
Part C Topology and Geometry

Dissertation — Upon completing the qualifying examination, students are required to complete a minimum of 24 credits of doctoral dissertation research under the direction of a faculty member.

Dissertation Defense — The student presents a completed dissertation to the dissertation committee, which conducts a final oral examination.

Mechanical Engineering

Administered by: Department of Mechanical Engineering

Chairperson: Dennis Siginer
Associate Chairpersons: Pasquale Florio, Rong Chen (graduate)
Foundation Professor: William C. Van Buskirk (biomechanical engineering)
Jacobus Chair: Nadine Aubry
Distinguished Professor: Van Buskirk
Professors: Aubry‡, Chen, Dave, Droughton, Fenster, Geskin, Harnoy, Kirchner, Koplik, Linden, Magee, Siginer, Wilson
Associate Professors: Dubrovsky, Fischer, Florio, Ji, Khusid, Rosato, Sodhi
Assistant Professors: Chu, Narh, Singh, Zhu
Research Professor: Ugural
Special Lecturers: Kountouras, Surjanhata

Graduate Advisor: Rong Chen (973) 596-3327 (Room 205 ME), e-mail chenr@admin.njit.edu

‡ Joint appointee with the Department of Mathematical Sciences

Degrees Offered: Master of Science in Mechanical Engineering; Doctor of Philosophy in Mechanical Engineering

Mechanical engineering is concerned with the design, development, manufacture, and operation of a wide variety of energy conversion and machine systems. The research and education facilities of the department are housed in the 60,000-square-foot Mechanical Engineering Building. Major research laboratories include Particle Technology, Machine Vision and Motion Analysis, Waterjet Machining, Robotics and Intelligent Manufacturing, Bearing Lubrication, and Plastic Processing and Analysis.

■ MASTER OF SCIENCE IN MECHANICAL ENGINEERING

A program for engineering graduates who want advanced professional preparation and further graduate study in mechanical engineering.

Admission Requirements

Applicants are expected to have an accredited undergraduate degree in mechanical engineering or a related field. General admissions requirements for master's programs as described in this catalog apply to applicants to the M.S. in Mechanical Engineering. Sufficient preparation in science and mathematics to complete the course of study is also necessary.

Bridge Program — Students who lack appropriate undergraduate preparation may be admitted and are asked to make up deficiencies by taking a program of courses that is designed in consultation with the graduate advisor. These courses are taken in addition to the degree requirements and may include undergraduate courses.

† Degree Requirements

The program shown below offers numerous areas of specialization, each with its own list of required and elective courses. Once the specialization is chosen, the student consults the graduate advisor to plan and develop an individualized and cohesive sequence of courses that meet program requirements of at least 30 degree credits.

Seminar — In addition to the minimum 30 degree credits required, every student must take a minimum of two semesters of ME 794 Mechanical Engineering Colloquium. Students who receive departmental or research-based awards must enroll every semester in ME 794.

PROJECT, THESIS

Thesis is required of all students who receive departmental or research-based awards. For all others, a project or thesis is optional.
3 credits: ME 700 Master's Project
6 credits: ME 701 Master's Thesis

† AREAS OF SPECIALIZATION

The range of possible areas of specialization is broad. Students should consult with the graduate advisor in designing specialization and related degree requirements. With the approval of the advisor, students may take courses from other departments to enhance areas of specialization after completion of 12 credits in mechanical engineering. Some example areas of specialization and the courses for each follow. The number of elective credits for each area of specialization will vary according to the number of required course credits and also if a student enrolls in ME 700 or ME 701.

Biomechanical Engineering

REQUIRED
15 credits:

ME 616	Matrix Methods in Mechanical Engineering
ME 620	Stress Methods in Mechanical Design
ME 622	Finite Element Methods in Mechanical Engineering
ME 635	Computer-Aided Design
ME 671	Biomechanics of Human Structure and Motion

ELECTIVE

Select 9 credits if completing a master's thesis; 12 credits if completing a master's project; 15 credits if not completing either a master's project or thesis.

BME 669	Quantitative Physiology for Engineers
ME 670	Introduction to Biomechanical Engineering
ME 672	Biomaterials — Characterization

Other suitable courses selected with approval of the graduate advisor.

Particle Technology

REQUIRED
12 credits:

ME 616	Matrix Methods in Mechanical Engineering
ME 620	Stress Methods in Mechanical Design
ME 624	Microlevel Modeling in Particle Technology
ME 664	Experiments and Simulations in Particle Technology

ELECTIVE

Select 12 credits if completing a master's thesis; 15 credits if completing a master's project; 18 credits if not completing either a master's project or thesis.

ME 628	Machine Vision Principles and Applications

Other suitable courses selected with approval of the graduate advisor.

Robotics and Controls

REQUIRED
12 credits:

ME 616	Matrix Methods in Mechanical Engineering
ME 620	Stress Methods in Mechanical Design
ME 625	Introduction to Robotics
ME 655	Introduction to Modern Control Methods

ELECTIVE

Select 12 credits if completing a master's thesis; 15 credits if completing a master's project; 18 credits if not completing either a master's project or thesis.

ME 628	Machine Vision Principles and Applications
ME 633	Dynamics of Machinery
ME 635	Computer-Aided Design
ME 735	Advanced Topics in Robotics
ME 755	Adaptive Control Systems

Other suitable courses selected with approval of the graduate advisor.

Design and Mechanisms

REQUIRED
12 credits:

ME 616	Matrix Methods in Mechanical Engineering
ME 620	Stress Methods in Mechanical Design
ME 621	Energy Methods in Mechanical Design
ME 637	Kinematics of Spatial Mechanisms

† Note: Before registering for courses, all students must see the graduate advisor to obtain the latest version of the brochure, "Graduate Programs in Mechanical Engineering." All new students must obtain approval from the graduate advisor before registering for courses.

ELECTIVE
Select 12 credits if completing a master's thesis; 15 credits if completing a master's project; 18 credits if not completing either a master's project or thesis.
ME 615 Advanced Mechanical Vibrations
ME 630 Analytical Methods in Machine Design
ME 633 Dynamics of Machinery
ME 635 Computer-Aided Design
ME 636 Mechanism Design: Analysis and Synthesis
ME 736 Advanced Mechanism Design
Other suitable courses selected with approval of the graduate advisor.

CAD/CAM

REQUIRED
12 credits:
ME 616 Matrix Methods in Mechanical Engineering
ME 620 Stress Methods in Mechanical Design
ME 622 Finite Element Methods in Mechanical Engineering
ME 635 Computer-Aided Design

ELECTIVE
Select 12 credits if completing a master's thesis; 15 credits if completing a master's project; 18 credits if not completing either a master's project or thesis.
ME 625 Introduction to Robotics
ME 628 Machine Vision Principles and Applications
ME 630 Analytical Methods in Machine Design
ME 638 Computer-Aided Machining
ME 734 Analysis and Synthesis for Design
ME 736 Advanced Mechanism Design
Other suitable courses selected with approval of the graduate advisor.

Thermal Systems

REQUIRED
12 credits:
ME 607 Advanced Thermodynamics
ME 610 Applied Heat Transfer
ME 611 Dynamics of Incompressible Fluids
ME 616 Matrix Methods in Mechanical Engineering

ELECTIVE
Select 12 credits if completing a master's thesis; 15 credits if completing a master's project; 18 credits if not completing either a master's project or thesis.
ME 641 Refrigeration and Air Conditioning
ME 644 Building Environmental Control Principles
ME 711 Convection Heat Transfer
ME 712 Mechanics of Viscous Fluids
Other suitable courses selected with approval of the graduate advisor.

Fluid Dynamics

REQUIRED
12 credits:
ME 611 Dynamics of Incompressible Fluids
ME 616 Matrix Methods in Mechanical Engineering
ME 712 Mechanics of Viscous Fluids
* ME 713 Non-Newtonian Fluid Dynamics

ELECTIVE
Select 12 credits if completing a master's thesis; 15 credits if completing a master's project; 18 credits if not completing either a master's project or thesis.
ME 609 Dynamics of Compressible Fluids
ME 610 Applied Heat Transfer
ME 631 Bearings and Bearing Lubrication
Math 611 Numerical Methods for Computation
Other suitable courses selected with approval of the graduate advisor.

Materials and Processing

REQUIRED
12 credits:
ME 610 Applied Heat Transfer
ME 616 Matrix Methods in Mechanical Engineering
ME 675 Mechanics of Fiber Composites
ME 678 Engineering Design of Plastic Products

* pending

ELECTIVE
Select 12 credits if completing a master's thesis; 15 credits if completing a master's project; 18 credits if not completing either a master's project or thesis.

ME 624 Microlevel Modeling in Particle Technology
ME 680 Polymer Processing Equipment
ME 776 Dynamics of Polymeric Liquids
MtSE 605 Fundamentals of Engineering Materials
MtSE 610 Mechanical Properties of Materials
MtSE 615 Composite Materials
MtSE 650 Physical Metallurgy
Other suitable courses selected with approval of the graduate advisor.

■ DOCTOR OF PHILOSOPHY IN MECHANICAL ENGINEERING

This is a program for superior students with master's degrees in mechanical engineering or allied fields who wish to do advanced research in an area of mechanical engineering. In exceptional circumstances, highly qualified students with bachelor's degrees in mechanical engineering may be accepted directly into the doctoral program.

Admission Requirements

Applicants should have a master's degree from an accredited institution, and have successfully taken courses in applied mathematics and engineering sciences. In addition, applicants must fulfill the admissions requirements for doctoral study as specified in the Admissions section of this catalog. Students who lack an appropriate background will be required to take additional courses before gaining admission to the program. These courses are prescribed by the department on an individual basis and may not be applied as degree credit.

Degree Requirements

Specific degree requirements and dissertation topics are approved by the department on an individual basis. Before being permitted to register for dissertation research, students must complete courses specified by the department, pass qualifying examinations and demonstrate that there are facilities and a faculty member available to supervise the research. Should dissertation research not be completed within the normal 36 credits of ME 790, students must register for a minimum of 3 credits per semester until the dissertation is completed and approved. An oral defense of the dissertation is required after submission of the final document to the department for approval.

REQUIRED
24 credits of course work beyond the master's degree
ME 794 Mechanical Engineering Colloquium; required every semester for all doctoral students
36 credits of ME 790 Doctoral Dissertation

Qualifying Examination — Once admitted to the program, candidates are expected to pass a two-part written qualifying examination. It is given at least once a year. Students must apply in writing to the graduate advisor for permission to take qualifying examinations. From the time of formal admission into the program, the examination must be taken by the second time it is offered, except students with departmental or research-based assistantships who must take the examination the first time it is offered. At the discretion of the department, an additional oral examination may be required.

Part I Applied Mathematics (ordinary and partial differential equations, vector analysis, complex variables, numerical methods, and boundary value problems)

Part II Two parts selected from engineering mechanics, fluid mechanics, heat transfer, stress analysis, system dynamics, thermodynamics.

Occupational Safety and Health Engineering

Administered by: Department of Industrial and Manufacturing Engineering

Chairperson: Athanassios K. Bladikas
Associate Chairperson: George Abdou

Program Director and Graduate Advisor: One-Jang Jeng
(973) 596-3659 (Room 2509 GITC), e-mail jeng@admin.njit.edu

Professors: Abdel-Malek, Caudill, Chao, Hatch, Ranky, Sebastian, Tricamo, Wolf
Associate Professors: Abdou, Bengu, Bladikas, Das, McDermott
Assistant Professor: Jeng

Degree Offered: Master of Science in Occupational Safety and Health Engineering

The curriculum has been designed in accordance with the National Institute for Occupational Safety and Health (NIOSH), which sponsors the program. Through course work and research, individuals are exposed to all of the principal areas of concern to the entry-level safety professional, including how technology and hazardous materials affect the safety of the workplace.

NJIT's program is just one of a handful offered in the United States and the only master's-level program in New Jersey. NIOSH offers a limited number of stipends and tuition remission grants to qualified students.

■ MASTER OF SCIENCE IN OCCUPATIONAL SAFETY AND HEALTH ENGINEERING

This master's program educates engineers in the specialty of occupational safety and health. Upon graduation, students are able to assume both the technical and managerial responsibilities of safety professionals.

Admission Requirements

Applicants normally are practicing engineers with an accredited bachelor's degree in an engineering or scientific field.

Bridge Program — Students who lack an appropriate background may be admitted and required to make up deficiencies by taking a program of courses that is designed in consultation with graduate advisors. These courses are taken in addition to the degree requirements and may include undergraduate courses.

Degree Requirements

A minimum of 36 credits is required.

Seminar — In addition to the minimum 36 degree credits required, all students who receive departmental or research-based awards must enroll each semester in IE 791 Graduate Seminar.

REQUIRED
18 credits:

EM 633	Legal Aspects of Health and Safety
IE 614	Safety Engineering Methods
IE 615	Industrial Hygiene and Occupational Health
IE 661	Man-Machine Systems
IE 677	Applied Statistics and Epidemiology for Hazard Analysis
IE 685	Systems Safety

THESIS
Required of NIOSH trainees; optional for all others.
6 credits: IE 701 Master's Thesis

ELECTIVE
Select 12 credits if completing a master's thesis; 18 credits if not completing a master's thesis.

BME 669	Quantitative Physiology for Engineers
ChE 671	Chemical Process Safety
EvSc 614	Quantitative Environmental Risk Assessment
EvSc 616	Toxicology for Engineers and Scientists
IE 608	Product Liability Control
IE 665	Applied Industrial Ergonomics
IE 669	Human Design Factors in Engineering
IE 670	Industrial Work Physiology
IE 675	Safety in Facility and Product Design
IE 725	Independent Research
ME 660	Noise Control
ME 670	Introduction to Biomechanical Engineering

Occupational Safety and Industrial Hygiene

Administered by: Department of Chemical Engineering, Chemistry and Environmental Science

Chairperson: Gordon Lewandowski
Associate Chairperson and Program Director: Richard Trattner

Program Advisor: Norman Van Houten (973) 596-3059 (SPEC), e-mail vanhouten@admin.njit.edu

Degree Offered: Master of Science in Occupational Safety and Industrial Hygiene

Because the M.S. in Occupational Safety and Industrial Hygiene (OSIH) program is offered in an interdisciplinary department, there are strong ties to environmental science and chemistry. The program also enjoys additional collaborations with the Federated Department of Biological Sciences as well as nearby UMDNJ. The OSIH program has the strong support of industry, and is served by an industrial advisory committee.

■ MASTER OF SCIENCE IN OCCUPATIONAL SAFETY AND INDUSTRIAL HYGIENE

The M.S. in Occupational Safety and Industrial Hygiene is an interdisciplinary program of advanced study for individuals with backgrounds in science and technology related fields.

Admission Requirements

Applicants are expected to have an undergraduate degree in public health, environmental science, chemistry, biology, or related disciplines from an accredited institution, with a minimum GPA of 2.8 and at least 40 credits in mathematics and science. Students who lack these requirements will be required to take a program of courses that is designed in consultation with the graduate advisor. These may include undergraduate courses that are not counted toward degree credit.

Degree Requirements

A minimum of 30 credits is required: 18 credits in core courses and 12 in elective courses. A master's project is optional. Students must consult with the graduate advisor in designing appropriate programs of study.

Students must attain a minimum GPA of 3.0 in the core courses listed below, and a minimum overall GPA of 3.0.

CORE
18 credits:

EM 633	Legal Aspects of Health and Safety
EvSc 616	Toxicology for Engineers and Scientists
OSIH 601	Environmental, Safety and Health Program Management
OSIH 610	Sampling and Testing Methods for Industrial Hygiene I
OSIH 611	Sampling and Testing Methods for Industrial Hygiene II
OSIH 612	Fundamentals of Controls

PROJECT (optional)
3 credits: OSIH 700 Master's Project

ELECTIVES
Select 9 credits if completing a master's project; 12 credits if not completing a master's project, from:

EvSc 602	Special Topics in Environmental Science
EvSc 603	Hazardous Waste Operations and Emergency Response
EvSc 610	Environmental Chemical Science
EvSc 611	Hazardous Waste Management
EvSc 612	Environmental Analysis
EvSc 614	Quantitative Environmental Risk Assessment
OSIH 602	Worker Compensation and Risk Management
OSIH 603	Transportation of Hazardous Materials
OSIH 604	Construction Safety
OSIH 605	Principles of Radiation Safety
OSIH 606	Health Care/Hospital Health and Safety
OSIH 607	Industrial Issues in Occupational Safety and Industrial Hygiene
OSIH 608	Safety Training Program Development
OSIH 609	Food Process Safety and Clean Design
OSIH 698	Special Topics in OSIH
OSIH 725	Independent Study

Power Engineering

Administered by: Department of Electrical and Computer Engineering

Program Director: Edwin Cohen (973) 596-3540 (Room 323 ECE), e-mail cohen@admin.njit.edu

Faculty: from Newark College of Engineering, College of Science and Liberal Arts, and School of Management, as appropriate

Graduate Advisors: faculty assigned from Newark College of Engineering, depending on student's interest

Degree Offered: Master of Science in Power Engineering

Large and plentiful supplies of energy are at the foundation of modern industrial societies. It makes possible industrial and economic activities on a very large scale, enabling people to be more productive, enhancing their well-being and quality of life in the process. Energy, however, is rarely used at its source, such as a coal mine, oil well, or river. It has to be transported to the location of use or, most of the time, converted to another form before being used. Electrical energy, for example, is the most often converted power because it affords tremendous flexibility in transportation (transmission) and economical utilization. This characteristic is the reason for building large power plants and stringing thousands of miles of transmission lines for distribution to users. Whether electric, gas or water, these industries support their own specialized workforces, including engineers and other technical professionals who engage in an array of tasks in field work, plant operation, management, and government and corporate relations.

Because the power industry is multifaceted, its engineers come from a variety of disciplines such as electrical, mechanical, civil, industrial and chemical engineering. Engineers in the power industries interact closely with other engineers as well as with non-engineering professionals.

A power engineer in industry needs to know a variety of topics, which cannot be categorized as mainly belonging to a particular school or traditional engineering department. This power engineering program enables the student to easily cross boundaries between engineering departments, with the objective of advanced training pertinent to the power industry.

The M.S. in Power Engineering is designed for engineers already in the power industries, engineers seeking to enter the field, and other professionals in the power industry who desire a relevant master's degree.

The individual is teamed immediately after admission with a graduate faculty advisor appointed on the basis of background and interests. A course of study is tailored to meet the student's needs and interests. In some cases, the faculty advisor may recommend a bridge program to enable the individual to proceed with the graduate plan of study.

■ MASTER OF SCIENCE IN POWER ENGINEERING

This interdisciplinary program offers a wide selection of courses from the Newark College of Engineering, the College of Science and Liberal Arts and the School of Management in order to provide training and information necessary to meet the demands of unique work environments — an area not covered by traditional engineering discipline graduate programs.

Admission Requirements

A baccalaureate degree in any engineering discipline is required. Graduates from non-engineering programs may also be admitted but are required to take a bridge program to acquire the necessary engineering fundamentals. Bridge courses do not count toward degree requirements.

Degree Requirements

Based on the student's background and expressed interests, the student is assigned to a faculty advisor from the most suitable engineering field: electrical, mechanical, civil or industrial. The advisor, in consultation with the student, is responsible for tailoring a coherent program of studies that follows the program guidelines and that meets the student's interests.

The Master of Science in Power Engineering requires the completion of at least 30 credits: 6 in core courses, 12 in technical courses, 6 in management courses and 6 in electives. A 6-credit thesis or 3-credit project may be part of the program. Professional courses given in the power industry may be evaluated for transfer credit.

Seminar — All students receiving departmental or research-based support are required to register every semester for a graduate seminar course selected from an appropriate engineering discipline.

CORE

6 credits from:

CE 610	Construction Management
ECE 610	Power System Steady-State Analysis
IE 618	Engineering Cost and Production Economics
ME 642	Power Plant Design

REQUIRED

Technical

12 credits from:

ECE 601	Linear Systems
ECE 610	Power System Steady-State Analysis
ECE 611	Transients in Power Systems
ECE 612	Computer Methods Applied to Power Systems
ECE 613	Protection of Power Systems
ECE 615	Advanced Electromechanical Energy Conversion I
ECE 616	Power Electronics
ECE 618	Power System Design of Alternative Energy Sources
ECE 660	Control Systems I
ECE 710	Economic Control of Interconnected Power Systems
ECE 711	Power System Dynamics and Stability
IE 642	Networks Flow and Applications
IE 644	Application of Stochastic Modeling in Systems Control
ME 610	Applied Heat Transfer
ME 640	Gas Turbines
ME 642	Power Plant Design
ME 654	Pressure Vessel Design
ME 656	Piping Stress Analysis
ME 661	Thermal Pollution of Water and Air
ME 662	Air Pollution Control and Design

Appropriate courses from CE, ChE, CIS, Math, and Phys selected in consultation with the graduate advisor. Only one course each is permitted from Math, CIS and Phys.

Management

6 credits from:

CE 611	Project Planning and Control
EM 617	Environmental Risk Assessment
EM 631	Legal Aspects in Environmental Engineering
EM 632	Legal Aspects in Construction
EM 636	Project Management
EM 691	Cost Estimating for Capital Projects
EM 695	Public Utility Energy Management
EM 696	Nuclear Power Reactor Management
EnE 671	Environmental Impact Analysis
IE 614	Safety Engineering Methods
IE 618	Engineering Cost and Production Economics
IE 653	Facility Maintenance

One Mrkt course

Courses in power engineering special topics are being developed.

ELECTIVE

6 credits: any 600- or 700-level courses approved by the program director. A master's project or thesis can be used for elective credit.

PROJECT OR THESIS (optional)

Project or thesis courses are selected from an appropriate engineering discipline.

3 credits: master's project

6 credits: master's thesis

Professional and Technical Communication

Administered by: Department of Humanities and Social Sciences

Chairperson: Norbert Elliot
Associate Chairperson: Richard Quinn
Program Director: Robert Friedman
Professors: Elliot, Lynch
Associate Professors: Kimmelman, Steffen-Fluhr
Assistant Professor: Coppola
Special Lecturers: Fleischer, Funkhouser
University Lecturer: Kerley
Adjunct Faculty: Bojsza, Massaro

Degree Offered: Master of Science in Professional and Technical Communication

This program is designed to prepare students for careers in the highly skilled field of technical communication. In a scholarly and professional manner, students develop abilities in writing, research, editing, collaboration, and visual design. Students also acquire an understanding of new communication technologies and media in the program's modern computer laboratory.

■ MASTER OF SCIENCE IN PROFESSIONAL AND TECHNICAL COMMUNICATION

The program is intended for students and communications professionals who want to develop abilities in communication theory, proposal writing, editing, graphics and visual arts, interpersonal and collaborative communication, hypertext and hypermedia, desktop publishing, technical, professional and scientific writing, and multimedia design.

Admission Requirements

Students must have an undergraduate degree in a field of science, computer science or engineering, or have an undergraduate degree in another area with experience or strong interest in science and technology. Undergraduate transcripts must show at least a 3.0 GPA overall and a 3.0 GPA in communication courses. A portfolio with samples of the applicant's writing from college and/or work as well as GRE scores are required.

Graduate Certificate Program — 12-credit graduates certificates in Electronic Media Design and Practice of Technical Communications are available as a step toward this degree. See "Graduate Certificates" in this catalog. For further information, call the associate vice president of continuing and distance education, Division of Continuing Professional Education, 1 (800) 624-9850 or (973) 596-3060; e-mail cpe@njit.edu

Degree Requirements

Students must complete a minimum of 30 credits: 12 credits of core courses, 12 credits of elective courses, and 6 credits of master's thesis or the combination of a master's project and one independent study course related to the project. The elective courses allow students to specialize in selected areas of technical communication. The thesis or project allows students to demonstrate the ability to conceive and execute an extended writing project with professional graphics and to make an oral and visual presentation of that work.

Seminar — In addition to the minimum 30 degree credits required, all students who receive departmental or research-based awards must enroll in Eng 791 Graduate Seminar or an appropriate graduate seminar each semester that it is offered.

CORE

12 credits:

Eng 601	Advanced Professional and Technical Communication
Eng 603	Cultural and Technological Change
Eng 604	Communication Theory
Eng 605	Document Design and Desktop Publishing

THESIS OR PROJECT/INDEPENDENT STUDY (required)

6 credits from either:

Eng 701	Thesis in Professional and Technical Communication *or*
Eng 700	Project in Professional and Technical Communication *and*
Eng 725	Independent Study in Professional and Technical Communication

ELECTIVE

12 credits from:

CIS 675	Information System Evaluation
CIS 677	Information System Principles
CIS 732	Design of Interactive Systems
Eng 610	Creating Hypertext: A Task-Oriented Approach
Eng 611	Research Methods in Professional and Technical Writing
Eng 613	Multimedia Presentations
Eng 620	Proposal Writing
Eng 622	Collaborative and Interpersonal Communication
Eng 624	Professional and Technical Editing
Eng 698	Special Topics in Professional and Technical Communication
Eng 725	Independent Study in Professional and Technical Communication
Eng 791	Graduate Seminar
EPS 644	The Rhetoric of Environmental Policy

Public Health

Administered by: Department of Humanities and Social Sciences, Rutgers-Newark, UMDNJ–NJMS

Acting Program Director: Anthony J. Garro (UMDNJ–NJMS)
Associate Program Director: Marian R. Passannante (UMDNJ–NJMS)
MPH Administrative Director: Yvette Holding-Ford (UMDNJ–NJMS)

NJIT Faculty
Distinguished Professors: Lewandowski, Turoff
Professors: Beaton, Elliot, Perl, Trattner
Associate Professors: Deek, Geller, Recce
Assistant Professors: Hodge, Linton, Markowitz

Rutgers-Newark Faculty
Professors: Dubnick, Holzer
Associate Professors: Canino, Olshfski, Schofer, Stark
Assistant Professors: Burbridge, Gelobter

UMDNJ Faculty
Professors: H. Baker, S. Baker, Bogden, Chinard, Evans, Haque, Johanson, Lavenhar, Louria, Najem, Oleske, Reichman, Wedeen
Associate Professors: Caine, Guttman, Holland, Passannante, Sheffet, Skurnick, Weiss
Assistant Professors: Aloi, Brachman, Kennedy, Touger-Decker, Von Hagen, Wenger
Adjunct Professor: Kantor
Adjunct Instructor: Gause

Track Coordinators:
Norbert Elliot (NJIT) (973) 596-6487 (Room 431 CUL), e-mail elliot@admin.njit.edu
Marvin A. Lavenhar (UMDNJ–NJMS) (973) 972-4686 (MSB F-594), e-mail lavenhma@umdnj.edu
Marian R. Passannante (UMDNJ–NJMS) (973) 972-4775 (MSB F-588), e-mail passanna@umdnj.edu
Evan Stark (Rutgers-Newark) (973) 353-5052 ext. 22 or (203) 387-2275 (Room 701 Hill Hall), e-mail EDS203@juno.com

Degree Offered: Master of Public Health offered jointly with Rutgers-Newark and UMDNJ

The Master in Public Health (M.P.H.) degree program, established by UMDNJ–NJMS, Rutgers-Newark and NJIT, addresses critical issues surrounding the nation's health, especially that of high-risk, urban, and under-served populations. The program in public health develops and applies knowledge from multiple disciplines for the promotion and protection of the health of the human population, giving due consideration to cultural perspectives that abound in our multicultural world. This program is part of the UMDNJ–School of Public Health.

Program participants carry out research, and formulate policies that answer local needs and provide models for similar nationwide and worldwide problems. The three universities collaborate with community-based practitioners and researchers in Newark and in northern New Jersey. Student projects and placements are designed to maximize problem solving in large urban settings.

■ MASTER IN PUBLIC HEALTH

The program is designed to prepare existing professionals to assume new and expanded analytical and administrative roles in the planning and organization of efficient and cost-effective health services, health education, and health policy; to increase the number of public health professional qualified to assist and conduct original community-based research that will lead to advances in health promotion and disease prevention; and to provide systems thinking about public health and social values that relate to physical and mental well being.

Admission Requirements

Applicants must meet one of these criteria: hold degrees or positions in the health or health-related professions; be graduates of baccalaureate or post-baccalaureate programs with formal training and/or experience in the health field; be candidates for joint degree programs (M.D./M.P.H., D.M.D./M.P.H.); hold exceptionally strong credentials from baccalaureate; post-baccalaureate programs outside of the health field.

Applicants must supply scores from the GRE or its equivalent (e.g., MCAT, GMAT, or LSAT) from within the last five years. Those with a doctoral degree from a U.S. or Canadian university may seek a waiver of test scores by providing supporting documentation with the application. Test score waivers for individuals with other graduate degrees are decided on a case-by-case basis. Contact the administrative director.

International students applying for admission must show a TOEFL score of at least 550. All applicants must supply official academic transcripts; an essay/statement addressing career goals, how the course offerings would help meet them, and how previous experience has contributed to personal and professional growth; and three letters of recommendation.

An application may be obtained from Newark Public Health Program at Science Park, UMDNJ-New Jersey Medical School, 185 South Orange Ave., MSB F-506, Newark, N.J. 07103-2714 or by calling (973) 972-7212.

Degree Requirements

The MPH program requires the successful completion of 45 credits. The credits are divided into 18 credits in core courses, 6 to 12 credits in required courses in one of three tracts, 9 to 15 credits of electives and 3 credits each in fieldwork and thesis.

Three general tracks are available. While they share a common core, each is designed to suit various interests:

Urban and Environmental Health brings a multi-disciplinary perspective to bear on the identification, assessment, and remediation of stressors specific to health problems in the urban environment.

Quantitative Methods: Biostatistics and Epidemiology develops quantitative, analytic, and research skills for public health practitioners.

Health Policy and Administration teaches the concepts, principles, and scientific skills necessary for health services management, policy development, and program evaluation.

CORE

18 credits:

BINF 601/BINF 5005	Health Information Systems
MPH 601	Introduction to Epidemiology
* MPH 602	Introduction to Biostatistics
MPH 603	Principles of Environmental Health
MPH 604	Introduction to Health Care Systems and Policy
* MPH 605	Health Education and Public Health Issues

FIELDWORK AND THESIS (required)
See the track coordinator for course numbers.
3 credits: fieldwork
3 credits: master's thesis

TRACKS

Urban and Environmental Health
Select either urban health or environmental health.

REQUIRED
6 credits:

EPS 642	Urban Environmental Policy Studies
EPS 601	Behavioral Research Design and Analysis

Urban Health
3 credits:

MPH 644	Social Foundations of Urban Health

12 credits from:

25:705:504	Human Diversity and Social Issues in the Community
Hist 620	City and Disease in History
Hist 622	Culture and Science in the History of American Medicine
Hist 624	Technology, Environment, and Medicine in World History: 1500-1900
Hist 626	Social History of American Medicine Since 1800
Hist 630	History of the Body in Modern Western Culture
Hist 640	The Urban Environment
MPH 645	Society, Chronic Illness, and Disability: An Urban Perspective
MPH 646	Urban Child in a Global Perspective
MPH 647	Perinatal Health and Family Planning
MPH 648	Community and Environmental Approaches to Health Behavior Change in Urban Disadvantaged Populations

* pending

Environmental Health
3 credits:

EPS 651	Introduction to Urban Environmental Health

12 credits from:

EM 631	Legal Aspects of Environmental Engineering
{ EPS 609	Environmental Risk Assessment *or*
{ EvSc 614	Quantitative Environmental Risk Assessment
EPS 612	Introduction to Environmental Policy Studies
EPS 613	Environmental History and Policy
EPS 614	Environmental Economics
EPS 660	Ethics and Environmental Policy
EvSc 610	Environmental Chemical Science
EvSc 613	Environmental Problem Solving
EvSc 616	Toxicology for Engineers and Scientists
Hist 634	Environmental History of North America
Hist 635	History, Technology and Medicine: Theory and Method
MPH 650	Medical Geography

Quantitative Methods: Epidemiology and Biostatistics
Select either epidemiology or biostatistics.

REQUIRED
6 credits:

QM 611	Design of Epidemiological Studies and Clinical Trials
QM 612	Linear Models: Regression and Analysis of Variance

Epidemiology
6 credits:

EPI 615	Introduction to Epidemiology and Control of Chronic and Infectious Diseases
EPI 616	Advanced Topics in Infectious and Chronic Disease Epidemiology

9 credits from:

BINF 7570	Health Care Outcomes Measurement and Research
EPI 621	Survey Research Methods/Questionnaire Design
EPI 625	Community-Based Epidemiological Research
EPI 626	Emerging and Re-Emerging Infections
EPI 627	Innovations in Public Health
EPI 628	Pharmacoepidemology
EPI 629	Oral Epidemiology of Chronic and Infectious Diseases

The following courses are in development: genetic epidemiology, and environmental and occupational epidemiology

Biostatistics
6 credits:

BIO 613	Life Tables and Survival Analysis
BIO 614	Categorical Data Analysis

9 credits from:

BIO 618	Nonparametric Statistical Methods
BIO 619	Biosatistical Consulting

The following courses are in development: advanced topics and sampling design

Health Policy and Administration
Select either health policy or health care administration.

REQUIRED
6 credits:

26:834:582	Health Care Management
26:834:585	Health Care Policy

Health Policy
15 credits from:

26:790:501	Policy Making in the American Political System
26:790:512	Ethical Issues in Public Policy and Administration
26:790:516	Urban Public Policy
26:834:541	Political Economy and Public Administration
26:834:562	Policy and Program Assessment
26:834:586	Public Health and Violence
26:834:587	Environmental Politics and Policy
26:834:602	Decision Making and Policy Analysis
MPH 660	Health Economics

The following courses are in development: law, health care and public policy; advanced policy analysis; human rights in health care; public health and family; privatization and public health; comparative health care; and quality assurance in health.

Health Care Administration
12 from:
26:705:534 Community Health Nursing Theory II
26:834:521 Technology and Public Administration
26:834:523 Human Resources Administration
26:834:524 Strategic Planning and Management
26:834:527 Cases in Public and Non-Profit Productivity
26:834:584 Health Care Finance
26:834:542 Government Budgeting Systems
The following courses are in development: accounting and financial analysis; public budgeting; managing managed care; health services research; fundamentals of human resource administration; cases in public sector productivity.

Telecommunications

Administered by: Department of Computer and Information Science (CIS) and Department of Electrical and Computer Engineering (ECE)

Chairpersons: Richard A. Haddad (ECE); Joseph Y. Leung (CIS)
Faculty: see listings under the Computer Science, Computer Engineering, Electrical Engineering, and Management degree programs in this catalog

Graduate Advisors: Alexander Haimovich (973) 596-3534 (Room 311 ECE), e-mail haimovic@megahertz.njit.edu; Dennis Karvelas (973) 596-2987 (Room 4211 GITC), e-mail karvelas@cis.njit.edu

Degree Offered: Master of Science in Telecommunications

Telecommunications is one of the most rapidly growing fields in engineering. Telecommunications specialization also is rapidly becoming necessary in such diverse fields as banking, reservation systems, office information systems, corporate networks, and the Internet. Rapid technological progress in gigabit optical networks, multimedia communications, and wireless network access, make the future of the field very exciting.

■ MASTER OF SCIENCE IN TELECOMMUNICATIONS

The objective of this program is to educate individuals in one or more telecommunication specializations.

Admission Requirements

Applicants are expected to have an undergraduate degree in computer science, computer engineering or electrical engineering from an accredited institution (or its equivalent) with a minimum GPA of 3.0 on a 4.0 scale. These students should have taken CIS 333, EE 321 and EE 333 (or their equivalents) or ECE 501. Students without this course work will be required to complete a bridge program. Applicants having degrees in other fields may be considered for admission on an individual basis and required to complete a bridge program.

Bridge Program — The curriculum requires a basic knowledge of computer and communications fundamentals such as programming, data structures, computer architecture, signals and systems, and basic communication systems. Bridge courses do not count toward the degree. The bridge courses are selected from the following list depending on individual background in consultation with the graduate advisor. See the undergraduate catalog for descriptions of 200- to 400-level courses.

CIS 251 Computer Organization
CIS 332 Principles of Operating Systems
CIS 333 Introduction to UNIX Operating Systems
CIS 505 Programming, Data Structures, and Algorithms
CoE 353 Advanced Computer Architecture
* ECE 501 Linear Systems and Random Signals
EE 321 Random Signals and Noise
EE 333 Circuits and Systems III
EE 352 Microprocessors
EE 481 Communications Systems

* EE 321 and EE 333 may be substituted for ECE 501

Graduate Certificate Program — A 12-credit graduate certificate in Telecommunications Networking is available as a step toward this degree. See "Graduate Certificates" in this catalog. For further information about extension programs and graduate certificates, call the associate vice president of continuing and distance education, Division of Continuing Professional Education, 1 (800) 624-9850 or (973) 596-3060; e-mail cpe@njit.edu

Degree Requirements

Candidates must complete a minimum of 30 credits: 15 in core courses and 15 in elective courses in an area of specialization with a minimum overall GPA of 3.0. In addition, a minimum cumulative 3.0 GPA is required in the five core courses. Students with an exceptionally strong telecommunications background may be allowed to replace required courses with advanced electives. Permission of the graduate advisor from the CIS Department or ECE Department is required.

CORE
15 credits:
CIS 630 Operating System Design
CIS 651 Data Communications
{ CIS 652 Computer Networks-Architectures Protocols and Standards *or*
{ ECE 683 Computer Network Design and Analysis
ECE 642 Communication Systems I
ECE 644 Introduction to Wireless and Personal Communication Systems

ELECTIVE
Select 9 credits if completing a master's thesis; 12 credits if completing a master's project; 15 credits if not completing either a master's project or thesis. These courses are to be used in an area of specialization.
CIS 604 Client/Server Computing
CIS 631 Data Management System Design
CIS 633 Distributed Systems
CIS 637 Real-Time Systems
{ CIS 650 Computer Architecture *or*
{ ECE 690 Computer Systems Architecture
CIS 654 Telecommunication Networks Performance Analysis
CIS 656 Internetworking and Higher Layer Protocols
{ CIS 658 Multimedia Systems *or*
{ ECE 649 Compression in Multimedia Engineering
CIS 665 Algorithmic Graph Theory
{ CIS 668 Parallel Algorithms *or*
{ ECE 785 Parallel Processing Systems
CIS 679 Management of Computer and Information Systems
{ CIS 696 Network Management and Security *or*
{ ECE 638 Network Management and Security
{ CIS 697 Principles of Broadband ISDN and ATM *or*
{ ECE 639 Principles of Broadband ISDN and ATM
CIS 752 Communication Protocol Synthesis and Analysis
ECE 673 Random Signal Analysis
ECE 685 Network Interface Design
ECE 646 Introduction to Data Communications
ECE 742 Communication Systems II
ECE 755 Advanced Topics in Digital Communication
ECE 757 Wireless Communications
ECE 783 Computer Communication Networks
MIS 635 Management of Telecommunications
MIS 636 Telecommunications: Policies and Regulations

PROJECT, THESIS (optional)
3 credits:
CIS 700 Master's Project *or*
ECE 700 Master's Project
6 credits:
CIS 701 Master's Thesis *or*
ECE 701 Master's Thesis

AREAS OF SPECIALIZATION
The following are suggested areas of specialization and sample elective courses for each. Students may develop an individual area of specialization in consultation with a graduate advisor.

Management and Administration

CIS 696 / ECE 638	Network Management and Security *or* Network Management and Security
CIS 679	Management of Computer and Information Systems
MIS 635	Management of Telecommunications
MIS 636	Telecommunications: Policies and Regulations

and one additional course

Communication Systems

CIS 697 / ECE 639	Principles of Broadband ISDN and ATM *or* Principles of Broadband ISDN and ATM
CIS 658 / ECE 649	Multimedia Systems *or* Compression in Multimedia Engineering
ECE 646	Introduction to Data Communications
ECE 673	Random Signal Analysis I
ECE 742	Communication Systems II
ECE 755	Advanced Topics in Digital Communication
ECE 757	Wireless Communications
ECE 685	Network Interface Design

Networking

CIS 604	Client/Server Computing
CIS 633	Distributed Systems
CIS 637	Real-Time Systems
CIS 650 / ECE 690	Computer Architecture *or* Computer Systems Architecture
CIS 654	Telecommunication Networks Performance Analysis
CIS 656	Internetworking and Higher Layer Protocols
CIS 665	Algorithmic Graph Theory
CIS 668 / ECE 785	Parallel Algorithms *or* Parallel Processing Systems
CIS 696 / ECE 638	Network Management and Security *or* Network Management and Security
CIS 697 / ECE 639	Principles of Broadband ISDN and ATM *or* Principles of Broadband ISDN and ATM
EE 673	Random Signal Analysis I
EE 783	Computer Communication Networks

Information Technologies

CIS 604	Client/Server Computing
CIS 631	Data Management System Design
CIS 658 / ECE 649	Multimedia Systems *or* Compression in Multimedia Engineering
CIS 696 / ECE 638	Network Management and Security *or* Network Management and Security

one additional course

Other CIS and ECE courses related to telecommunications may be selected as elective courses with the written approval of the corresponding graduate advisor.

Transportation

Administered by: Executive Committee for the Interdisciplinary Program in Transportation

Acting Program Director and Graduate Advisor: Athanassios K. Bladikas (973) 596-3694 (Room 260 TIE), e-mail bladikas@admin.njit.edu

Degrees Offered: Master of Science in Transportation; Doctor of Philosophy in Transportation

NJIT's transportation program prepares students to be transportation planners, engineers, and managers who can plan, design, operate, and manage transportation systems capable of satisfying society's transportation needs.

Transportation is vital to our society's proper functioning, providing mobility of people, goods and services. It enables people to access job markets and participate in recreational, cultural, educational, and social activities. It adds value to products by moving them to their destination in time for their use. The transportation field also is a major contributor to the economy, as a consumer of resources and as a supplier of jobs.

Transportation functions in a very complex environment which, at the beginning of the 21st Century, is characterized by constant change in the technological, regulatory and legal frameworks. Transportation professionals must not only be able to meet the technological challenges of new systems, they must also be capable of fitting these systems into the social, economic, and physical environments in a manner that improves the quality of life for all.

Through the NJIT-based Institute for Transportation, the transportation graduate program provides excellent opportunities for students to engage in research on all forms of transportation, including all phases of activities concerned with the provision of services and the movement of people and goods. The Institute for Transportation is a major resource for public and private organizations and is well-known for its academic programs and research activities.

■ MASTER OF SCIENCE IN TRANSPORTATION

This is a program for students from diverse educational backgrounds with a variety of career goals that prepares them for careers in designing, planning, operating, maintaining and managing urban and rural transportation systems. The master's degree is a valued professional credential for individuals engaged in the transportation field.

Off-Campus Programs — At the New Jersey Department of Transportation (NJ DOT), in Trenton, NJIT offers sufficient courses to fulfill all degree requirements. All courses are taught by NJIT faculty and are open to non-DOT employees. For further information about extension programs, call the associate vice president of continuing and distance education, Division of Continuing Professional Education, 1 (800) 624-9850 or (973) 596-3060; e-mail cpe@njit.edu

Admission Requirements

Applicants should have a bachelor's degree from an accredited institution with some undergraduate background in economics, mathematics, probability and statistics, and computers.

Bridge Program — Students who lack an appropriate background may be admitted and required to make up deficiencies by taking a program of courses designed in consultation with graduate advisors. These courses are taken in addition to the degree requirements. See the undergraduate catalog for descriptions of 100- to 400-level courses. Students may be required to take or demonstrate that they already have taken courses equivalent to the following:

* CE 350	Transportation Engineering
CIS 101	Computer Programming and Problem Solving
Econ 265	Microeconomics
Math 105	Probability and Statistics
Math 309	Mathematical Analysis for Technology

* Students who have demonstrated professional transportation work experience may have this course waived.

Degree Requirements

Students must select one area of specialization and take a minimum of 30 credits. Tran 792 Seminar is required for all students who receive departmental or research-based awards. A maximum of 6 credits may be taken from the 500-level courses for the master of science.

Three general areas of specialization are available. While they share a common methodological core, each is designed to suit various interests:

Transportation Engineering focuses on traffic engineering, physical design and operational aspects of transportation systems. This area is best suited for students with an undergraduate engineering degree.

Transportation Planning emphasizes the analysis and planning aspects, in particular the integration of transportation systems with urban and regional considerations such as economics, land use, and the environment.

Advanced Transportation Systems and Technologies emphasizes the use of emerging technologies such as intelligent transportation systems in planning, design and operations of multi- and inter-modal transportation systems.

CORE
Required for all specializations
9 credits:
Tran 603 Introduction to Urban Transportation Planning
{ Tran 610 Transportation Economics *or*
{ Econ 565 Managerial Economics
{ Tran 650 Urban Systems Engineering *or*
{ EM 602 Management Science

PROJECT, THESIS (optional)
Students may elect to complete a master's project or thesis. These courses are considered as electives.
3 credits: Tran 700 Master's Project
6 credits: Tran 701 Master's Thesis

AREAS OF SPECIALIZATION
Additional elective courses for all areas of specialization may be taken with approval of the graduate advisor.

Transportation Engineering

REQUIRED
9 credits:
Tran 615 Traffic Studies and Capacity
Tran 625 Public Transportation Operations and Technology
Tran 752 Traffic Control

ELECTIVE
Select 6 credits if completing a master's thesis; 9 credits if completing a master's project; 15 credits if not completing either a master's project or thesis, from:
CE 611 Project Planning and Control
EM 691 Cost Estimating for Capital Projects
EnE 671 Environmental Impact Analysis
HRM 601 Organizational Behavior
IE 651 Industrial Simulation
Math 661 Applied Statistics
ME 635 Computer-Aided Design
Mgmt 692 Business Strategy
MIS 648 Decision Support Systems
Mktg 632 Marketing Strategy for Technology-Based Organizations
Tran 552 Geometric Design of Transportation Facilities
Tran 553 Design and Construction of Asphalt Pavements
Tran 602 Geographic Information Systems
Tran 608 Behavioral Issues in Transportation Studies
Tran 640 Distribution Logistics
Tran 653 Traffic Safety
Tran 659 Flexible and Rigid Pavements
Tran 700 Master's Project
Tran 701 Master's Thesis
Tran 753 Airport Design and Planning
Tran 754 Port Design and Planning
Tran 755 Intelligent Transportation Systems
Tran 760 Urban Transportation Networks

Transportation Planning

REQUIRED
9 credits:
Tran 655 Land Use Planning
{ Tran 625 Public Transportation Operations and Technology *or*
{ Tran 705 Mass Transportation Systems
Tran 765 Multi-modal Freight Transportation Systems Analysis

ELECTIVE
Select 6 credits if completing a master's thesis; 9 credits if completing a master's project; 15 credits if not completing either a master's project or thesis, from:
CE 611 Project Planning and Control
EnE 671 Environmental Impact Analysis
Fin 630 Applied Business Econometrics
HRM 601 Organizational Behavior
HRM 606 Human Resource Management
HRM 662 Organizational Diagnosis and Development
Math 661 Applied Statistics
Mgmt 691 Legal and Ethical Issues
Mgmt 692 Business Strategy
MIS 620 Computing Concepts for Managers
Mktg 632 Marketing Strategy for Technology-Based Organizations
Tran 602 Geographic Information Systems
Tran 604 Public and Private Financing of Urban Areas
Tran 608 Behavioral Issues in Transportation Studies
Tran 615 Traffic Studies and Capacity
Tran 640 Distribution Logistics
Tran 643 Transportation Finance
Tran 653 Traffic Safety
Tran 700 Master's Project
Tran 701 Master's Thesis
Tran 720 Discrete Choice Modeling for Travel Demand Forecasting
Tran 740 Management of Transportation Carriers
Tran 753 Airport Design and Planning
Tran 755 Intelligent Transportation Systems
Tran 760 Urban Transportation Networks

Advanced Transportation Systems and Technologies

REQUIRED
9 credits:
Tran 615 Traffic Studies and Capacity
Tran 755 Intelligent Transportation Systems
Tran 765 Multi-modal Freight Transportation Systems Analysis

ELECTIVE
Select 6 credits if completing a master's thesis; 9 credits if completing a master's project; 15 credits if not completing either a master's project or thesis, from:
CIS 610 Data Structures and Algorithms
CIS 651 Data Communication
CIS 661 System Simulation
ECE 609 Artificial Neural Networks
ECE 642 Communication Systems
EM 714 Multicriteria Decision Making
EnE 671 Environmental Impact Analysis
HRM 601 Organizational Behavior
IE 624 Heuristic Methods
IE 642 Network Flows and Applications
IE 644 Application of Stochastic Modeling in Systems Control
IE 651 Industrial Simulation
IE 705 Mathematical Programming in Management Science
IE 706 A Queueing Approach to Performance Evaluation
Math 661 Applied Statistics
ME 635 Computer-Aided Design
Mgmt 692 Business Strategy
MIS 648 Decision Support Systems
Mktg 632 Marketing Strategy for Technology-Based Organizations
Mktg 636 Design and Development of High Technology Products
Mktg 640 Industrial Marketing Management
Tran 602 Geographic Information Systems
Tran 608 Behavioral Issues in Transportation Studies
Tran 625 Public Transportation Operations and Technology
Tran 640 Distribution Logistics
Tran 700 Master's Project
Tran 701 Master's Thesis
Tran 752 Traffic Control
Tran 760 Urban Transportation Networks

■ DOCTOR OF PHILOSOPHY IN TRANSPORTATION

The doctoral program is for well-qualified students who are mature in scholarship and purpose. It offers a well-balanced mixture of theoretical studies and experimental research. A student must demonstrate creative thinking, self-motivation, and ability to do independent research. In their research, students are expected to deal with complex issues, effectively formulate difficult problems, devise new methodology, and achieve new and exceptional results.

Admission Requirements

Students should have adequate preparation in mathematical and other analytical techniques, and substantial knowledge of the ideas and techniques of synthesis. A thorough understanding of the social and economic factors intrinsic to the functioning and development of transport in urban areas also is necessary. It is expected that students will have earned a minimum GPA of 3.5 in a master's degree program in engineering, planning, or business administration from an accredited university. Outstanding students with baccalaureate degrees also may be accepted. All applicants must take the GRE. Full-time study is preferred for doctoral studies.

Degree Requirements

Requirements consist of a minimum of 54 credits of course work beyond the bachelor's degree, including at least 12 credits of 700-level courses, passage of a qualifying examination, a minimum of 36 credits of Tran 790 Doctoral Dissertation and Tran 791 Doctoral Seminar. Independent original research must be conducted by the candidate in a specific area of transportation. Dissertation work must be of publishable quality.

Dissertation — A program committee must approve a dissertation topic and an NJIT faculty member, approved by the program, must be available to supervise the dissertation research. An oral defense of the dissertation is required after the dissertation committee accepts the written document.

Qualifying Examination — All doctoral students must pass a doctoral qualifying examination. To prepare adequately for the examination, students should take appropriate course work in transportation engineering, transportation planning, and advanced transportation systems and technologies, as well as other related subjects.

The examination has four parts: the first three are written, and the fourth is oral. The oral part is given after the written parts are evaluated.

Part I Analytical Techniques
Part II Transportation Facilities and Operations
Part III Transportation Planning and Technologies
Part IV Oral (includes a field problem)

For additional information about doctoral degree requirements, refer to the Academic Policies and Procedures section of this catalog.

Graduate Certificates

Administered by: Division of Continuing Professional Education

Associate Vice President, Continuing and Distance Education:
Gale Tenen Spak (973) 596-8540

Graduate Certificates Offered: Computer Networking; Electronic Media Design; Environmental Infrastructure and Management; Health Care Information Systems; Information Systems Design and Development; Internet Applications Development: Managing Human Resources; Object-Oriented Design; Practice of Technical Communications; Programming Environment Tools; Project Management; Telecommunications Networking.

Note: Because they are employment-driven, the particular graduate certificates offered in any given year may change. See the Continuing Professional Education Catalog for current listings.

Students study through electronic means or attend one or two, 3-hour class(es) per week in a lock-step sequence on weeknights and Saturdays at NJIT's Newark campus or at off-campus, extension locations.

The Graduate Certificate program is designed to facilitate the return to formal advanced education by busy adult professionals. Each Graduate Certificate is in a professional field externally validated as "fast track" with employment opportunities through the year 2005. Critical to the arrangement for each Graduate Certificate is the philosophy that NJIT course work can proceed quickly in one calendar year and in tandem with other endeavors of an equally demanding nature such as full-time employment and family/childcare responsibilities.

Certificates may be completed in one calendar year by attending designated or lock-step courses in fall, spring and summer sessions. A typical schedule for students who begin in the fall is: one course in the fall, two in the spring, and one in the summer. Students who start in a spring semester register for one course each in the spring and summer; and two in the following fall. (Should students' outside pursuits or constraints prevent adherence to this pacing, it may be possible either to accelerate the pacing or to register for missed courses at a later time).

Students can complete some Graduate Certificates in whole and others in part through classes conducted via electronic communications that demand equal effort but which do not require formal classroom attendance. More details concerning the electronic classroom are furnished in the Continuing Professional Education Catalog.

Academic Standards

Whether taking courses at the Newark campus, at extension sites or by distance learning, participants in the Certificate Program are expected to comply with all the standards and regulations governing NJIT graduate study as set forth in this catalog. Students should be cognizant of any bridge courses or prerequisites for courses within the certificate programs.

Admission Requirements

As documented by transcript(s), students must possess, at minimum, an undergraduate degree from an accredited college or university with a GPA that meets NJIT academic standards for regular admission as a matriculated master's program student.

Students must submit an application form for the certificate program in the non-degree (non-matriculated) NJIT admission classification. Application forms are available from the Division of Continuing Professional Education or on-line: www.njit.edu/CPE/form/CPEadmission.html.

On evaluation of prior academic record and other factors, program directors or designees may advise prior completion of bridge course(s) required to facilitate the student's academic performance.

In general, students attending NJIT on a non-matriculated basis are limited to enrolling in no more than three graduate courses. As a special feature of the Graduate Certificate Program, students in good standing who have completed 9 credits toward a certificate will be granted a waiver by the Office of Graduate Studies to continue as a non-matriculated student for the purpose of completing the remaining graduate certificate requirements.

It is anticipated that some certificate recipients may desire to continue their studies to a corresponding master's degree. Regular university procedures and policies will apply to those interested in making such a progression. These will typically include completion of an application for admission to a degree program, submission of all required transcripts, test scores and letters of reference, and payment of application fees.

Certificate Requirements

A student must complete 12 graduate credits in the four pre-selected courses that define the certificate and achieve a 3.0 GPA. Any bridge course requirements must also have been satisfactorily completed. If, after the advisor's evaluation of courses taken in prior programs at NJIT or at other institutions, the student demonstrates that as many as two of the four courses required for the certificates have already been completed, substitute courses may be approved by the advisor for the certificate. The graduate certificate programs, required courses and corresponding related master's degrees are listed below.

Computer Networking
Relates to M.S. in Computer Engineering
CIS 656 Internetworking and Higher Layer Protocols
** ECE 681 Broadband Packet Switches
** ECE 682 Computer Networks
ECE 685 Network Interface Design

Electronic Media Design
Relates to M.S. in Information Systems or M.S. in Professional and Technical Communication
CIS 677 Information System Principle
CIS 732 Design of Interactive Systems
Two courses from:
CIS 675 Information System Evaluation
* Eng 610 Creating Hypertext: A Task-Oriented Approach
Eng 613 Multimedia Presentations
** Eng 698 Special Topics in Professional and Technical Communication

Environmental Infrastructure and Management
Relates to M.S. in Environmental Policy Studies
EM 631 Legal Aspects of Environmental Engineering
EPS 612 Introduction to Environmental Policy Studies
One course from:
EPS 614 Environmental Economics
EvSc 614 Quantitative Environmental Risk Assessment
One course from:
Acct 615 Concepts of Strategic Cost Analysis
CE 602 Geographic Information System
** EvSc 602 Special Topics in Environmental Science I
EvSc 613 Environmental Problem Solving

* pending
** See Continuing Professional Education catalog for course descriptions.

Health Care Information Systems
Depending on courses, relates to M.S. in Management, M.S. in Information Systems or M.S. in Biomedical Informatics, offered jointly with UMDNJ. This certificate is offered in cooperation with UMDNJ.
One course from:
BINF 600/BINF 5100 Introduction to Biomedical Informatics
MIS 620 Computer Concepts for Managers
One course from:
BINF 601/BINF 5005 Health Care Information Systems
MIS 645 Operations Management, Planning and Control
One course from:
CIS 675 Information System Evaluation
MIS 690 Executive Information Systems
One course from:
CIS 677 Information System Principles
MIS 648 Design Support Systems

Information Systems Design and Development
Relates to M.S. in Information Systems
CIS 675 Information System Evaluation
CIS 677 Information System Principles
Two courses from:
CIS 634 Information Retrieval
CIS 731 Applications of Database Systems
CIS 732 Design of Interactive Systems
OR
CIS 673 Software Design and Production Methodology
CIS 676 Requirements Engineering
CIS 679 Management of Computer and Information Systems

Internet Applications Development
Relates to M.S. in Information Systems
CIS 675 Information System Evaluation
CIS 677 Information System Principles
Two courses from:
CIS 601 Object-Oriented Programming
* CIS 602 WWW: Applications Development and Java
CIS 656 Internetworking and Higher Layer Protocols

Managing Human Resources
Relates to M.S. in Management
HRM 650 Human Resource Information Systems
HRM 662 Organizational Diagnosis and Development
One course from:
HRM 601 Organizational Behavior
HRM 630 Managing Technological and Organizational Change
One course from:
HRM 606 Human Resource Management
HRM 693 Employment Relationships and the Law

Object-Oriented Design
Relates to M.S. in Computer Science or M.S. in Information Systems
CIS 601 Object-Oriented Programming
CIS 673 Software Design and Production Methodology
CIS 677 Information System Principles
CIS 683 Object-Oriented Software Development

Practice of Technical Communications
Relates to M.S. in Professional and Technical Communication
Eng 601 Advanced Professional and Technical Communication
Eng 605 Document Design and Desktop Publishing
Two courses from:
Eng 613 Multimedia Presentations
Eng 620 Proposal Writing
Eng 622 Collaborative and Interpersonal Communication
Eng 624 Professional and Technical Editing
Eng 642 Professional Writing

Programming Environment Tools
Relates to M.S. in Computer Science or M.S. in Information Systems
CIS 601 Object-Oriented Programming
CIS 603 Advanced Programming Environments and Tools
Two courses from:
CIS 604 Client/Server Computing
CIS 631 Data Management System Design
CIS 658 Multimedia Systems

Project Management
Relates to M.S. in Engineering Management
EM 637 Project Control
EM 691 Cost Estimating for Capital Projects
One course from:
CE 610 Construction Management
EM 636 Project Management
One course from:
EM 631 Legal Aspects in Environmental Engineering
EM 632 Legal Aspects in Construction Management
EM 634 Legal, Ethical and Intellectual Property Issues for Engineering Managers

Telecommunications Networking
Depending on courses, relates to M.S. in Computer Science, M.S. in Telecommunications or M.S. in Electrical Engineering
CIS 652 Computer Networks—Architectures, Protocols and Standards
ECE 683 Computer Network Design and Analysis
One Course from:
ECE 501 Linear Systems and Random Signals
ECE 673 Random Signal Analysis I
One course from:
CIS 656 Internetworking and Higher Layer Protocols
ECE 783 Computer Communication Networks

* pending

Courses of Instruction

NJIT Courses

The courses listed here have been approved in accordance with the policies of NJIT. Department or university needs may necessitate changes in this list, and courses may be cancelled because of insufficient registration. A list of scheduled courses will be issued by the registrar before each semester begins. Information found in the Degree Programs section of this catalog serves as a guide for program planning in consultation with departmental or program advisors.

ALPHABETICAL CODE

Acct	Accounting
Arch	Architecture
BINF	Biomedical Informatics
BME	Biomedical Engineering
CE	Civil Engineering
ChE	Chemical Engineering
Chem	Chemistry
CIS	Computer and Information Science
ECE	Electrical and Computer Engineering (formerly CoE, EE)
Econ	Economics
EM	Engineering Management
EnE	Environmental Engineering
Eng	English
EPS	Environmental Policy Studies
EvSc	Environmental Science
Fin	Financial Management
Hist	History
HRM	Human Resource Management
IE	Industrial Engineering
Math	Mathematics
ME	Mechanical Engineering
Mech	Mechanics
Mgmt	Management
MIP	Infrastructure Planning
MIS	Management Information Systems
MnE	Manufacturing Systems Engineering
MPH	Public Health
Mrkt	Marketing Management
MtSE	Materials Science and Engineering
OPSE	Optical Science and Engineering
OSIH	Occupational Safety and Industrial Hygiene
Phys	Physics
Tran	Transportation

NUMERICAL CODE

Numbers from 500 to 599 (500G to 599G for Architecture) indicate entry-level graduate courses normally offered for students who require additional background for admission to 600- or 700-level courses.

Numbers from 600 to 699 indicate intermediate-level graduate courses normally associated with master's-level study.

Numbers from 700 to 799 indicate advanced-level graduate courses normally associated with doctoral-level study.

Rutgers-Newark Courses

The number preceding each course title is divided into three parts. The first two digits are the administrative code (standing for a faculty or a school), the next three digits are the subject code, and the final three digits are the course code.

ADMINISTRATIVE CODES

The following administrative codes are used in this catalog.

16 Graduate School-New Brunswick
25 College of Nursing
26 Graduate School-Newark

SUBJECT CODES

The following subject codes are used in this catalog.

120 Biology
215 Ecology and Evolution
460 Geology
510 History
620 Management
630 Marketing
705 Nursing
711 Operations Management
755 Physics, Applied
790 Political Science
834 Public Administration
960 Statistics

COURSE CODES

Two course codes separated by a comma indicate that each term course may be taken independently of the other, e.g., 26:70:537,538.

Courses numbered in the 500s and 600s are for graduate students in advanced-degree programs. Courses numbered in the 700s are ordinarily intended for students preparing individual research theses for advanced degrees.

UMDNJ Courses

NUMERICAL CODE

The UMDNJ School of Health Related Professions courses listed in this catalog are at the 5000 and 6000 level and correspond to NJIT's 600-level courses, those normally associated with master's-level study; those at the 7000 level correspond to NJIT's 700-level courses, those normally associated with doctoral-level study. The UMDNJ–New Jersey Medical School courses listed in this catalog numbered in the 600s correspond to NJIT's 600-level courses, those normally associated with master's-level study.

ALPHABETICAL CODE

BINF	Biomedical Informatics
BIO	Biostatistics
EPI	Epidemiology
QM	Quantitative Methods

Accounting

Offered by the School of Management

Acct 515
Accounting for Managerial Control 3 credits
Case study approach to accounting issues that have an impact on management decision making: nature of managerial accounting, cost behavior, cost-volume-profit analysis, full costing and its use, standard costs, variances, differential cost analysis, and responsibility accounting.

Acct 610
Internal Auditing Concepts and Procedures 3 credits
The entire internal audit function including planning, surveying, audit performance, work paper documentation, reporting, standards, controls, sampling, and fraud detection.

Acct 615
Concepts of Strategic Cost Analysis 3 credits
Builds on traditional concepts of managerial accounting (break-even analysis, alternate choice decisions, profit planning, and transfer pricing) and develops the skills that an executive needs in strategic cost analysis. Explores strategic decisions of value chains and activity-based management. Emphasis on using managerial accounting data in executive planning and control.

Acct 630
Concepts and Applications of Control 3 credits
Examines the need for and implementation of internal controls to protect corporate assets. Emphasizes the role of the controller in the organization.

Acct 650
Operational Auditing 3 credits
Stresses the functions of the auditor in assessing the effectiveness and efficiency of operations. Includes such areas as environmental auditing, auditing the human resource management function, auditing OSHA, psychological impact on internal auditors, auditing in a just-in-time environment, ethics, and auditing for fraud. Financial areas are discussed only to the extent of their operational impact.

Acct 670
Seminar in Accounting Theory 3 credits
Focuses on contemporary areas relating to accounting theory. Taught from the viewpoint of the corporate controller.

Acct 680
Seminar in Auditing 3 credits
Discusses contemporary auditing topics as they impact on management control and decisions.

Acct 690
Seminar in Taxation 3 credits
Focuses on contemporary issues in taxation as they impact on the corporate decision making process.

Architecture

Offered by the School of Architecture

Arch 500G
Computer Programming and Graphics Problems 2 credits
Introductory computer science with applications in computer graphics for architecture. Emphasizes programming methodology using a high-level language as the vehicle to illustrate concepts. Basic concepts of computer systems, software engineering, algorithm design, programming languages, and data abstraction, with applications.

Arch 501G
Architectural Design I 5 credits
Prerequisite: graduate level standing. Core Studio. Fundamentals of architectural design. Sequence of projects explore two- and three-dimensional design. Choice of form and aesthetics is related to spatial resolution of function and context. Design as a representational medium is emphasized. Taken concurrently with Arch 555G.

Arch 502G
Architectural Design II 5 credits
Prerequisites: Arch 501G, Arch 521G, Arch 528G, Arch 555G. Core Studio. Extends the knowledge of design, basic concepts and ideas introduced in Arch 501G. Emphasis is on developing technical drawing, and model-making skills. Also covered are two- and three-dimensional composition. Links to the history and theory sequence are made.

Arch 503G
Architectural Design III 5 credits
Prerequisites: Arch 502G, Arch 511G, Arch 522G, Arch 529G, Core Studio, Intermediate design studio. Introduction to structure. Properties of materials both physical and in the abstract. Builds on knowledge gained from construction and structures courses, spatial demands and design possibilities of different structural systems. Design of structure type, model and context, and comparisons of building typology for rational structure. Drawing and its role in design thinking.

Arch 504G
Architectural Design IV 5 credits
Prerequisites: Arch 503G, Arch 512G, Arch 523G. Arch 500G, Core Studio. Second semester intermediate design studio. Design of buildings and integration of systems, physical and conceptual. Design methodology generates new information on buildings as coherent assemblies of systems. Also covers analysis and synthesis of form and introduction to applications of computer-assisted design (CAD). Preparation of design portfolio will complete core studio sequence.

Arch 505G, Arch 506G, Arch 507G
Advanced Design Options I, II, III
6 credits each
Prerequisites: completion of all core courses or their equivalent. Required vertical studio electives; must be taken sequentially. Covers a range of advanced design issues in depth: integration of organizational, social, technical, spatial, and aesthetic issues within consistently articulated applied design solutions.

Arch 511G
Structures I 3 credits
Prerequisites: graduate level standing, college level physics and calculus or equivalent, Arch 521G. Introduces structural statics through timber and steel design. Analysis and selection of building materials and structural systems related to their impact on building design.

Arch 512G
Structures II 3 credits
Prerequisites: Arch 511G, Arch 522G. Builds on information presented in Arch 511G. Emphasizes details and methods of concrete design, mixing, pouring and testing. Methods and details of steel design are summarized.

Arch 513G
Structures III 3 credits
Prerequisite: Arch 512G. Review of methods and procedures for choosing structural systems. Overview of differences among wood, steel and concrete systems. Students are introduced to complex structural behavior, prestressed concrete and new structural technology.

Arch 521G
Construction I 3 credits
Prerequisite: graduate level standing. Introduction to the construction process and how it relates to architecture. Compatibility of materials and methods of construction are studied with respect to wood, heavy timber, steel and masonry construction. Emphasis is placed on materials compatibility, construction technology, and the role of architectural documents in the construction process.

Arch 522G
Construction II 3 credits
Prerequisite: Arch 521G. Continuation of 521G. Construction practices and details of steel, precast and poured-in-place concrete construction. Review of testing methods, procedures for setting standards, forces of determination, and new materials research. Emphasis is on materials and systems selection criteria.

Arch 523G
Building Performance 3 credits
Prerequisites: Arch 522G, college level physics or equivalent. Impact on building design of heat, air movement, and thermal mass in an array of climatic conditions. Also covered are dynamic thermal and passive solar analysis for energy-conscious architectural design.

Arch 524G
Environmental Control Systems 3 credits
Prerequisite: Arch 523G. Analysis of different configurations of building equipment systems related to building design and life cycle costs. Relationships among mechanical, electrical, plumbing and transport systems are examined. The role of the architect and other professionals in equipment design and selection are studied, with an emphasis on criteria for system selection.

Arch 528G
History of Architecture I 3 credits
Prerequisite: graduate level standing. Introduction to the history of architecture. Emphasis on classical architecture from antiquity to the modern period. Evolution of the various themes and theories that underlie western architecture is presented chronologically.

Arch 529G
History of Architecture II 3 credits
Prerequisite: Arch 528G. Continuation of Arch 528G. Introduces concepts of modernism and brings the history of western architecture to the contemporary period.

Arch 555G
Architectural Graphics 3 credits
Prerequisite: graduate level standing. Documentary, descriptive and denotative media are introduced. Also covers methods of representation, delineation and reproduction. Skills are developed in technical drawing, perspective construction, projections, and format design. Taken concurrently with Arch 501G.

Arch 569G
Building and Development 3 credits
Familiarization with the larger process of building production, of which architecture is one important part. Focus on the role of the architect in the areas of current building development: an examination of how redefinition or change might improve the process. Lectures deal with all factors of the building process and interviews with the various actors involved in designing, approving, financing and making buildings. Students have various assignments including a major term project.

Arch 579G
Professional Architectural Practice
3 credits
Prerequisite: completion of M.Arch. core sequence. Review of the formal, informal, legal, and ethical obligations of the professional architect. Traditional relationships among the architect, clients, engineers and other participants in the design and building industry are studied. Principles of office management and problems of liability are introduced. Also fulfills core requirement of dual degree option for M.Arch./Master of Science in Management.

Arch 619
Architectural Photography 3 credits
Prerequisites: Arch 501G, Arch 502G, Arch 503G. Photography for architectural presentations and portfolios. Lectures include orientation on light and space, slide presentations, and the use of text to reinforce photographic material. Demonstrations include basic darkroom techniques, and methods to encourage experimentation in photography.

Arch 630
Methodology of Architectural History, Theory and Criticism 3 credits
Prerequisites: Arch 528G, Arch 529G. This seminar is structured around notable readings on architectural history, theory and criticism to provide students with a sound basis for critical analysis and assessment. It is recommended for students who select history and theory as their area of concentration.

Arch 631A
History of Renaissance Architecture 3 credits
Prerequisites: Arch 528G, Arch 529G. Development of architecture and urban design in Italy and elsewhere in Europe during the Renaissance: re-emergence of the classical Greek and Roman architectural tradition; social, political and economic developments; formal intentions and transformations in the 16th and 17th centuries.

Arch 631B
History of Baroque Architecture 3 credits
Prerequisites: Arch 528G, Arch 529G. The emergence of baroque architecture and urban design in Rome in the 17th century; analysis of the works of Bernini, Borromini, Cortona and their contemporaries and successors through 1750. Development of baroque architecture elsewhere in Italy and Europe; late baroque and rococo; the advent of neo-classicism.

Arch 631C
History of Modern Architecture 3 credits
Prerequisites: Arch 528G, Arch 529G. Major tendencies in architectural theory and practice from the mid-19th to the mid-20th centuries. Formal and stylistic transformation considered in relation to theory, social, cultural, and technical developments.

Arch 631D
History of American Architecture 3 credits
Prerequisites: Arch 528G, Arch 529G. Aesthetic, social, cultural and technical developments in American architecture and planning, from colonial times to the mid-20th century.

Arch 631E
History of Non-Western Architecture 3 credits
Prerequisites: Arch 528G, Arch 529G. Examination of major architectural traditions and styles of China, Japan, Southeast Asia, India and the Middle East.

Arch 631F
Thresholds of Architectural Theory 3 credits
Prerequisites: Arch 528G, Arch 529G. Seminar on Western architectural theory dating from Vitruvius to the present time. Examines critical texts and studies related building and projects.

Arch 631H
History and Theory of Infrastructure 3 credits
Prerequisites: Arch 528G, Arch 529G. The historical role of infrastructure in the formation of cities and the relation of planning theories to urban culture. Case studies are used to develop effective ways of learning urban design; method and substance are equally emphasized. Concentration on the social, economic, political, technological and topographic factors that affect urban form; analysis of urban design schemata and their relation to patterns of use; and the critical appraisal of planning ideologies and strategies. *Same as MIP 631.*

Arch 632
Problems and Methods in Architectural Preservation 3 credits
Prerequisites: Arch 528G, Arch 529G. Theory and practice of preservation planning. Compares American and European preservation concepts, problems and techniques. Also covers theories on continuity and change in urban environments, and preservation-planning for community development and neighborhood conservation.

Arch 633
Case Studies in Architectural Creativity 3 credits
Prerequisite: Arch 528G, Arch 529G. Considers creativity in architecture from psychological, philosophical and autobiographical perspectives. The buildings writings and lives of contemporary architects are discussed in the context of general theories of creativity. Each student chooses an individual architect noted for creative accomplishments and prepares a case study of his or her life.

Arch 634
History of Architectural Technology 3 credits
Prerequisites: Arch 528G, Arch 529G. Survey of the development of building methods and materials. Impact of structural and environmental technology on architectural form and the design process. The role of technology in contemporary architectural theory and practice including the modern movement is emphasized. Recommended for students who select building science as their area of concentration.

Arch 640
Acoustics 3 credits
Prerequisites: completion of core sequence or equivalent. Architectural acoustics: how we hear, physics of sound and materials, aesthetics of design and the processes of construction. Audible sounds, their interaction, perception of echo and directional hearing are applied to interior and exterior building transmission, room acoustics, and setting acceptable acoustical environments.

Arch 641
Experiments in Structural Form 3 credits
Prerequisites: completion of core sequence or equivalent. Architectural form through model design, construction and testing of minimum structures, including elements of soap film study, orthogonal and diagonal grids, design of tension grids through deflection loading, photoelastic models and calculation. Also compares geometric systems, patterning and proportion, symmetry, asymmetry, relative size, nesting, linearity and spiral orders, rectilinear patterns, and randomness in architectural structure and form.

Arch 643
Lighting 3 credits
Prerequisites: Arch 501G, Arch 502G, Arch 503G, Arch 523G, Arch 524G. Through modeling and calculation, influence of the luminous environment on architectural form and detail. Perceptions of visual comfort and daylight are examined. Topics include daylighting footprints, model design and testing, and computer-assisted, light-level analysis. Relationship between daylight and artificial light in architecture, variations of light with time, analysis of seasonal and weather differences, role of task in lighting strategies, and means of control for light quantity and quality.

Arch 644
Systems Approach to Design and Construction 3 credits
Prerequisite: completion of core sequence. Lectures, case studies and student projects on understanding human aspirations and needs through design. Topics include land, finance, management, technology and labor.

Arch 645
Case Studies in Architectural Technology 3 credits
Prerequisite: completion of core sequence. Case-study method used for in-depth investigation of the relationship among various technological systems in a building and technologically-related problems in architecture and construction.

Arch 646
Designing and Optimizing the Building Enclosure 3 credits
Prerequisite: completion of core sequence. Considers the "building envelope," the boundary dividing the inside of a structure from the outside environment. Students study and design optimal enclosures considering energy exchange, the relationship between energy and lighting, and life cycle costs.

Arch 647
Special Topics in Computer Applications 3 credits
Prerequisite: completion of core sequence. Evaluation and use of computer graphics hardware and software for architectural applications. Focus is on computers as tools, operating systems and methods of data manipulation. Two- and three-dimensional modeling software are discussed, and assignments using such software are given to provide understanding of the modeling of built environments.

Arch 649
Life Safety Issues in Contemporary Buildings 3 credits
Prerequisite: completion of core sequence. A variety of life safety and comfort situations are studied in different building types. Topics include building evacuation, compartmentalizing, fire fighting and suppression, evaluation and testing of new building materials and systems, systems control and management. Special attention is placed on multi-use, high-density buildings.

Arch 650
Economy of Building 3 credits
Prerequisite: completion of core sequence or equivalent. Economic consequences of design decisions. Topics include: relationship among economy, efficiency and quality; life-cycle cost of design; improving the economy of building processes and products through innovation;

and environmental concerns. This course is required for the dual degree M.Arch./Master of Science in Management program. It can also be used as an elective in the M.Arch. program.

Arch 651
Real Estate Analysis for Architects 3 credits
Prerequisite: completion of core sequence. Introduction to the economic, financial and political aspects of real estate and their effect on architectural decision-making. Topics include: needs assessment, real estate appraisal, financial instruments, regulations and real estate, design as value-adding, and the effect of tax policies on real estate development. This course is required for the dual degree M.Arch./Master of Science in Management program. It can also be used as an elective in the M.Arch. program.

Arch 652
Architectural Project Management 3 credits
Prerequisites: completion of core sequence and Arch 579G. Management of architectural projects: project costs, timing, personnel, documentation, professional ethics and resource management. This course is required for the dual degree M.Arch./Master of Science in Management program. It may be used as an elective in the M.Arch. program.

Arch 661
Directed Studies of Architecture 3 credits
Prerequisites: completion of core and two elective courses; and approval from the graduate advisor. Independent, in-depth research on an analytical, theoretical or technical area of architecture. Student prepares formal research proposal with permission of faculty advisor and approval of graduate advisor. Required as prethesis research. See also course description for MARC 701.

Arch 662
Special Topics in Architecture 3 credits
Topics vary each semester. Refer to the School of Architecture bulletin during university registration periods for a list of current topics and possible prerequisites.

Arch 672
Architecture and Social Change 3 credits
Prerequisite: graduate level standing. Analysis of architectural form with respect to political, economic and technological change. The built environment is studied in relation to society and culture. The role of design professions in initiating or supporting change is also considered.

Arch 673
Infrastructure Planning in Practice 3 credits
Infrastructure planning principles, methods and tools. Through selected examples, acquaintance with infrastructure planning theories and models, quantitative methods of research and analysis, information management, decision making, and implementation techniques. *Same as MIP 673.*

Arch 674
Infrastructure and Architecture 3 credits
Examination of areas of overlap and continuity between architecture, landscape architecture, urban design, building science and infrastructure. Topics include the typology, programming and design of public facilities; the housing fabric; the relation between built form, urban space and infrastructure. *Same as MIP 674.*

Arch 675
Elements of Infrastructure Planning
3 credits
Introductory survey of the basic principles, operation and design of physical infrastructure systems including roads, public transportation, community facilities, public open space, surface drainage, and electric, gas, water, waste disposal, and telecommunications services. *Same as MIP 675.*

Arch 676
The Architecture of Utopia 3 credits
Prerequisite: graduate level standing. Seminar looks at several ideas of utopia from literature and philosophy and how they embody transformations in the structure of space, and their architectural implications.

Arch 678
Graduate Problems in Modern Housing
3 credits
Prerequisite: graduate level standing. Students learn to analyze political, technical and economic aspects of contemporary housing policy and practice. Attempts to provide well-designed, affordable housing responsive to the needs of large numbers of people are examined. Examples of housing from the mid-19th century to the present day are outlined.

Arch 680
Graduate Co-op Work Experience I
3 additive credits
Prerequisites: completion of core sequence, permission from graduate advisor and Division of Career Development Services. Students gain work experience and reinforcement of their academic programs. An architecture faculty Co-op advisor monitors and evaluates student work and project. Co-op work experiences may be acceptable equivalents for apprenticeships mandated by the New Jersey State Board of Architects and for eligibility to take the architecture licensing examination. This course is required for participation in the Housing Scholars Program. Course does not fulfill degree requirements.

Arch 681/682
Graduate Co-op Work Experience II and III
3 additive credits
Prerequisites: completion of core sequence, permission of graduate advisor and Division of Career Development Services. Used for extended summer-fall (681) or spring-summer (682) work experience. Does not fulfill degree requirements.

Arch 686
Research Methods for Environmental Design 3 credits
Introduction to methods of inquiry useful to professionals planning and designing buildings, communities and cities. Skills developed in problem definition and phenomena: measurement, modeling, testing and evaluation. Open to undergraduates with permission of instructor.

MARC 701
Master's Thesis 6 credits
Prerequisites: Arch 506G, Arch 661, and approval from graduate advisor. Alternative to Arch 507G. Under the supervision of a faculty advisor, independent study of issues in the student's area of concentration developed during Arch 661.

MSAS 701
Master of Science in Architectural Studies Thesis 6 credits
Prerequisites: completion of required courses, electives, Arch 661 and approval from MSAS advisor. Under supervision of a thesis advisor, independent, in-depth examination of a subject in the student's area of concentration developed during Arch 661.

Biology

Offered by the Federated Biological Sciences Department of NJIT and Rutgers-Newark

26:120:501
Neuroanatomy 3 credits
Equivalent to 26:112:501. Overview of the neuroanatomical systems of the mammalian nervous system.

26:120:503
Plant Morphology 3 credits
Prerequisites: undergraduate ecology or botany, or permission of instructor. A study of the major groups of vascular plants: lycopods, ferns, gymnosperms, and angiosperms. Emphasis on their morphology, anatomy, and reproductive biology with discussion of evolutionary trends and occurrence in the fossil record.

26:120:504
Plant Physiology 3 credits
Prerequisites: 26:120:503, organic chemistry, and physics, or permission of instructor. Survey of modern aspects of plant physiology with emphasis on recent literature. Topics include photosynthesis, nitrogen metabolism, transport, development, and physiological genetics.

26:120:505
Biostatistics and Computer Methodology
3 credits
Prerequisite: college algebra. Advanced introduction to computer programming and biometry with some use of common mathematical procedures useful to the biologist.

26:120:506
Quantitative Plant Ecology 3 credits
Prerequisite: 26:120:503 or permission of instructor. A survey of plant autecology, synecology, plant geography, and analytical techniques and methods useful in studying the relationships between plants and their environment.

26:120:509,510
Advanced Problems in Biology
1 to 6 credits by arrangement
Advanced studies to meet the needs of individual students.

26:120:512
Mammalian Physiology 3 credits
Prerequisites: introductory courses in anatomy, physiology, and biochemistry, or permission of instructor. The function, regulation, and interrelationships of the different organs and organ systems of mammals, particularly the nervous, cardiovascular, respiratory, excretory, and digestive systems.

26:120:515
Molecular Biology of Eukaryotes 3 credits
Prerequisite: biochemistry. First-year graduate course providing an accelerated review of eukaryotic molecular biology. Introduces critical reading and discussion of current journal articles. Nucleic acid biochemistry, molecular technology, transcription, RNA processing, chromosomal structure, molecular anatomy of the genome, genomic rearrangements, gene control signals, DNA-protein binding, carcinogenesis and oncogenes.

26:120:517
Developmental Neurobiology 3 credits
Prerequisite: 21:120:342. Developmental processes in vertebrate nervous systems with a critical analysis of current theories.

26:120:518
Nucleic Acids 3 credits
Prerequisites: 21:115:403,404 or 26:120:571 or equivalent, or molecular biology, or permission of instructor. An advanced seminar emphasizing current research in selected topics in nucleic acid biochemistry and molecular biology.

26:120:519
Microbial Metabolism 3 credits
Prerequisites: 21:115:403,404 or equivalent. Biology of procaryotic organisms. Emphasis on those physiological, biochemical, and ecological aspects that are unique to bacteria.

26:120:523
Biogeography 3 credits
Prerequisite: permission of instructor. Historical and ecological factors determining the geographical distribution of animals as exemplified by vertebrates.

26:120:526
Cell Biology 3 credits
Prerequisites: upper-level undergraduate courses in biochemistry, genetics, and cell structure and function. A detailed study of the structure and function of cells and their organelles; the composition, organization, and functioning of various membrane systems; investigative techniques.

26:120:530
Biophysical Membrane Physiology 4 credits
Prerequisites: differential and integral calculus, physical chemistry, or permission of instructor. Basic biophysical principles as applied to membrane transport in animals, plants, and microbes. Special emphasis on compartmental ion flux analyses, the thermodynamics of irreversible processes, and electrophysiology.

26:120:532
Evolution 3 credits
Prerequisite: genetics. A critical examination of theories and mechanisms of evolution of animal groups. Emphasis on gene pool dynamics, models of speciation, and adaptive radiations. Consideration of evolutionary relationships of major invertebrate and vertebrate groups.

26:120:536
Multivariate Biostatistics 3 credits
Prerequisite: biostatistics. Covers a variety of statistical techniques useful in ecological and behavioral research. Includes sampling methods, multiple regression, discriminant analysis, weighted regression, and multidimensional chi-square. Emphasis on a conceptual understanding of the uses, assumptions, and limitations of each technique.

26:120:538
Topics in Molecular Genetics 3 credits
Prerequisites: microbiology and biochemistry. A review of current journal literature in the field of mechanisms of gene expression, recombinant DNA methods, and current application.

26:120:551
Biology of Pollution 3 credits
Prerequisite: ecology or permission of instructor. Survey of major environmental pollutants, their occurrence in the environment, their effect on biota at the cellular and physiological levels, as well as their effects at the population, community, and ecosystem levels. Emphasis on aquatic pollution.

26:120:552
Paleobotany 4 credits
Survey of evolutionary trends in the plant kingdom; comparative study of the morphology, anatomy, and reproduction of fossil plants and their survivors, with emphasis on the vascular plants.

26:120:561
Quantitative and Analytical Light Microscopy 4 credits
Laboratory intensive course with lectures and discussion covering the physical principles governing eukaryotic cell function. Emphasis placed on electrical properties of excitable cells and model membrane systems. Introduction to the principles underlying light and electron microscopy.

26:120:563
Developmental Plant Physiology 3 credits
Prerequisite: 26:120:504 or permission of instructor. An analysis of physiological and environmental factors controlling growth and differentiation in vascular plants with emphasis on recent advances in the biochemistry of plant growth regulators.

26:120:564
Techniques in Developmental Botany 2 credits
Prerequisite: permission of instructor. Presentation of the major procedures used in plant tissue culture, including suspension culture, callus culture, organ culture, and protoplast isolation and culture. Emphasis on independent study.

26:120:565
Medical Mycology 3 credits
Prerequisite: 26:120:503 or permission of instructor. The taxonomy, morphology, and symptomatology of pathogenic fungi. Emphasis on common mycoses, fungi as allergens, toxic fungi, and recent progress in medical mycology.

26:120:566
Neurophysiology and Behavior 3 credits
Prerequisites: comparative or mammalian anatomy and organic chemistry. Aspects of the nervous system and the endocrine system as they relate to the organization of behavior and the physiological analysis of such phenomena as hunger and thirst, and learning. Lecture is 2 hours, recitation is 1 hour.

26:120:568
Neuroendocrinology and Behavior Laboratory 3 credits
Prerequisite: permission of instructor. Gross stimulation of nervous system; brain lesions and their effects; hormone implants. Recording of brain activity. Laboratory is 6 hours.

26:120:571
Biochemistry 4 credits
Prerequisite: one year of organic chemistry. A detailed examination of the chemistry and metabolism of biological compounds; structure and function of macromolecules, biosynthetic pathways; bioenergetics; photosynthesis and other sequential biological processes.

26:120:584
Plant Responses to the Environment 3 credits
Prerequisite: ecology and plant physiology. Examination of the anatomical, morphological and physiological responses of plants to environmental variability and stress; utilization of current instrumentation; physiological mechanisms underlying higher-scale ecological processes.

26:120:585
Behavioral Ecology 3 credits
Prerequisite: ecology or animal behavior. The behavior of vertebrates and insects in their natural environments; sociobiology and the evolution of communication, foraging, and mating systems. Lectures, student seminars.

26:120:586
Landscape Ecology 3 credits
Prerequisite: one ecology and one course in statistics. Study of how spatial and spatiotemporal configurations of resources, influences, and constraints shape ecological patterns and processes at local, regional, and global scales.

26:120:587
Systems Ecology: Ecosystems in the Landscape 3 credits
Prerequisite: one ecology course. Ecological energetics; soil-plant-atmosphere continuum; effect of spatial pattern on ecological process; landscape ecology.

26:120:588
Topics in Advanced Ecology 3 credits
Prerequisite: graduate course(s) in ecology. A discussion of selected topics in advanced ecology. Current literature and newly developing approaches and theories stressed.

26:120:589
Chemical Bases of Neural Function
3 credits
Prerequisites: undergraduates, one year of chemistry and biology; graduate students, baccalaureate degree. Recommended: organic chemistry and biochemistry. An interdisciplinary course on biochemical bases of nervous system activity. Special emphasis on developmental neurochemistry, genomic and nongenomic mechanisms of hormone action, and membrane proteins involved in neurotransmitter action.

26:120:593
Physiological Ecology 3 credits
Prerequisites: ecology and physiology. The physiological and ecological factors that permit and facilitate the adaption of animal populations to diverse environments.

26:120:594
Systematics 3 credits
Prerequisites: genetics, vertebrate or invertebrate zoology, and permission of instructor. Present theory of the nature of the Mendelian species: theories of species origin, polytypic species content; isolating mechanisms; the reduction of interspecific competition and mechanisms of evolution above the species level.

26:120:601
Human Molecular Genetics 3 credits
Prerequisites: genetics and molecular biology or permission of instructor. In-depth introduction to the study of human molecular genetics, with emphasis on the methods and stategies used to identify genetic defects associated with illness. Classical and molecular genetics. Laboratory techniques in current use. Examples of different types of known genetic defects, with particular attention to the experimental strategies used in each example.

26:120:604
Microbiology: Principles and Applications
3 credits
Restricted to NJIT students only. An introduction to microorganisms for graduate students in Environmental Sciences or Chemical Engineering. Emphasis is on the growth, physiology, and environmental effects of bacteria.

26:120:616
Topics in Biology
1 to 3 credits by arrangement

26:120:640
Topics in Immunology 3 credits
Prerequisite: 21:120:443 or permission of instructor. Discussion of selected, up-to-date topics in immunology. Current literature, student discussions, and presentations stressed.

26:120:651,652
Biology Colloquium 1 credit each
Open to all graduate students in good standing in the biology graduate program and by permission to students in other graduate programs. Various biological topics of current interest discussed by a series of experts in the field.

26:120:697
Neuroendocrinology 3 credits
Prerequisite: permission of instructor. Equivalent to 26:112:567. Central nervous system effects on the endocrine system, including neural pathways in pituitary control and behavioral effects; endocrine control mechanisms and the effects of hormones on the nervous system.

Biomedical Engineering

Offered by the Biomedical Engineering Committee

BME 627
Introduction to Biomedical Engineering
3 credits
Prerequisite: undergraduate courses in thermodynamics and differential equations. Introduction to the structure and composition of the body followed by an exploration of the properties of the blood and its flow in the cardiovascular system; the body as a heat source and as a series of compartments involved in the mass transfer of materials (such as those in the kidneys and lungs). Design of artificial kidneys and heart-lung machines is also explored. *Same as ChE 627.*

BME 667
Systems Studies in Biomedical Engineering
3 credits
Prerequisite: undergraduate or graduate course in linear systems. Basic techniques of simulation including digital simulation languages. Physiologic systems of current interest using systems analysis techniques leading to formulation of mathematical, digital computer, or electric circuit models. Systems examined include the circulatory, respiratory or hormonal control systems. Basic techniques of signal processing are explored which are necessary to analyze data from physiologic systems. *Same as ECE 667.*

BME 669
Quantitative Physiology for Engineers
3 credits
An introduction to mammalian physiology for students enrolled in the biomedical engineering program, or for students interested in the fundamental principles of mammalian physiology, particularly the heart, lungs and kidneys.

BME 672
Biomaterials 3 credits
Prerequisite: Mech 232 (see undergraduate catalog for description) or the equivalent. Materials and processes used to develop devices that are implanted in the human body; clinical aspects of biomechanical engineering; federal government requirements for design and testing of human implant devices; biocompatibility, metal implant devices, material design parameters, plastic and ceramic devices, sterilization techniques, and their effect on biocompatibility.

BME 698
Selected Topics in Biomedical Engineering
3 credits
Special area course given when suitable interest develops. Advance notice of forthcoming topics will be given.

BME 699
Selected Topics in Biomedical Engineering
3 credits
See description for BME 698 above.

BME 701
Master's Thesis 6 credits
Prerequisite: written permission from thesis advisor. Projects include design, construction, experimental or theoretical investigation of the engineering applications to the diagnosis and/or treatment of disease. Research may be in cooperation with industry or medical institutions. Completed work should be of sufficient quality to be acceptable for publication. Oral presentations are required.

BME 791
Seminar in Biomedical Engineering 1 credit
This course is required every semester for the M.S. in Biomedical Engineering if the student receives program or research-based support. Students will present discussions on their thesis research. Guest speakers will also be invited to present developments in biomedical engineering.

Biomedical Informatics

Offered by UMDNJ and the Department of Computer and Information Science. Courses are taken at UMDNJ.

BINF 600/BINF 5100
Introduction to Biomedical Informatics
3 credits
Introduction to mainframe and microcomputer interactive computing environments: overview of computer applications for medical records; clinical, laboratory, pharmacy, education, and medical database management; patient care and hospital information systems using software for spreadsheets, database management, telecommunication, and literature retrieval. Also covers a decentralized hospital computer program, and computer-stored ambulatory record systems. Programming environment in relation to existing databases is discussed. Students complete small hands-on projects.

BINF 601/BINF 5005
Health Care Information Systems 3 credits
General systems theory applied to health care systems and information technology. Computer-based information system operation and management functions in the context of various professional settings, and the impact of information technology on health care management. Demonstrations of current health information systems emphasizing design, system components, data structures and database management. Costs and benefits of current applications, justification, specification and evaluation of computer systems, and the capacity for future modification and development of existing systems in various health care settings.

BINF 602/BINF 5020
Biomedical Modeling and Decision-Making Systems 3 credits
Introduction to use of differential equations and relevant mathematical concepts to describe health care and physiological systems. Methods and resources of computer simulation and modeling for analyzing and solving medical and health-care problems related to both organization and treatment, including decisions for effective information transfer, productivity and resource utilization, as well as physiological systems such as drug dosage, pulmonary transport, cardiac output, kidney function, and others.

BINF 603/BINF 5030
Visualization in Biomedical Sciences 3 credits
Fundamentals of biomedical signal and image processing including image digitization, display, and processing algorithms with emphasis on computer systems, processing methodologies, and display of images. Visualization procedures, tools and technologies for 3-D representation of images, animation and image manipulation are provided.

BINF 612/BINF 5125
Clinical Problem Solving and Decision Making 3 credits
An overview of computer methodology for clinical decision making. Application of decision trees for clinical and health care problems, estimation and revision of probabilities. Artificial intelligence, expert systems and decision-making techniques and their implementation as decision support systems in clinical and HIS settings. Examination of quantitative and symbolic approaches to medical decision making including application of statistical methods (discriminant and Bayesian statistics), decision analysis and utility theory.

BINF 613/BINF 5130
Health Care Decision Support Systems 3 credits
Overview of methods of decision support in health sciences, including artificial intelligence, Bayesian methods, classical multivariate analysis, dynamic screening (Markov) models, and theoretical and empirical limitations of these decision methods. Discussion of literature on human perception and judgment as well as practice on database management software and expert system tools to design decision support prototype systems for clinical, health care finance and patient management systems.

BINF 614/BINF 5135
Clinical Systems Interface Design 3 credits
Prerequisites: BINF 5100, BINF 5005 and BINF 4000 or equivalent. Practice of principles of interface design, data exchange, program-to-program communication, and knowledge-based systems using Windows-based GUI design packages. Exposure to application development tools with expert system shell capabilities and system integration tools with good communication interfacing between various hardware platforms from PCs to minicomputers and mainframes. Exploration of a wide array of user interface system design and development techniques. Term project using the GUI package required.

BINF 615/BINF 5150
Seminar: Biomedical Teaching Systems Design 1 credit
Based on knowledge gained from courses in biomedical informatics, students engage in serious discussion and analysis of the various aspects of computer-based instructional systems. Examples of technologies covered include: microcomputer courseware, CD/ROM, CD-I, DVI, instructional television, interactive microcomputer and videodisc systems, multimedia intelligent tutoring and expert systems, and instructional games and simulations.

BINF 621/BINF 5210
Research Methods in Health Sciences 3 credits
Use of computer as a tool for scientific inquiry including techniques for searching computer databases of research literature, and formulating problems and hypotheses for statistical analysis of educational, health services, laboratory and clinical data. Use of computers in management and analysis of health science data. Laboratory instruction in use and application of software packages for micro- and mainframe computers. Issues in the design, organization and operation of randomized controlled clinical trials and intervention studies, and analysis of qualitative and quantitative data.

BINF 622/BINF 5220
Topics in Bioinformatics 3 credits
Prerequisites: BINF 5005 or BINF 5010, and Chem 673 or equivalent. An extensive review of computational biology necessary to understand research and developments in bioinformatics. Topics include: covalent bonding, quantum mechanical basis of bond formation, 3-D structure of molecules, reaction mechanisms, catalysis, polymers, enzymes, thermodynamics and kinetics, metabolic pathways, and sequence and structure of macromolecules. Extensive use of computer approaches and computer graphical techniques to enhance interpretation of results.

BINF 623/BINF 5230
Advances in Molecular and Cellular Genetics 3 credits
Prerequisites: BINF 5005 or BINF 5010, and Chem 673 or equivalent. Extensive use of computer approaches to cover the following important areas: cell structure, intracellular sorting and signaling; structure and function of proteins; and nucleic acid; enzymology, membrane structure and function; DNA-replication, transcription and recombinant DNA molecules; genetic mutation, cell fusion, chromosomal mapping and gene transfer; and immunological principles applied to genetics.

BINF 631/BINF 5311
Intelligent Instructional Systems 3 credits
Current developments and trends in instructional technology applied to knowledge and learning in health science: processes of perception, learning, motivation, problem-solving and decision making in relation to the design of intelligent tutoring and educational expert systems. The students will work with knowledge engineering, expert system and authoring tools to develop intelligent tutorials and expert system models on selected/assigned topics.

BINF 632/BINF 5312
Interactive Learning Systems for the Health Sciences 3 credits
Introduction to use of interactive videodisc and CD-ROM technology for health sciences instructional software. Students try existing interactive software and videodiscs on biomedical subjects, and then design, edit and evaluate an interactive videodisc learning module of their own.

BINF 700/BINF 6000
Directed Research/Project 6 credits

BINF 7910
Research and Developments in Medical Informatics: Colloquium 1 credit
This is a required course for all doctoral students. These seminar series prepare students for advanced research in biomedical informatics. Invited lecturers, experts in their various research domains, present major advances in biomedical informatics research. The lecturers are from within and outside the UMDNJ academic community as well as the health industry in general and affiliated industries.

Biostatistics

Offered by the UMDNJ – New Jersey Medical School

BIO 613
Life Tables and Survival Analysis 3 credits
Prerequisites: biostatistics core course; a thorough knowledge of pre-calculus mathematics is assumed; calculus is strongly recommended but not required. Introduction to theory and applications. Recognition of situations that call for life table methods. Selection and application of methods and analysis. Explanation and interpretation of analyses.

BIO 614
Categorical Data Analysis 3 credits
Prerequisites: biostatistics core course or equivalent. A practical introduction to methods for analysis of frequency tabulations commonly used in public health research. Exercises are based on public health literature. Evaluate relationships between categorical factors by which frequency data are cross-classified. Apply principles of study design and sample size

planning. Provide statistically valid interpretation of results from categorical data analysis. A statistical computer package such as SAS, STATA or SPSS is used for computation.

BIO 618
Nonparametric Statistical Methods
3 credits
Prerequisites: biostatistics core course or equivalent. Choose and apply the most appropriate parametric or nonparametric test or procedure for analyzing a given set of research data, taking into consideration the manner in which the sample was drawn, the nature of the population from which it was drawn, and the kind of measurement or scaling that was employed to define the variables in the study.

BIO 619
Biostatistical Consulting 2 credits
Prerequisites: biostatistics, epidemiology, and health information systems core courses. Provides skills needed for statistical consulting in public health.

Chemical Engineering

Offered by the Department of Chemical Engineering, Chemistry, and Environmental Science

ChE 501
Fundamentals of Chemical Engineering I
6 credits
Prerequisites: Math 222 or equivalent (see undergraduate catalog for description), Chem 231 or equivalent. An intensive course in basic chemical engineering science intended for students in the bridge program. Topics include material and energy balances, thermodynamics, kinetics and reactor design, and staged separation processes. May not be taken for degree credit in any chemical engineering program.

ChE 502
Fundamentals of Chemical Engineering II
4 credits
Prerequisites: Math 222 or equivalent (see undergraduate catalog for description), ChE 501 or equivalent. A continuation of ChE 501. An intensive course in basic chemical engineering science intended for students in the bridge program. Topics include fluid mechanics, heat transfer and diffusion-controlled processes. May not be taken for degree credit in any chemical engineering program.

ChE 551
Principles of Mass Transfer 3 credits
Prerequisites: undergraduate thermodynamics and integral calculus. An introductory course in basic concepts of mass transfer. Special emphasis is placed on mass transfer concepts applicable to stage and continuous operations. Topics covered include evaporation, gas absorption, and distillation. Cannot be used for degree credit in Chemical Engineering.

ChE 590
Graduate Co-op Work Experience I
3 additive credits
Prerequisite: permission from department and Division of Career Development Services. Cooperative education internship provides on-the-job reinforcement of the academic program by placement in major-related work situations. Work assignment developed or approved by the co-op office and evaluated by the department. Cannot be used for degree credit.

ChE 591
Graduate Co-op Work Experience II
3 additive credits
Prerequisite: permission from department and Division of Career Development Services.

ChE 592
Graduate Co-op Work Experience III
3 additive credits
Prerequisite: permission from department and Division of Career Development Services.

ChE 599
Methods for Teaching Assistants and Graduate Assistants 3 credits
Prerequisite: graduate standing. Required for all chemical engineering teaching assistants and graduate assistants. Covers techniques of teaching, interaction with students, and safety. Does not count as degree credit.

ChE 602
Selected Topics in Chemical Engineering I
3 credits
Prerequisite: graduate standing and permission of the instructor. Topics of current interest in chemical engineering.

ChE 611
Thermodynamics 3 credits
Prerequisites: undergraduate courses in physical chemistry and thermodynamics, or equivalent. Principles of thermodynamics developed quantitatively to include thermodynamic functions and their application to chemical engineering processes.

ChE 612
Kinetics of Reactions and Reactor Design
3 credits
Prerequisite: undergraduate course in chemical engineering kinetics, or equivalent. Elements of optimum design introduced for reactor types, series and parallel reactor systems, multiple reactions, and temperature effects. Introduction to non-ideal reactor design. Study of various models for catalytic and non-catalytic solid-fluid reactions.

ChE 624
Transport Phenomena I 3 credits
Prerequisites: undergraduate courses in fluid mechanics, heat transfer, and mass transfer. A unified treatment of molecular and turbulent momentum, energy, and mass transport. Emphasis is on the mathematical description of physical mechanisms in momentum and energy transport.

ChE 625
Microlevel Modeling in Particle Technology
3 credits
Presents methodologies for analyzing the macroscopic properties of particulate systems in terms of the underlying microlevel processes. Significant components are the mathematical modeling of particulate systems at the microlevel, analytical and numerical methods for predicting macroscopic properties from microlevel models, and comparison of theoretical predictions with experimental results. Demonstrates the importance of the interaction of these three components in the scientific process. The first part concerns the flow of dry particles where any interstitial fluid can be ignored. The second part considers the flow of particles suspended in an interstitial fluid. Also includes a class project involving development of simulations. *Same as ME 624.*

ChE 626
Mathematical Methods in Chemical Engineering 3 credits
Prerequisite: undergraduate course in differential equations. The purpose of the course is to emphasize the importance of mathematics to chemical engineering practice. Applications of non-linear regression, series solution of ordinary differential equations, Sturm-Liouville problems in partial differential equations, and numerical methods. It is suggested that students take this course before taking ChE 624.

ChE 627
Introduction to Biomedical Engineering
3 credits
Prerequisites: undergraduate courses in thermodynamics and differential equations. Introduction to the structure and composition of the body followed by an exploration of the properties of blood and its flow in the cardiovascular system; the body as a heat source and as a series of compartments involved in mass transfer of materials (such as those in the kidneys and lungs). Design of artificial kidneys and heart-lung machines is also explored. *Same as BME 627.*

ChE 628
Biochemical Engineering 3 credits
Prerequisite: undergraduate degree in chemical engineering. The application of chemical engineering to biological processes, biochemical reaction systems, and their technological use. Special attention given to problems in momentum, energy, and mass transport, as well as chemical reaction kinetics in biological systems.

ChE 629
Biological Engineering Analysis 3 credits
Prerequisite: undergraduate degree in chemical engineering. Emphasis is on chemical engineering reactor design employing microbial populations. The dynamics of microbial interactions are described mathematically, as are cell attachment and reactor stability.

ChE 634
Chemical Process Dynamics and Control
3 credits
Prerequisite: undergraduate chemical engineering course in process dynamics and control. Mathematical principles of process dynamics and control; derivation and solution of differential equations describing the behavior of typical chemical engineering processing units; and mathematical analysis and design of control systems. Digital and sampled data control systems also discussed.

ChE 645
Fundamentals of Rheology 3 credits
Prerequisite: ChE 626 or permission of the instructor. Rheology of polymer melts and polymer solutions. Various types of time-dependent and time-independent non-Newtonian fluids are classified. Experimental techniques used to characterize these materials are discussed.

ChE 646
Polymerization Reactor Design and Analysis 3 credits
Prerequisite: ChE 612 or equivalent. Mathematical analysis of polymerization systems occurring in batch, continuous stirred tank, and tubular reactors, including stability, control, and optimization.

ChE 656
Catalysis 3 credits
Prerequisite: ChE 612. Introduction of mass transfer and physical characterization of catalysts: the effectiveness factor; absorption; surface reaction; catalytic reactor design.

ChE 662
Chemical Processing of Electronic Materials 3 credits
Prerequisite: undergraduate degree in chemical engineering. Processes necessary for manufacturing electronic materials into semiconductor devices and systems including single crystal growth, chemical vapor deposition, ion implantation, dry etching, and other considerations.

ChE 663
Operations Analysis of Chemical Manufacturing Processes 3 credits
Prerequisite: undergraduate degree in chemical engineering. Introduction of mathematical tools and analytic approaches needed to manage resources, operations and product quality in a chemical engineering plant. Topics include cost analysis, decision analysis, production planning, energy conservation, process optimization, reliability analysis, and statistical quality control.

ChE 664
Experiments and Simulations in Particle Technology 3 credits
Prerequisites: graduate standing and consent of the instructor. Covers particle size analysis using sieves as well as laser diffraction technique, size reduction with ball mill, measurement of powder flow properties and internal angle of friction, measurement of angle of repose, design of mass flow hoppers using Jenike direct shear tester, measurement of minimum sintering temperature of powders, particle sedimentation, powder mixing, dry particle coating, and fluidized beds. Simulations involve various dry and fluid based particle systems, focusing on particle-particle and fluid-particle interactions. *Same as ME 664.*

ChE 671
Chemical Process Safety 3 credits
Prerequisite: graduate standing. Chemical and physical principles in chemical process safety and fire and explosion hazard evaluation. Emphasis is on materials, their reactions, and effect on surroundings. Course intended for students in the master's program in occupational safety and health engineering, and may not be taken for credit by ChE graduate students.

ChE 675
Statistical Thermodynamics 3 credits
Prerequisite: ChE 611 or permission of instructor. Application of equilibrium statistical mechanics to chemical engineering problems. Basic postulates and relationships of statistical thermodynamics, including the ideal gas, ideal crystal, and virial equation; statistical theories of fluid mixtures and other advanced topics.

ChE 685
Industrial Waste Control I 3 credits
Prerequisite: undergraduate degree in chemical engineering or permission of the instructor. Physical/chemical treatment of industrial wastewaters: ionic equilibria; surface characterization; thermodynamic applications; transport phenomena; and sludge treatment.

ChE 686
Industrial Waste Control II 3 credits
Prerequisite: undergraduate degree in chemical engineering or permission of the instructor. Biological treatment of industrial wastewaters: biological mechanisms; kinetics; vapor-liquid equilibria; and settling phenomena.

ChE 687
Industrial Gas Cleaning 3 credits
Prerequisite: undergraduate degree in chemical engineering, or permission of the instructor. Review of available tools for cleaning atmospheric effluents from manufacturing facilities and power plants; use of a systems approach to minimize gas cleaning costs; alternatives involving combinations of process modification and effluent clean-up; methods for estimating key design parameters for cyclones, baghouses, electrostatic precipitators and scrubbers. Applications of design parameters through the solution of extensive problem-sets.

ChE 701
Master's Thesis 6 credits
Prerequisite: matriculation for the master's degree in chemical engineering. Approval of thesis advisor is necessary for registration. Original research under the guidance of a departmental advisor. The final product must be a written thesis approved by at least three faculty members: the primary advisor, another from the department, and one other faculty member. A student must continue to register for at least 3 credits per semester until at least 6 credits have been completed and a written thesis is approved. Only a total of 6 credits will count toward the degree.

ChE 702
Selected Topics in Chemical Engineering II
3 credits
Prerequisite: graduate standing and permission of the instructor. Topics of current interest in chemical engineering.

ChE 705
Independent Study 3 credits
Prerequisites: permission from the graduate advisor (not dissertation advisor) in chemical engineering, as well as courses prescribed by a supervising faculty member (who is not the student's dissertation advisor). This special course covers areas of study in which one or more students may be interested, but which isn't of sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once with the same supervising faculty member.

ChE 711
Phase Equilibrium 3 credits
Prerequisite: ChE 611 or equivalent. Low-pressure and high-pressure vapor-liquid equilibrium and liquid-liquid equilibrium. Among the topics covered are experimental methods, consistency tests of the data, expressions for the dependence of the activity coefficient on composition and temperature, and prediction of multicomponent vapor-liquid and liquid-liquid equilibrium from binary data. Prediction methods of vapor and liquid phase nonidealities, based on equations of state and solution theories, are discussed.

ChE 725
Transport Phenomena II 3 credits
Prerequisite: ChE 624 or equivalent. Transport in laminar and turbulent flow: in solids, between phases, and macroscopic transport in flow systems.

ChE 726
Applied Fluid Mechanics 3 credits
Prerequisite: ChE 624 or equivalent. Brief review of the equations of change and tensor analysis; generalized Newtonian fluid and its flow, material function for non-Newtonian fluids through porous media.

ChE 740
Biological Treatment of Hazardous Chemical Wastes 3 credits
Prerequisite: ChE 686 or the permission of the instructor. A doctoral level seminar on the limitations of biological treatment for hazardous wastes that looks at the fundamental processes taking place.

ChE 790
Doctoral Dissertation Credits as designated
Required of all students for the degree of Doctor of Philosophy. A minimum of 36 credits is required. Approval of dissertation advisor is necessary for registration. Students must register for at least 6 credits of dissertation per semester until 36 credits are reached and then for 3 credits each semester thereafter until a written dissertation is approved.

ChE 791
Graduate Seminar Non-credit
Required of all chemical engineering or chemistry graduate students receiving departmental or research-based awards and all doctoral students. The student must register each semester until completion of the degree. Outside speakers and department members present their research for general discussion.

Chemistry

Offered by the Department of Chemical Engineering, Chemistry and Environmental Science

Chem 552
Laser Chemistry and Technology 3 credits
Prerequisites: one year of chemistry, one year of physics, and calculus. An introduction to the underlying chemical and physical principles of lasers, their operation and uses and the related optoelectronic technology. Analysis of classes of laser; pumping mechanisms; detection of light; absorption and emission of radiation and current industrial and state-of-the-art uses.

Chem 599
Methods for Teaching Assistants and Graduate Assistants 3 credits
Prerequisite: graduate standing. Required for all chemistry teaching assistants and graduate assistants. Covers techniques of teaching, interaction with students, and safety. Does not count as degree credit.

Chem 601
Special Topics in Chemistry I 3 credits
Prerequisite: graduate standing and permission of the instructor. Topics of current interest in chemistry.

Chem 602
Advanced Organic Chemistry II: Reactions 3 credits
Prerequisite: undergraduate organic chemistry. The study of organic syntheses including principles underlying chemical reactions; chemical thermodynamics, structural theory, rates of reaction, mechanisms and stereochemistry; IR, UV, and NMR spectroscopy; organic synthesis; formation of aliphatic carbon-carbon bonds; pericyclic reactions; carbon-nitrogen bonds; electrophilic and nucleophilic aromatic substitution, molecular rearrangements; photochemical and free-radical reactions; oxidation and reduction; and organometallic reagents containing phosphorous, boron, sulfur, and silicon.

Chem 603
Advanced Organic Chemistry Laboratory 3 credits
Prerequisite: undergraduate organic chemistry. More advanced syntheses than those normally carried out in the undergraduate laboratory are emphasized including current analytical techniques and methods of separation. Both small and large scale preparations are assigned.

Chem 605
Advanced Organic Chemistry I: Structure 3 credits
Prerequisite: undergraduate organic chemistry. Structure of organic molecules. Topics include atomic and molecular structure, stereochemistry, reactive intermediates (cations, anions, radicals, and carbenes), orbital symmetry, and spectroscopy.

Chem 606
Physical Organic Chemistry 3 credits
Prerequisite: Chem 502 or equivalent. Emphasis is placed on the physical aspects of the subject. Determination of reaction mechanisms, equilibria, and kinetics using simple molecular orbital theory and absolute reaction rate theory.

Chem 610
Advanced Inorganic Chemistry 3 credits
Prerequisite: undergraduate physical chemistry or permission of the instructor. Theories of observed chemical and physical properties of the elements and their compounds; prediction of reactivity and properties of proposed new compounds.

Chem 611
Solid-State Inorganic Chemistry 3 credits
Prerequisite: undergraduate physical chemistry or physics. Structure, physical and chemical properties of solid-state materials, and their formation.

Chem 626
Chemistry of Contemporary Materials 3 credits
Prerequisite: one year of general chemistry. An introduction to the structure and chemical, electrical, and mechanical properties of metallic, ceramic, and polymeric materials and their use in science and engineering.

Chem 640
Polymer Chemistry 3 credits
Prerequisites: undergraduate organic and physical chemistry. Kinetics of polymerization; properties of polymer solutions; characterization of molecular size and shape.

Chem 641
Polymer Properties 3 credits
Prerequisite: undergraduate organic and physical chemistry. Forces between polymer molecules and their relation to crystal structure; fundamentals of rheology and viscoelastic properties of polymers; polymer crosslinking, reinforcement, and aging from a chemical viewpoint.

Chem 643
Polymer Laboratory I 3 credits
Prerequisites: Chem 440 or Chem 640. Experimental preparations of polymers and copolymers. Preparations include standard condensation, free radical, emulsion, and ionic types. Elementary methods of polymer characterization and extrusion are included.

Chem 644
Fundamentals of Adhesion 3 credits
Prerequisite: Undergraduate organic and physical chemistry. Adhesion phenomena; intermolecular and interatomic forces; surface chemistry; absorption of polymers on surfaces; mechanisms of adhesion; bulk properties of adhesives; and rheology of polymers used as adhesives.

Chem 645
Polymer Laboratory II 3 credits
Prerequisite: Chem 643. Experiments illustrating contemporary methods of polymer characterization including osmometry, viscometry, laser light scattering, vapor pressure osmometry, differential thermal analysis, dilatometry, x-ray diffraction, birefrigence, polymer factionation/gel permeation chromatography, extrusion, swelling crosslinking, molding, viscoelasticity, and infrared, ultraviolet, and NMR spectroscopy.

Chem 654
Corrosion 3 credits
Prerequisite: one year of general chemistry. Fundamental principles including thermodynamics and kinetics of corrosion; forms of corrosion (e.g., galvanic crevice and stress); methods of corrosion measurement; high temperature corrosion; and special case histories.

Chem 655
Electrochemistry: Principles and Applications 3 credits
Prerequisites: one year of general chemistry and a course in physical chemistry or equivalent. Principles governing electrochemical methods such as conductance, emf, polarography, cyclic voltammetry, chronopotentiometry, coulometry, and their application to electric energy storage and conversion, corrosion, electroplating, pollution monitoring, electrochemical sensors, and electrochemical synthesis.

Chem 658
Advanced Physical Chemistry 3 credits
Prerequisite: one year of undergraduate physical chemistry. Principles and applications of quantum chemistry; the wave equation, its properties and mathematics; the Schrodinger equation and wave functions; the harmonic oscillator; variational and perturbational methods; atomic theory, structure, and properties; simple molecules, LCAO and valence bond theories; semi-empirical methods; time dependence, and introduction to electronic and vibration-rotation spectroscopy.

Chem 659
Atomic and Molecular Structure 3 credits
Prerequisite: Chem 658 or equivalent. Application of quantum chemistry and molecular structure; techniques for calculation of physical properties of molecules; and use of state-of-the-art computer graphics.

Chem 661
Instrumental Analysis 3 credits
Prerequisite: one year of physical chemistry. The various instruments used for chemical and environmental analysis; basic theory; use of instruments and interpretation of data; UV-VIS, IR spectroscopy: NMR, AA; HPLC, GC; and mass spectroscopy.

Chem 662
Air Pollution Analysis 3 credits
Prerequisite: undergraduate physical chemistry. Chemical and physical principles of gaseous species and trace level measurement techniques for airborne vapors and particulates. Emphasis on analyzing real air samples at the parts-per-billion level, meteorological dispersion and life times of pollutants are covered. Laboratory work in air pollution sampling methods for vapor and particulate species. Determination of primary air pollutants using wet chemical and instrumental techniques.

Chem 664
Advanced Analytical Chemistry 3 credits
Prerequisite: undergraduate physical chemistry. The principles of chemical analysis as they apply to chromatography, electrochemistry, and spectroscopy. Sampling considerations, separations, and sample preparation steps. This course is a useful adjunct to Chem 661, where these analytical techniques are considered in a more practical way.

Chem 670
Environmental Toxicology for Engineers and Scientists 3 credits
Prerequisite: Chem 673 or equivalent. Toxicology at the molecular level, including methods of evaluation and quantification, as well as mechanisms of absorption, distribution, metabolism, and excretion of toxicants. Discussions of systemic toxicology (e.g., liver, kidneys, nervous system) and survey of toxic agents. Particular emphasis placed on environmental toxicology including air, water and soil pollutants, food additives, and contaminants.

Chem 671
Industrial Toxicology Workshop 3 credits
Prerequisite: Chem 670 or equivalent. A case study approach that applies basic theory and methods of toxicology to real-life problems related to hazardous materials transport, toxic commercial products and by-products, chemical industrial fires, unsafe landfills and illegal dumping.

Chem 673
Biochemistry 3 credits
Prerequisites: undergraduate organic and physical chemistry, or suitable background in these subjects. Fundamentals of biochemistry related to physical organic chemistry for students who have an interest in biomedical engineering, chemistry, chemical engineering, or environmental science.

Chem 700
Master's Project 3 credits
Prerequisite: matriculation for the master's degree. An extensive report involving an experimental, theoretical, or literature investigation is required. The literature investigation should result in a critical review of a specific area. Approval to register for the master's project must be obtained from the project advisor. Students must continue to register for at least 3 credits each semester until the project is completed and a written report is accepted. Only a total of 3 credits will count toward the degree.

Chem 701
Master's Thesis 6 credits
Prerequisite: matriculation for the master's degree in applied chemistry. Approval of thesis advisor is necessary for registration. Original research under the guidance of a departmental advisor. The final product must be a written thesis approved by at least three faculty members: the primary advisor, another from the department, and one other faculty member. Once registration for thesis has begun, a student must continue to register for a minimum of 3 credits per semester until at least 6 credits have been completed and a written thesis is approved. Only a total of 6 credits will count toward the degree.

Chem 702
Special Topics in Chemistry II 3 credits
Prerequisite: Graduate standing. Topics of current interest in chemistry.

Chem 705
Independent Study 3 credits
Prerequisites: permission from the graduate advisor (not thesis advisor) in chemistry, as well as courses prescribed by a supervising faculty member (who is not the student's thesis advisor). This special course covers areas of study in which one or more students may be interested, but which isn't of sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once with the same supervising faculty member.

Chem 734
Thermochemical Kinetics-Detailed Mechanistic Modeling 3 credits
Prerequisite: graduate level course in either kinetics or reactor design, or permission of instructor. Quantitative estimation of thermochemical data and chemical reactions in the vapor phase, and to some extent in the liquid phase; theories of transition state, RRKM, and Quantum RRK; and detailed chemical modeling concepts for reactor design. Applied computer project is required.

Chem 735
Combustion 3 credits
Prerequisite: thermodynamics and kinetics or equivalent, or permission of instructor. Thermodynamic properties of stable molecules and free radical species in combustion and oxidation of aliphatic hydrocarbons; reactions occurring in high temperature combustion systems; and related kinetic principles.

Civil Engineering

Offered by the Department of Civil and Environmental Engineering

CE 501
Introduction to Soil Behavior 3 credits
Prerequisites: CE 320, Mech 235 and Mech 236 (see undergraduate catalog for descriptions). Open only to the students in bridge program. Permission from CEE department graduate advisor is required. Covers the necessary concepts in strength of materials, geology and soil mechanics required for the bridge program in M.S. in Environmental Engineering and Geoenvironmental Engineering option.

CE 506
Remote Sensing of Environment 3 credits
Prerequisite: Phys 234 (see undergraduate catalog for description). Covers the principles of remote sensing, general concepts, data acquisition procedures, data analysis and role of remote sensing in terrain investigations for civil engineering practices. Data collection from airborne and satellite platforms will be emphasized. Photographic and non-photographic sensing methodologies will be covered as well as manual and computer assisted data analysis techniques for site investigations and examination of ground conditions.

CE 530
Applied Finite Element Method 3 credits
Prerequisites: CE 332 and CIS 101 (see undergraduate catalog for descriptions). Introduction to applications of finite element method to problems of structural analysis and design. Review of matrix algebra and the stiffness method of structural analysis. Applications include trusses, frames, plates, shells, and problems of plane stress/strain. Application of finite element method to design.

CE 531
Design of Masonry and Timber Structures 3 credits
Prerequisite: CE 332 (see undergraduate catalog for description). Study of basic properties of clay and concrete masonry units and wood. The masonry segment includes discussion of unreinforced bearing walls subjected to concentric as well as eccentric loads. Lateral-force resistance of unreinforced and reinforced masonry systems are introduced and new developments to strengthen and retrofit unreinforced masonry walls are discussed. The timber design portion includes design and behavior of wood fasteners, beams, columns, and beam-columns as well as introduction to plywood and glued laminated members.

CE 545
Rock Mechanics I 3 credits
Prerequisite: approved undergraduate course in soil mechanics within last five years or permission of instructor. Rock mechanics including geological aspects, mechanical properties, testing, and in-situ measurements of rock properties, and a brief introduction to design of structures in rock.

CE 552
Geometric Design of Transportation Facilities 3 credits
Prerequisite: CE 350 or equivalent (see undergraduate catalog for description). Design principles and criteria related to highways and railroads resulting from requirements of safety, vehicle performance, driver behavior, topography, traffic, design speed, and levels of service. Elements of the horizontal and vertical alignments and facility cross-section, and their coordination in the design. Computer-aided design procedures including COGO, CADAM, Digital Terrain Modeling. *Same as Tran 552.*

CE 553
Design and Construction of Asphalt Pavements 3 credits
Importance of designing proper asphalt pavements. Topics include the origin of crude, refining crude, types of asphalts, desired properties of asphalt cement, specification and tests for asphalt cement, aggregates for asphalt mixtures, aggregate analysis, gradation and blending, hot-mix asphalt (HMA) mix design, manufacture of HMA and HMA-paving, hot and cold recycling. *Same as Tran 553.*

CE 590
Graduate Co-op Work Experience I
3 additive credits
Prerequisites: permission from the civil engineering department and the Division of Career Development Services. Cooperative education/internship providing on-the-job reinforcement of academic programs in civil engineering. Work assignments and projects are developed by the co-op office in consultation with the civil engineering department; and evaluated by civil engineering faculty co-op advisors.

CE 591
Graduate Co-op Work Experience II
3 additive credits
Prerequisites: permission from the civil engineering department and the Division of Career Development Services.

CE 592
Graduate Co-op Work Experience III
3 additive credits
Prerequisites: permission from the civil engineering department and the Division of Career Development Services.

CE 601
Advanced Remote Sensing 3 credits
Prerequisite: a first course in remote sensing. Principles of computer processing of satellite and aircraft remote sensing data as well as image enhancement, image transformation and image classification techniques using advanced image analysis system — ERDAS in the interactive mode. Multiple applications on land use/land cover, water quality assessment and terrain evaluation will be emphasized. During final weeks of the semester students will apply the acquired techniques to specific projects.

CE 602
Geographic Information System 3 credits
Prerequisite: course or working knowledge of CADD or permission of instructor. Geographical/Land Information System (GIS/LIS) is a computerized system capable of storing, manipulating and using spatial data describing location and significant properties of the earth's surface. GIS is an interdisciplinary technology used for studying and managing land uses, land resource assessment, environmental monitoring and hazard/toxic waste control. Introduces this emerging technology and its applications. *Same as MIP 652 and Tran 602.*

CE 603
Introduction to Urban Transportation Planning 3 credits
Urban travel patterns and trends; community and land activity related to transportation study techniques including survey methods, network analysis, assignment and distribution techniques. Case studies of statewide and urban areas are examined. *Same as Tran 603.*

CE 604
Environmental Modeling in Remote Sensing
3 credits
Prerequisites: CE 602 and CE 605. Advanced course consisting of three main components: review of current research and literature dealing with environmental RS/GIS, applied and computer modeling of land and oceans; case studies in RS/GIS applications, emphasizing "real world" environmental problems presented by outside experts; and presentation of student projects.

CE 605
Research Methods in Remote Sensing
3 credits
Prerequisites: CE 601 and Math 661. Major components of RS data acquisition systems, overview of image processing techniques with emphasis on neural network and traditional pattern recognition, principal component transformations, and data reduction. Emphasizes geometric and mapping aspects of RS/GIS techniques for linking RS images with spatial data, sources of error, and accuracy assessment techniques. Hands-on experience with existing hardware/software (ERDAS & GENESIS).

CE 610
Construction Management 3 credits
Prerequisite: B.S. degree in CE, technology, architecture, or related field. Managerial aspects of contracting. Study of an individual firm in relation to the entire construction industry. Topics include contractor organization and management, legal aspects of construction, and financial planning.

CE 611
Project Planning and Control 3 credits
Prerequisite: CE 610. Management tools as related to construction projects are analyzed and applied to individual projects. Emphasis is on network scheduling techniques, time-cost analysis, resource allocation and leveling, cost estimating, bidding strategy, and risk analysis.

CE 614
Underground Construction 3 credits
Prerequisite: undergraduate course in soil mechanics. Various aspects of underground construction, including rock and soft ground tunneling; open cut construction; underpinning; control of water; drilling and blasting rock; instrumentation; and estimating underground construction costs. Case studies and a field trip to an underground construction site will be included.

CE 615
Infrastructure and Facilities Remediation
3 credits
Prerequisites: graduate standing in civil engineering and basic knowledge of structures, and material science. Examines the methodology of inspection, field testing, evaluation and remediation of existing infrastructure and facilities, which include pipelines, tunnels, bridges, roadways, dams, and buildings. Typical materials distress and failure scenarios will be covered with remediation options through the use of case studies.

CE 616
Construction Cost Estimating 3 credits
Prerequisite: CE 610. Full range of construction cost-estimating methods including final bid estimates for domestic building and heavy/highway projects; computerized takeoff and estimating techniques; international construction; financial and cost reporting; databases; indices; risk; competition; performance; and profit factors.

CE 618
Applied Hydrogeology 3 credits
Prerequisites: undergraduate courses in earth science/geology, fluid mechanics, and calculus or permission of instructor. Examines ground water and contaminant movement through the subsurface environment. A basic understanding of the aquifer geology is emphasized. Hydrogeologic applications including well design, pumping tests, and computer modeling of subsurface flow, and methods to monitor and remediate contaminated groundwater are introduced.

CE 620
Open Channel Flow 3 credits
Prerequisite: undergraduate fluid mechanics. The principles developed in fluid mechanics are applied to flow in open channels. Steady and unsteady flow, channel controls, and transitions are considered. Application is made to natural rivers and estuaries.

CE 621
Hydrology 3 credits
Prerequisite: undergraduate fluid mechanics. The statistical nature of precipitation and runoff data is considered with emphasis on floods and droughts. The flow of groundwater is analyzed for various aquifers and conditions. Flood routing, watershed yield, and drainage problems are considered.

CE 622
Coastal Engineering 3 credits
Prerequisites: fluid mechanics and calculus. An introductory course covering basic wave theory, sediment transport and ocean circulation. The application of these principles to various coastal engineering problems will be discussed, including beach erosion, pollution transport in coastal waters, and the design of shore protection structures.

CE 623
Groundwater Hydrology 3 credits
Prerequisites: undergraduate fluid mechanics and computer programming, or consent of instructor. Basic principles of groundwater hydraulics; Darcian analysis of various aquifer systems; unsaturated flow into porous mediums; transport of contaminants in soil media; and mathematical models for fluid and contaminant transport.

CE 625
Public Transportation Operations and Technology 3 credits
Prerequisite: graduate standing in a cross-listed department or instructor approval. Presentation of the technological and engineering aspects of public transportation systems. Historical development of public transportation technologies. Vehicle and right-of-way characteristics, capacity and operating strategies. Public transportation system performance. Advanced public transportation systems. *Same as Tran 625.*

CE 630
Matrix Analysis of Structures 3 credits
Prerequisites: undergraduate courses in theory of structural analysis and computer programming. A review of matrix operation and energy method, and development of flexibility and stiffness methods used in linear-elastic structural analysis. Behavior of continuous beams, plane trusses and frames, and space trusses and frames will be studied.

CE 631
Advanced Reinforced Concrete Design 3 credits
Prerequisite: an undergraduate course in theory and design of reinforced concrete. A review of basic concepts of elastic and ultimate strength theories and a study of the present design codes. Topics include: design of concrete building frames, two-way slabs, flat slabs, deep beams, and other structural elements using the above two theories.

CE 632
Prestressed Concrete Design 3 credits
Prerequisite: undergraduate course in theory and design of reinforced concrete. Analysis and design of pre-tensioned and post-tensioned prestressed concrete elements for both determinate and indeterminate structures will be studied. Examples of prestressed elements used in buildings and bridges will be discussed, as well as the source and magnitude of prestress losses.

CE 634
Structural Dynamics 3 credits
Prerequisite: undergraduate course in structural analysis. Dynamic analysis of beams, frames, and other types of structures. Practical methods developed are applied to problems such as the analysis of the effects of earthquakes on buildings and moving loads on bridges.

CE 635
Fracture Mechanics of Engineering Materials 3 credits
Prerequisites: graduate standing in civil and/or mechanical engineering and basic knowledge of structures and mechanics of materials. Basic principles of fracture mechanics to increase understanding of cracking and fracture behavior of materials and structures. Emphasis on practical applications of fracture mechanics.

CE 636
Stability of Structures 3 credits
Prerequisite: undergraduate course in theory of structural analysis. Topics include structural design concept; stability criteria; elastic and inelastic buckling; column buckling; lateral buckling of beams; stability of frames; stability of plates and shell; local buckling and post-buckling.

CE 637
Short Span Bridge Design 3 credits
Prerequisite: undergraduate courses in steel design and concrete design, and some knowledge of prestressed concrete fundamentals. Design and performance of highway and railroad bridges, particularly steel and prestressed concrete structures since they are most common in the northeast; and computer applications including bridge geometry, abutment design and composite beam design.

CE 638
Nondestructive Testing Methods in Civil Engineering 3 credits
Familiarizes the civil engineering student with nondestructive testing (NDT) techniques currently employed for evaluation and condition monitoring of civil structures and construction materials. Major emphasis in the application of NDT methodologies to steel, concrete, and timber as the construction material. Covers theories, principles, and testing methodologies associated with individual technologies from specific material point of view. Discusses advantages and limitations pertaining to the application of individual NDT technologies to construction materials.

CE 641
Engineering Properties of Soils 3 credits
Prerequisite: approved undergraduate course in soil mechanics within last five years. An in-depth study of physical and mechanical properties of soils. Topics include clay mineralogy, shear behavior and compressibility of fine and coarse grained soil; and in-situ measuring techniques such as vane shear, core penetration and pressure meter. Laboratory work includes consolidation test and triaxial test, with emphasis on analysis, interpretation and application of data to design problems.

CE 642
Foundation Engineering 3 credits
Prerequisites: approved undergraduate courses in soil mechanics and foundation engineering. The salient aspects of shallow foundation design such as bearing capacity and settlement analyses. Topics are relevant to the deep foundation, selection of the type and the determination of load bearing capacity from soil properties, load tests, and driving characteristics utilizing wave equation analyses. Earth pressure theory and retaining wall design.

CE 643
Advanced Foundation Engineering 3 credits
Prerequisite: CE 642. Lateral and earth pressure computations for the design of retaining walls, bulkheads, cellular cofferdams, and sheetpiles. Also considers the design of internal bracing systems and anchors, soil nailing and reinforced earth. Slope stability of embankments and dams.

CE 644
Geology in Engineering 3 credits
Prerequisites: undergraduate courses in soil mechanics and geology. Review of the fundamentals of physical geology and discussion of the theory and the applications of geophysical methods with emphasis on geoenvironmental engineering. Presentation of concepts pertaining to natural hazards such as earthquakes, mass wasting, and well logging and coastal geology. Students are expected to prepare and present at least one relevant case history. Not recommended for those with backgrounds in geology.

CE 645
Rock Mechanics II 3 credits
Prerequisite: CE 545 or equivalent, or permission of instructor. Applications of design problems in underground structures, subways, stability of rock slopes, blasting, and seismic effects. A design project is a course requirement.

CE 646
Geosynthetics and Soil Improvement 3 credits
Prerequisite: CE 341 (see undergraduate catalog for description). Includes engineering properties of geosynthetics and their application in civil engineering, such as filtration, seepage, and erosion control; subgrade and slope stabilization. Soil improvement topics include preloading, electrokinetic stabilization, soil modification, admixtures and grouting.

CE 647
Geotechnical Aspects of Solid Waste 3 credits
Prerequisites: CE 341, CE 341A or equivalents (see undergraduate catalog for descriptions). Geotechnical aspects of solid waste such as municipal landfill, dredged materials, coal and incinerator ashes, identification and classification of waste materials, geological criteria for siting, laboratory and field testing, design for impoundment and isolation of waste, methods of stability analyses of landfill sites, techniques for stabilizing waste sites, leachate and gas collection and venting systems. Primary emphasis is on municipal wastes.

CE 648
Flow Through Soils 3 credits
Prerequisite: CE 641. Explains the fundamentals of fluid flow through saturated and unsaturated soils and the use of computer programs for the solution of boundary value fluid flow problems in soils. The first two-thirds of the

course are devoted to flow through saturated soils. The topics are mathematical description of flow through soils, solutions for steady state and transient state fluid flow and geotechnical applications. The last one-third is devoted to flow through unsaturated soils. Topics include steady state of transient state fluid flow and a presentation of how these concepts are applied to geoenvironmental problems.

CE 650
Urban Systems Engineering 3 credits
Prerequisites: B.S. degree in engineering or in the physical or social sciences with some computer programming background. Identifies the various urban problems subject to engineering analysis, and modern techniques for their solution, including inductive and deductive mathematical methods, mathematical modeling and simulation, and decision making under uncertainty. *Same as Tran 650.*

CE 653
Traffic Safety 3 credits
Prerequisite: CE 660. System behavioral principles are applied to safety aspects of highway operation and design, and improvements of existing facilities. Solutions are evaluated on the basis of cost effectiveness. *Same as Tran 653.*

CE 655
Land Use Planning 3 credits
Spatial relations of human behavior patterns to land use; methods of employment and population studies are evaluated; location and spatial requirements are related to land use plans; and concepts of urban renewal and recreational planning are investigated by case studies. *Same as MIP 655 and Tran 655.*

CE 659
Flexible and Rigid Pavements 3 credits
Prerequisite: CE 341 or equivalent (see undergraduate catalog for description). Types of rigid (Portland cement) and flexible (bituminous) pavements. Properties of materials, including mineral aggregates. Design methods as functions of traffic load and expected life. Importance and consequences of construction methods. Maintenance and rehabilitation of deteriorated pavements. *Same as Tran 659.*

CE 660
Traffic Studies and Capacity 3 credits
Prerequisite: elementary probability and statistics. Presentation of the characteristics of the traffic stream, road users, and of vehicles, and a review of traffic flow relationships. Students are exposed to the principal methodologies followed by transportation practices to perform volume, speed, travel time, delay, accident, parking, pedestrian, transit and goods movement studies. Presentation of the principal methodologies used to perform transportation facility capacity analyses for: basic freeway sections, weaving areas, ramps and ramp junctions, multi-lane and two lane roadways, signalized and unsignalized intersections. Students get hands on experience using the highway capacity software (HCS) and SIDRA. *Same as Tran 615.*

CE 661
Analysis and Design of Shell Structures
3 credits
Prerequisite: undergraduate course in structural analysis. Methods of analysis and design of shell structures for building. Topics include: domes, hyperbolic paraboloids, folded plates, and cylindrical shells. Materials considered include reinforced and prestressed concrete.

CE 700
Civil Engineering Project 3 credits
Prerequisite: student must have sufficient experience and/or graduate courses in major field to work on the project. Subject matter to be approved by the department. Permission to register must be obtained from the project advisor. Extensive investigation, analysis, or design of civil engineering problems not covered by regular graduate course work is required. A student with an exceptional project in CE 700 may, upon his/her own initiative and with the approval of his/her advisor, substitute the work of this course as the equivalent of the first 3 credits for CE 701 Master's Thesis. Students must register for 3 credits every semester until the project is completed.

CE 701
Master's Thesis 6 credits
The thesis is to be prepared on a subject in the student's major field approved by the department. Approval to register for thesis must be obtained from the thesis advisor. A student must register for a minimum of 3 credits per semester until completion and submittal of an approved document. Credit will be limited, however, to the 6 credits indicated for the thesis.

CE 702
Special Topics in Civil Engineering 3 credits
Prerequisite: advisor's approval. Topics of special current interest in civil engineering.

CE 705
Mass Transportation Systems 3 credits
Prerequisites: CE 625 and Tran 610 or IE 610. An investigation of bus, rapid transit, commuter railroad, and airplane transportation systems. Existing equipment, economics, capacity, and terminal characteristics are discussed, as well as new systems and concepts. Long- and short-range transportation systems are compared. *Same as Tran 705.*

CE 710
Systems in Building Construction 3 credits
Requirements and benefits of various building construction systems. Preliminary examination of the interrelation between design and construction. Topics include lift slab and tilt-up construction, slipforming, precasting, joist systems, modular construction, and mechanical and electrical systems.

CE 711
Methods Improvement in Construction
3 credits
Prerequisite: CE 610. Improved methods in construction; various techniques of work sampling and productivity measurement; and current innovations in the construction industry for increasing efficiency.

CE 720
Water Resource Systems 3 credits
Prerequisites: CE 620, CE 621. A system methodology is applied to the analysis of water resource development and operation. Topics include operational hydrology, water quality criteria, streamflow requirements, resource allocation, and economics. Mathematical models are developed and employed in the evaluation of a case study.

CE 725
Independent Study I 3 credits
Prerequisites: written permission from department chairperson plus courses to be prescribed by the supervising faculty member. Covers areas of study in which one or more students may be interested but which is not of sufficiently broad interest to warrant a regular course offering.

CE 726
Independent Study II 3 credits
Prerequisites: written permission from department chairperson plus courses to be prescribed by the supervising faculty member. Covers areas of study in which one or more students may be interested but which is not of sufficiently broad interest to warrant a regular course offering.

CE 727
Independent Study III 3 credits
Prerequisites: written permission from department chairperson plus courses to be prescribed by the supervising faculty member. Covers areas of study in which one or more students may be interested but which is not of sufficiently broad interest to warrant a regular course offering.

CE 730
Plastic Analysis and Design 3 credits
Prerequisite: CE 630. Theory of plasticity applied to structural design. Study of methods of predicting strength and deformation of single and multi-story steel frames in the plastic range. Comparison of plastic and prestressed concrete.

CE 733
Design of Metal Structures 3 credits
Prerequisites: CE 630 and CE 636. Methods of design of metal structural systems. Topics include combined action of unsymmetrical sections, torsion of open and closed sections, buckling of columns and plates with various end conditions, and design of curved and boxed girders.

CE 734
Design of Tall Buildings and Space Structures 3 credits
Prerequisites: CE 630 and CE 636. Design of tall buildings and space structures emphasizing framing systems, and recent developments and current research related to the design of such structures.

CE 736
Finite Element Methods in Structural and Continuum Mechanics 3 credits
Prerequisites: a working knowledge of computer programming, and Mech 630 and CE 630. Finite element approaches for analysis of plane stress problems, plates in flexure, shells,

and three-dimensional solids; and choice of interpolation functions, convergence, and the capabilities of the methods.

CE 737
Earthquake Engineering 3 credits
Prerequisite: CE 634. Practical design solutions for resisting the damaging effects of earthquake ground motions and other severe dynamic excitations. Factors which control dynamic response in elastic and inelastic ranges, and the nature of severe dynamic excitations. Theories of structural analysis and dynamics, and modern design methodologies on the behavior of structures.

CE 738
Advanced Matrix Analysis of Structures 3 credits
Prerequisite: CE 630. Advanced topics from structural analysis, including nonlinear analysis of trusses, frames and membrane finite elements, collapse by buckling, analysis and design of fabric structures.

CE 739
Structural Optimization 3 credits
Prerequisite: CE 630. Application of methods of mathematical programming to problems of optimal structural design. Optimal criteria methods, discrete and continuous systems, and code design will be covered.

CE 741
Theoretical Soil Mechanics 3 credits
Prerequisite: CE 641. An advanced graduate course for Ph.D. students and interested M.S. students in Civil Engineering. Explains the fundamentals of constitutive models for soils and their use in the solution of boundary value problems. Covers the theory of elasticity and theory of plasticity as tools in developing constitutive models for soils. Introduces critical state concept for soils. The triaxial experimental behavior of soils is discussed to introduce the concept of soil flow and strength. Critical state concept and elastoplastic material concepts are incorporated in the constitutive models, models predictions will be compared with experimental results for sands and for clays. Constitutive models will incorporated into finite element codes to analyze boundary value problems such as stability of slopes and performance of footings.

CE 742
Geotechnology of Earthquake Engineering 3 credits
Prerequisite: CE 641. Explains the fundamentals of propagation of the earthquakes through soils to supporting structures and the use of computer programs in the solution of boundary value problems in soils. The first half is devoted to synthesis of earthquakes, mathematical formulation of the problem, measurement of applicable soil parameters, use of computer programs to solve 1-D wave propagation problems in soils with structures. The second half is devoted to soil liquefaction, soil-structure interaction, and design of machine foundations.

CE 743
Contaminant Transport in Soils 3 credits
Prerequisites: CE 618, CE 623 and CE 648. An advanced graduate course for Ph.D. students and interested M.S. students in civil, environmental, and chemical engineering. Explains the fundamental mechanisms involved in the organic chemical flow and transport in soils. Includes new concepts and recent findings associated with leaking underground storage tanks. First half deals with flow of nonaqueous phase liquids (NAPL) through a soil-water-air system. The second half discusses the sorption and dissolution of organics in the soil-water-air system, and transport of organics in the dissolved phase.

CE 751
Transportation Design 3 credits
Prerequisite: CE 603. Design problems for airports, terminals, and highway intersections and interchanges are undertaken. *Same as Tran 751.*

CE 752
Traffic Control 3 credits
Prerequisite: CE 660. Traffic laws and ordinances; regulatory measures; traffic control devices; markings, signs and signals; timing of isolated signals; timing and coordination of arterial signal systems; operational controls; flow, speed, parking; principles of transportation system management/administration; highway lighting; and state-of-the-art surveillance and detection devices and techniques. Hands-on experience with TRAF/NETSIM and FREESIM. *Same as Tran 752.*

CE 753
Airport Design and Planning 3 credits
Prerequisites: Tran 610 or EM 693 and CE 660. Planning of individual airports and statewide airport systems. Functional decision of air and landside facilities. Orientation, number and length of runways. Concepts of airport capacity. Passenger and freight terminal facility requirements. Airport access systems. FAA operating requirements. Financial, safety and security issues. *Same as IE 753 and Tran 753.*

CE 754
Port Design and Planning 3 credits
Prerequisites: Tran 610 or EM 693 and CE 660. Functional design of the water and landsides for general cargo, liquid and dry bulk, and container operations. Yard and storage systems. Port capacity in an intermodal network. Economic, regulatory, and environmental issues. *Same as IE 754 and Tran 754.*

CE 765
Multi-modal Freight Transportation Systems Analysis 3 credits
Prerequisites: Tran 610 or equivalent and CE 650 or EM 602 or equivalent. Quantitative methods for the analysis and planning of freight transportation services. The supply-performance-demand paradigm for freight transportation systems. Cost and performance as determined by system design and operations. Relationship of traffic and revenue to service levels and pricing. Optimal service design and redesign for transportation enterprises and operations planning. Fleet and facility investment planning. Applications to various modes. *Same as EM 765 and Tran 765.*

CE 790
Doctoral Dissertation Credits as designated
Required of all candidates for the degree of Doctor of Philosophy. A minimum of 36 credits is required. Students must register for at least 6 credits of dissertation per semester until 36 credits are reached. Registration for additional credits may be permitted beyond the 6, with the approval of the advisor, to a maximum of 12 credits per semester. If the dissertation is not completed after 36 credits, registration for an additional 3 credits per semester is required thereafter. Registration for 3 credits is permitted during the summer session, hours to be arranged.

CE 791
Graduate Seminar Non-credit
A seminar in which faculty or others present summaries of advanced topics suitable for research. Students and faculty discuss research procedures, thesis organization, and content. Students present their own research for discussion and criticism. Required of all doctoral students registered for CE 790 unless requirement is waived, in writing, by the dean of graduate studies.

Computer and Information Science

Offered by the Department of Computer and Information Science

CIS 500
Introduction to Systems Analysis 3 credits
Prerequisites: statistics and differential equations. Covers a wide variety of systems oriented approaches to solving complex problems. Illustrative examples are chosen from a wide variety of applications. Mathematical tools are only introduced to the extent necessary to understand the technique and its application to the problem. Topic areas include probabilistic and decision theory models, simulation, morphological analysis, cluster analysis, structural modeling, Delphi and dynamic system models. The role for the computer in applying these techniques to complex problems will be discussed. The student will be exposed to some of the fundamental controversies concerning the appropriateness or validity of systems approaches to human problem solving.

CIS 505
Programming, Data Structures, and Algorithms 3 credits
Prerequisite: knowledge of at least one procedure-oriented language such as PASCAL or C. Computer science students cannot use this course for graduate degree credit. Intensive introduction to computer science principles: a procedure-oriented language such as C++; program design techniques; introductory data structures (linked lists, stacks, sets, trees, graphs); and algorithms (sorting, searching, etc.) and their analysis. Programming assignments are included.

CIS 506
Foundations of Computer Science 3 credits
Prerequisite: knowledge of C/PASCAL. Corequisite: CIS 505. Cannot be used for graduate credit towards the M.S. in Computer Science. Introduction to the concepts of iteration, asymptotic performance analysis of algorithms, recursion, recurrence relations, graphs, automata and logic, and also surveys the main data models used in computer science including trees, lists, sets, and relations. Programming assignments are given.

CIS 510
Assembly Language Programming and Principles 3 credits
Prerequisite: knowledge of at least one procedure-oriented language such as PASCAL, C, or C++. Computer Science students cannot use this course for graduate degree credit. An intensive course in assembly language programming including basic machine organization, the structure of instruction sets, program linkage, macros and macro libraries. Extensive programming assignments are included.

CIS 515
Advanced Computer Programming for Engineers 3 credits
Prerequisite: knowledge of at least one procedure-oriented language such as PASCAL, C, or FORTRAN. Students specializing in computer science may not take this course for credit. This course is designed for engineering students who require an extensive knowledge of programming for their project or thesis work. Topics include review of basic programming techniques, treatment of algorithm design, error analysis and debugging. As time permits, problem-oriented languages are examined.

CIS 540
Fundamentals of Logic and Automata 3 credits
Prerequisite: Math 226 or equivalent (see undergraduate catalog for description). Theory of logic and automata and their influence on the design of computer systems, languages, and algorithms. Covers the application of Boolean algebra to design of finite state machines; formal systems, symbolic logic, computability, halting problem, Church's thesis, and the main ideas of the theory of computation.

CIS 590
Graduate Co-op Work Experience I 3 additive credits
Prerequisite: students must have the approval of the co-op advisor for the CIS department. Provides on-the-job reinforcement and application of concepts presented in the undergraduate computer science curriculum. Work assignments are identified by the co-op office and developed and approved by the CIS department in conjunction with the student and employer. Students must submit, for CIS department approval, a proposal detailing the nature of the intended work. A report at the conclusion of each semester's work experience is required. Credits for this course may not be applied toward degree requirements for either the bachelor's or master's in computer science.

CIS 591
Graduate Co-op Work Experience II 3 additive credits
Prerequisite: students must have the approval of the co-op advisor for the CIS department. Provides on-the-job reinforcement and application of concepts presented in the undergraduate computer science curriculum. Work assignments are identified by the co-op office and developed and approved by the CIS department in conjunction with the student and employer. Students must submit, for CIS department approval, a proposal detailing the nature of the intended work. A report at the conclusion of the semester work experience is required. Credits for this course may not be applied toward degree requirements for either the bachelor's or master's in computer science.

CIS 592
Graduate Co-op Work Experience III 3 additive credits
Prerequisites: graduate standing, and acceptance by the CIS department and the Division of Career Development Services. Students must have the approval of the co-op advisor for the CIS department. Provides on-the-job reinforcement and application of concepts presented in the undergraduate or graduate computer science curriculum. Work assignments are identified by the co-op office and developed and approved by the CIS department in conjunction with the student and employer. Students must submit, for CIS department approval, a proposal detailing the nature of the intended work. A report at the conclusion of the semester work experience is required. Credits for this course may not be applied toward degree requirements for either the bachelor's or master's in computer science.

CIS 601
Object-Oriented Programming 3 credits
Prerequisite: basic knowledge of C++. Covers the fundamentals of object-oriented programming. Includes object-oriented concepts such as data abstractions, encapsulation, inheritance, dynamic binding, and polymorphism, and uses C++ as the vehicle for illustrating and implementing these concepts. The object-oriented paradigm is systematically employed in the design of all concepts. Effects of this methodology on software maintenance, extensibility, and reuse. Significant programming/design projects.

CIS 602*
WWW: Applications Development and Java 3 credits
Prerequisite: advanced Web-based programming with an emphasis on the Java language and platform. No prior knowledge of Java is required but students are expected to have a good understanding of object-oriented programming concepts such as encapsulation, inheritance, and polymorphism, experience with C++. Basic constructs and syntax and then the core advanced features. Topics include: networking and sockets, remote method invocation (RMI), database connectivity (JDBC), Java Beans, multi-threading and lighweight components (Swing). Common gateway interface (CGI) languages and browser scripting (JavaScript and VBScript) are discussed when used as a complement to the functionality of the Java language. Emphasis is on the Java Development Kit version 1.1 (JDK1.1), both deprecated methods and newly introduced features are discussed.

*pending

CIS 603
Advanced Programming Environments and Tools 3 credits
Prerequisite: CIS 601. Introduction to Graphical User Interface (GUI) Programming in the X Windows System environment. Design and implementation of the GUI at various levels of abstraction using industry standard software tools. Trade-offs between flexibility and ease of use inherent in GUI building tools. Best suited for the advanced programmer.

CIS 604
Client/Server Computing 3 credits
Prerequisites: CIS 333 and CIS 432 or instructor approval (see undergraduate catalog for descriptions). Fundamentals of client/server architecture as applied to the development of software systems. Concepts of distributed systems such as open systems, middleware, software reengineering, and distributed computing environments. Components of distributed client/server technologies such as X Windows Systems, DCE, CORBA, NFS, and ODBC. Case studies are used to illustrate how client/server techniques can be used in a variety of applications. The importance of standards and their role in client/server architecture, such as Posix, DCE, and COS. Requires creation of distributed applications.

CIS 605
Discrete Event Dynamic Systems 3 credits
Prerequisite: Math 630 or EE 601 or MnE 603 or equivalent. Covers discrete event dynamic system theory and its applications in modeling, control, analysis, validation, simulation, and performance evaluation of computer systems, flexible manufacturing systems, robotic systems, intelligent supervisory control systems, and communication networks. Emphasis on Petri net and automation based approaches.

CIS 610
Data Structures and Algorithms 3 credits
Prerequisite: CIS 505 or CIS 335 or equivalents (see undergraduate catalog for description). Intensive study of the fundamentals of data structures and algorithms. Presents the definitions, representations, processing algorithms for data structures, general design and analysis techniques for algorithms. Covers a broad variety of data structures, algorithms and their applications including linked lists, various tree organizations, hash tables, strings, storage allocation, algorithms for searching and sorting, and a selected collection of other algorithms. Programs are assigned to give students experience in algorithms, data structure design and implementation.

CIS 611
Introduction to Computability and Complexity 3 credits
Prerequisites: mathematics bridge requirements. Introduces the theoretical fundamentals

of computing, and provides an understanding of both the inherent capabilities and limitations of computation. The main models of computation are deterministic and non-deterministic Turing machines. Auxiliary models include partial and total recursive functions, first order logic, recursive and recursively enumerable sets, and symbol systems. Covers the essentials of computational theory: first order logic, Russel's Paradox, completeness and consistency, Goedel's Theorem, Church's Thesis, countable and uncountable sets, simulation and computation, diagonalization, dove-tailing, decidable and undecidable problems, reduction, recursion theory, Rice's Theorem, Recursion Theorem, execution time measures, P and NP, polynomial-time reduction, NP-completeness and NP-hardness and formal correctness semantics of programs.

CIS 621
Numerical Analysis I 3 credits
Prerequisite: Math 511 (see undergraduate catalog for description) or an introductory course in numerical methods. An introduction to computational aspects of scientific and engineering problems. Time-dependent phenomena and corresponding quantitative models. Numerical stability and conditioning. Approximation of functions. Interpolation, integration. Solution of nonlinear equations. Ordinary differential equations of the first order. Finite and iterative algorithms for solution of systems of linear equations. Emphasis on computer implementation of algorithms and application to variety of engineering problems.

CIS 622
Numerical Analysis II 3 credits
Prerequisite: Math 511 (see undergraduate catalog for description) or an introductory course in numerical methods. This course covers the theory and design of computer solutions to mathematical equations. Included are iterative methods for solving systems of linear and nonlinear equations, the numerical eigenvalue-eigenvector problem, and methods for solving ordinary and partial differential equations. Emphasis is on the control of errors generated by the computer.

CIS 630
Operating System Design 3 credits
Prerequisites: CIS 332, CIS 432 (see undergraduate catalog for descriptions) and CIS 505. An intensive study of computer operating system design including multiprogramming, time-sharing, real-time processing, job and task control, synchronization of concurrent processes and processors, resource scheduling, protection, and management of hierarchical storage.

CIS 631
Data Management System Design 3 credits
Prerequisites: knowledge of C and data structures. Acquaintance with fundamental notions of relational database technology. Mathematical properties and usage of database programming languages. Methods of database design and conceptual modeling. Methods of physical storage for database information. Fundamental notions of concurrency control and recovery in database systems.

CIS 632
Advanced Database System Design
3 credits
Prerequisites: CIS 631 and knowledge of C++. Covers the concepts and principles of object-oriented data modeling and database systems, parallel and distributed database systems, database machines, real time (database) systems, multimedia and text databases, and imprecise information retrieval systems. Emphasis is on advanced data modeling, query optimization, indexing techniques, concurrency control, crash recovery, distributed deadlock detection, real-time scheduling, vague retrieval and system performance.

CIS 633
Distributed Systems 3 credits
Prerequisites: completion of bridge requirements. Fundamental topics concerning the design and implementation of distributed computing systems are covered, including interprocess communication, remote procedure calls, authentication, protection, distributed file systems, distributed transactions, replicated data, reliable broadcast protocols, and specifications for distributed programs. All topics will be illustrated with case studies. Optional topics may include synchronization, deadlocks, virtual time, and load balancing.

CIS 634
Information Retrieval 3 credits
Prerequisites: CIS 631. Covers the concepts and principles of information retrieval systems design. Techniques essential for building text databases, document processing systems, office automation systems, and other advanced information management systems.

CIS 635
Computer Programming Languages
3 credits
Prerequisites: CIS 505 and CIS 510. The theory and design of computer language systems; the formal theory of syntax and language classification; a survey of procedure and problem-oriented computer programming languages, their syntax rules, data structures, and operations; control structures and the appropriate environments and methods of their use; a survey of translator types.

CIS 636
Compiling System Design 3 credits
Prerequisite: CIS 635. Compiler organization; interaction of language and compiler design. The front end scanning, parsing, and syntax-directed translation: theory, standard approaches, and techniques; front-end tools such as Lex and Yacc. Attribute grammars. Code generation, register allocation, and scheduling; interaction with the run-time environment. Introduction to static analysis and optimization. As time permits, topics in modern compilers: compiling for object-oriented languages such as C++ or Java, memory hierarchies, pipelining, parallelism. Includes a significant programming component.

CIS 637
Real-Time Systems 3 credits
Prerequisites: completion of bridge requirements. Theory and principles that govern real-time systems design, and mechanisms and methodologies that enable their construction and operation. All aspects of such systems will be covered, including scheduling, device and resource management, communications, machine architecture, kernel software, language design and implementation, specification and user interfaces, and performance analysis and verification techniques.

CIS 640
Recursive Function Theory 3 credits
Prerequisite: CIS 540 or equivalent. Review of basic computability theory. Topics include Church's thesis; unsolvability results; creative, productive, and simple sets; computational complexity; P=NP problem; and classification of solvable problems according to their complexity.

CIS 641
Formal Languages and Automata 3 credits
Prerequisite: Math 226 or equivalent (see undergraduate catalog for description). Fundamentals of automata and formal languages: hierarchy of abstract machines and languages; nondeterministic finite state machines; tape and pushdown automata; context-free and context-sensitive grammars.

CIS 650
Computer Architecture 3 credits
Prerequisites: CIS 251 (see undergraduate catalog for description) and CIS 510. Exploiting instruction level parallelism (ILP) is central to designing modern computers. Presents design techniques used for such computers as IBM Power architectures, DEC Alpha, MIPS R4600, Intel P6, etc. Introduction of Instruction Set Architecture (ISA), various functional units, basic principles of pipelined computers. Modern techniques to ILP including superscalar, superpipelining, software pipelining, loop unrolling, and VLIW. Memory hierarchy, including instruction cache, data cache, second level cache, and memory interleaving. Advanced computer architectures, including vector, array processors, interconnection technology, and ATM network of workstations. Hands-on experience designing a simple pipelined computer on screen and using CAD tools such as Cadence or ViewLogic.

CIS 651
Data Communications 3 credits
Prerequisite: Math 333 (see undergraduate catalog for description). Intensive study of the analytic tools required for the analysis and design of data communication systems. Topics include: birth-death queuing systems, Erlang's distribution, bulk-arrival and bulk-service systems, design and analysis of concentrators and multiplexers, elements of Renewal Theory, M/G/1 system, analysis of Time Division Multiplexing, priority queues, analysis of random access systems, time reversibility, open and closed queuing networks, mean value analysis, flow and congestion, control mechanisms, routing algorithms, flow models, and network topological design.

CIS 652
Computer Networks-Architectures, Protocols and Standards 3 credits
Prerequisite: A high level programming language, Math 333 (see undergraduate catalog for description), or instructor approved equivalents. Intensive study of various network

architecture and protocol standards; with emphasis on the Open Systems Interconnection (OSI) model. Topics include: analog and digital transmission, circuit and packet switching, the Integrated Services Digital Network (ISDN), Frame Relay, Broadband ISDN, Cell Relay, SONET, Local Area Networks (CSMA/CD, Token Bus, Token Ring, switched and isochronous Ethernets), Metropolitan Area Networks (FDDI, FDDI-II, DQDB), wireless and satellite networks, synchronization and error control, routing and congestion control, X.25 standard.

CIS 653
Microcomputers and Applications 3 credits
Prerequisite: familiarity with an assembly level and higher-level language. An investigation of the personal computer based on the WinTEl architecture. Programming and use of the various input/output devices via operating system constructs. Use of computer in stand-alone (control) applications and networked applications. Investigation of non-Intel architectures and non-Windows systems as time permits.

CIS 654
Telecommunication Networks Performance Analysis 3 credits
Prerequisites: CIS 651, CIS 652, or instructor approved equivalents. Modeling and analysis of telecommunication networks; with emphasis on Local Area Networks (LANs) and Metropolitan Area Networks (MANs). Case studies will be presented and discussed, and the need for modeling and analysis will be established. Various types of LANs, and MANs will be modeled and analyzed. Problem sets and case studies will be assigned to facilitate understanding of the covered material.

CIS 656
Internetworking and Higher Layer Protocols 3 credits
Prerequisite: CIS 652 or instructor approved equivalents. Intensive study of the architecture of interconnected networks and corresponding protocols that make interconnected architectures function as a single unified communication system. Topics include: Internet services (archie, gopher, veronica, wais, netfind, world wide web, mosaic, etc.), the address resolution protocol (ARP) and reverse ARP, the Internet protocol, transparent gateways and subnetting, the domain name system, routing and multicasting in the Internet, the User Datagram Protocol (UDP), the Transmission Control Protocol (TCP), the socket interface, the client-server model of interaction, TCP/IP and OSI application level protocols.

CIS 657
Principles of Interactive Computer Graphics 3 credits
Prerequisites: CIS 505 or familiarity with the organization of at least one computer system, and knowledge of a structured programming language such as C. Graduate-level introduction to computer graphics concepts, algorithms, and systems. Includes 2-D raster graphics, algorithms, 2-D and 3-D geometric transformations, 3-D viewing, curves and surfaces. Emphasis on PC-based graphics programming projects. Principles of interactive graphics systems in terms of the hardware, software and mathematics required for interactive image production.

CIS 658
Multimedia Systems 3 credits
Prerequisites: CIS 610 and CIS 657, or CIS 631 or equivalent. Introduction to multimedia information systems; the nature of multimedia data types including text, image, audio, video and animation; multimedia data models and system architectures; design of multimedia systems including interfaces, storage models and structures, filtering, browsing and composing paradigms, query processing and information retrieval. Students will develop applications in multimedia authoring environments.

CIS 659
Image Processing and Analysis 3 credits
Prerequisite: CIS 505. Fundamentals of image processing, analysis and understanding. Topics include image representation, image data compression, image enhancement and restoration, feature extraction and shape analysis, region analysis, image sequence analysis and computer vision.

CIS 661
Systems Simulation 3 credits
Prerequisites: an undergraduate or graduate course in probability theory and statistics, and working knowledge of at least one higher-level language. An introduction to the simulation of systems, with emphasis on underlying probabilistic and statistical methodologies for discrete-event simulations. Design of simulation applications, and simulation programming in a high-level language. Algorithms for the generation of pseudorandom numbers. Algorithmic methodologies for the simulation of discrete and continuous probabilistic processes. Use of statistical tools. Simulation of queuing systems. Applications of simulation to a variety of system studies. The special purpose simulation language GPSS is studied in detail.

CIS 662
Model Analysis and Simulation 3 credits
Prerequisite: introductory course in simulation. Advanced topics in simulation methodology, including design of simulation experiments, variance reduction techniques, estimation procedures, validation, and analysis of simulation results. Queueing systems. Implementing a simulation with the SIMSCRIPT language. Models of continuous systems with applications to elementary socio-economic and industrial systems. Utilization of the DYNAMO II language.

CIS 665
Algorithmic Graph Theory 3 credits
Prerequisite: CIS 610. The elements of the theory of graphs and directed graphs with motivating examples from communication networks, data structures, etc; shortest paths, depth first search, matching algorithms, parallel algorithms, minimum spanning trees, basic complexity theory, planarity, and other topics. Programming assignments are included.

CIS 667
Design Techniques for Algorithms 3 credits
Prerequisite: CIS 610. An introduction to the principles of major design techniques in algorithms. Examples from a variety of topics and problems in computer science are used to demonstrate these design techniques and their appropriate application.

CIS 668
Parallel Algorithms 3 credits
Prerequisites: CIS 610 and CIS 650. This course examines a variety of parallel algorithms and architectures. Shared memory algorithms and algorithms for special architectures (tree processors, grids, systolic arrays, butterflies) are considered. The basic theory of algorithm/architecture performance will be described.

CIS 669
Computational Geometry 3 credits
Prerequisite: CIS 610 or permission of the instructor. Intensive study of the fundamentals of computational geometry data structures and algorithms. Emphasis is on the design of efficient algorithms and data structures, proofs of their correctness and complexity analysis. Fundamental topics including geometric searching, convex hull computation, nearest/farthest searching, Voronoi diagrams, Euclidean minimum spanning trees, planar triangulation, planar point location, arrangement of lines.

CIS 670
Artificial Intelligence 3 credits
Prerequisite: CIS 610 and CIS 631. Fundamental concepts and general techniques in artificial intelligence. Main topics include goal tree search, logic and deduction, adduction, uncertainty, fuzzy logic, knowledge representations, machine learning, vision, and action planning. The LISP programming language is used extensively. Students are required to do programming assignments, complete a programming term project, and review case studies.

CIS 671
Knowledge-Based Systems 3 credits
Prerequisite: CIS 670 or equivalent. Deals with the underlying architectures of "classical" knowledge-based systems, i.e., systems based on a knowledge representation formalism that are built by knowledge acquisition from a domain expert; and advanced database systems, especially object-oriented and deductive databases.

CIS 672
Expert System Methods and Design 3 credits
Prerequisite: CIS 670. Deals with expert systems, expert system shells, programming of rule-based systems, selection of shells, verification and validation of expert systems, and knowledge acquisition techniques for extracting knowledge from domain experts.

CIS 673
Software Design and Production Methodology 3 credits
Prerequisite: CIS 631. Modern techniques and methods employed in the development of large software systems, including a study of each of the major activities occurring during the lifetime of a software system, from conception to obsolescence and replacement. Topics include cost/performance evaluation, documentation requirements, system design and production techniques, system verification techniques, automated aids to system development, and project organization and management.

CIS 674
Natural Language Processing 3 credits
Prerequisite: CIS 670. Deals with techniques of natural language understanding. Topics are syntax and parsing (top down and bottom up), semantics, pragmatics and use of world knowledge in language understanding. Augmented Transition Networks will be used as programming tool set. Good knowledge of LISP or PROLOG.

CIS 675
Information System Evaluation 3 credits
Prerequisites: a course in statistics and CIS 677. Theoretical perspectives and methodological approaches to evaluate information systems within the context of the user and organizational environment. Topics include qualitative techniques such as protocol analysis and interviews; quantitative techniques such as sample surveys and controlled experiment; cost-benefit analysis, and analyses of data gathered by these approaches by methods such as regression, correlation, and analysis of variance. Emphasis on the application of these approaches to improve functionality, interface, and acceptance of information systems in organizations.

CIS 676
Requirements Engineering 3 credits
Prerequisites: completion of bridge requirements, CIS 673 or equivalent project experience in the field. Theory, principles, and practical application of the methodologies and tools of requirements engineering. The focus is development of large software systems and the integration of multiple systems into a comprehensive, domain dependent solution. All aspects of requirements engineering will be covered, including problem analysis, requirements specification techniques and tools, and specification of functional and non-functional requirements. Related technologies like domain analysis and pre-planned systems integration are also discussed.

CIS 677
Information System Principles 3 credits
Prerequisites: familiarity with the organization of a computer system and knowledge of at least one higher-level language. Reviews the role of information systems in organizations and how they relate to organizational objectives and organizational structure. Identifies basic concepts such as the systems point of view, the organization of a system, the nature of information and information flows, the impact of systems upon management and organizations, human information processing and related cognitive concepts. Introduces various types of applications that are part of information systems. The course focus is on management information systems.

CIS 678*
Medical Terminologies 3 credits
Describes in depth a number of medical terminologies in common use in the U.S. health care system, such as ICD-9-CM, SNOMED, HL7, MeSH, and especially the UMLS of the National Library of Medicine. Conduct hands-on work with the UMLS and write programs to extract and display information from the UMLS. Also covers European systems such as GALEN/SMK.

*pending

CIS 679
Management of Computer and Information Systems 3 credits
Prerequisite: CIS 675. Management of the development, planning, and utilization of information systems within organizations. Focuses on the current literature in the management of information systems. Topics include the approval and decision process for the development of systems, use of steering committees and various approaches to user involvement. Utilizes a number of Harvard University case studies. Project utilizing professional literature required.

CIS 682
Geometric Modeling 3 credits
Prerequisite: CIS 610. The techniques required to describe the shape of an object and to simulate dynamic processes; parametric geometry of curves, surfaces, and solids; and particular formulations for facilitating calculating geometric properties. Fundamentals of solid model construction and analysis are discussed extensively. Some applications in computer graphics, CAD, and CAM are also mentioned.

CIS 683
Object-Oriented Software Development 3 credits
Prerequisites: CIS 635, experience in software design and development or explicit approval of the instructor. Advanced course in software development. Presents the object-oriented methodology for software development and examines various areas to which this methodology can be applied. Analysis, design, and implementation of object-oriented software and the effect of this methodology on code reusability, extensibility, and robustness. Examines object-oriented languages, object-oriented databases, and object-oriented user-interfaces.

CIS 684
Business Process Innovation 3 credits
Prerequisites: CIS 631, CIS 673, knowledge of C or C++ programming. Discusses a balanced approach to business software process innovation (BPI) that includes both incremental improvement and re-engineering. Introduces, as the basic framework for managing change, the notion of a process architecture activity structure, infrastructure, and coordination structure. Details a spiral BPI implementation methodology, interwoven with many case studies. Discusses a software process engineering support environment.

CIS 688
Programming for Interactive Environments 3 credits
Prerequisite: knowledge of C++. A thorough study of the fundamental concepts and techniques of programming for modern interactive support environments, better known as graphical user interfaces (GUIs). A balanced blend of principle and practice, incorporating a general paradigm of interactive program development and numerous examples from, and projects in, the major GUI environments.

CIS 696
Network Management and Security 3 credits
Prerequisites: CIS 652 or ECE 683, and CIS 656. Thorough introduction to current network management technology and techniques, and emerging network management standards. In-depth study of the existing network security technology and the various practical techniques that have been implemented for protecting data from disclosure, for guaranteeing authenticity of messages, and for protecting systems from network-based attacks. SNMP family of standards including SNMP, SNMPv2, and RMON (Remote Monitoring), OSI systems management. Various types of security attacks (such as intruders, viruses, and worms). Conventional Encryption and Public Key Cryptology. Various security services and standards (such as Kerberos, Digital Signature Standard, Pretty Good Privacy, SNMPv2 security facility). *Same as ECE 638.*

CIS 697
Principles of Broadband ISDN and ATM 3 credits
Prerequisite: CIS 652 or ECE 683 or equivalent. Study of the Broadband Integrated Services Digital Network (B-ISDN) architecture and services. In-depth study of the Asynchronous Transfer Mode (ATM), ATM Adaptation Layer (AAL), ATM switching architectures, SONET/SDH, ATM traffic control, broadband integrated traffic models, Operation Administration and Management (OAM) functions, TCP/IP over ATM, and ATM market. *Same as ECE 639.*

CIS 700
Master's Project 3 credits
Prerequisite: matriculation for the master's degree. An approved project involving design, implementation, and analysis, or theoretical investigation is required of all students in the Master of Science degree program who do not take CIS 701 Master's Thesis. A project proposal must be submitted in a prior semester by an announced date and receive faculty approval. Project work is normally initiated in a computer science course with the knowledge and approval of the instructor who will become the student's project advisor.

CIS 701
Master's Thesis 6 credits
Prerequisite: matriculation for the master's degree. An approved project involving design, implementation, and analysis or theoretical investigation may be the basis for the thesis. The work will be carried out under the supervision of a designated member of the faculty. The thesis should be of such caliber as to warrant publication in a technical or scientific journal. Approval to register for the thesis must be obtained from the thesis advisor. A student must register for a minimum of 3 credits per semester. Credit will be limited, however, to the 6 credits indicated for the thesis.

CIS 725, 726
Independent Study in Computer Science I, II 3 credits
Prerequisites: graduate standing and department consent.

CIS 730
Seminar in Database Management Topics 3 credits
Prerequisite: CIS 631. A seminar in which students pursue intensive study of specialized topics in the current literature of database management. Each topic is supported by an initial reading list covering current problems in theory and practice. Students present the results of their studies in class with faculty and invited specialists participating. Topics include, but are not limited to, advanced data modeling, object oriented databases, query languages, semantic optimization, database mapping and integration, physical database architecture, database/knowledge-base integration, distributed databases, database machines, database version control, logical and deductive databases.

CIS 731
Applications of Database Systems 3 credits
Prerequisites: CIS 675 and CIS 631. Restricted to students who are specializing in computer and information systems management. Comparative study of different models of database management systems and their applications. Emphasis on the functions of the database administrator. Includes a survey of physical and logical organization of data, methods of accessing data, characteristics of different models of generalized database management systems, and case studies using these systems from various applications. Student teams design database systems for class projects.

CIS 732
Design of Interactive Systems 3 credits
Prerequisite: CIS 675. Design of interactive systems and human computer interfaces. Covers the current professional literature in this field and the "knowns" about design. Emphasizes application areas that have a great deal of cognitive variability and diverse user populations. Design interfaces for various applications. The impact of costs and operational practices upon user behavior and current research topics in interface design are covered.

CIS 735
Computer Mediated Communication Systems 3 credits
Prerequisite: CIS 675. Seminar for students contemplating research in the following areas: designs and the impact of, computer-based systems for human communication, including electronic mail, computer conferencing, Computer-Supported Cooperative Work (CSCW), Group Decision Support Systems (GDSS), the Internet and the World Wide Web. Topics include alternative design structures, impacts of primarily text-based asynchronous group communication, and recent empirical studies. Completion of a publishable state-of-the-art written review or design of a tailored CMC system is required.

CIS 741
Communication Network Design 3 credits
Prerequisites: CIS 651 and CIS 652. Basic problems of communication network design: analyzes their complexity and provides algorithms, heuristics and other techniques for their solution.

CIS 750
High Performance Computing 3 credits
Prerequisite: CIS 650. An in-depth study of the state of the art in high performance computing. Topics parallel computer architectures, programming paradigms, and their applications. Parallel architectures include PC clusters, shared-memory multiprocessors, distributed-memory multiprocessors, and multithreaded architectures. Parallel programming paradigms include message passing interface (MPI), its second-generation MPI-2, and multithreaded programming. Applications include computational science and high performance Web and database servers for Internet-based electronic commerce. Students program a parallel machine in class projects. First-hand experience in stable, scalable, high performance computing for Internet-based electronic commerce.

CIS 752
Communication Protocol Synthesis and Analysis 3 credits
Prerequisite: CIS 652 or basic familiarity with communication protocols. An in-depth study of the state of the art of protocol engineering. Enables students to apply the techniques of protocol design to real problems in communication protocols.

CIS 754
Measurement and Evaluation of Software Quality and Performance 3 credits
Prerequisites: Ph.D. core courses, CIS 630, CIS 661. A study of the tools for the measurement of software products and the use of these tools in the evaluation of software quality and performance. Structural and functional models of algorithms, programs, and systems are presented to define the quantitative and subjective characteristics of computer products. Course includes the use of hardware and software tools, the study of simulation and analytic techniques, description of workloads and benchmarks for system evaluation, problems of scale, proof of program correctness, feature value analysis, and the design and interpretation of experiments.

CIS 759
Advanced Image Processing and Analysis 3 credits
Prerequisite: CIS 659. Advanced study of recent research in image processing, analysis, and understanding. Topics include all image processing techniques, high-level recognition approaches, and automated expert vision systems.

CIS 762
Computerized Information Systems for Planning and Forecasting 3 credits
Prerequisite: CIS 675. Capturing and processing of subjective and empirical data for use in planning and forecasting information systems and the incorporation of these facilities into information systems designs. Emphasis on conveying understanding of the limitations of various methods and techniques to meet various planning and forecasting objectives. Use of various techniques such as the Delphi method, structural modeling, cluster analysis and regression approaches.

CIS 767
Decision Support Systems 3 credits
Prerequisite: CIS 675. The design, implementation, and utilization of models and their software support systems for application in managerial decision making at the strategic, tactical, and operational levels. Topics include the perspective of decision-support systems, the management of large simulation models and documentation standards, combined hybrid simulation languages and their applications, financial modeling and financial modeling languages. Systems dynamics and its managerial applications at the strategic level; specialized modeling and analysis software packages for managerial decision making; and recent research in computer-aided tools for capturing group judgment, modeling, and decision-making are also discussed.

CIS 775
Seminar in Software Engineering 3 credits
Prerequisite: CIS 673. A seminar in which students pursue intensive study of specialized topics in the current literature of software engineering. Each topic is supported by an initial reading list on current problems in theory and practice. The results of the studies are discussed in class with students, faculty and invited specialists.

CIS 776
Independent Study in Information Systems 3 credits
Prerequisite: restricted to students in the doctoral program in computer science or in management who have a major or minor in computer and information systems in management. Students must have an approved advanced program of study and approval of a faculty advisor to register for this course. Independent study is in a student-selected specialization. Students must present to a field exam committee a "state-of-the-art" review of the specialization topic area.

CIS 777
Seminar in Software Management and Production 3 credits
Prerequisites: Ph.D. core courses. A seminar in which students pursue intensive study of specialized topics in the current literature of software management and production. Each topic is supported by an initial reading list covering current problems in theory and practice. The results of the studies are discussed in class with students, faculty, and invited specialists participating. Topics include, but are not limited to, theory of algorithm structure, analysis of algorithms and programs, hardware technology assessment, automated tools for software production, software measurements and quality, peripheral device interfaces, data communications, computer networks, distributed processing, software verification, implementation standards, documentation standards, system security, software copyright, and project control and organization.

CIS 780
Computer Vision 3 credits
Prerequisite: CIS 505. Intensive study of the construction of explicit and meaningful descriptions of physical objects from computer images. Covers ideas from artificial intelligence, psychology, computer graphics, and image processing.

CIS 785
Seminar in Computer and Information Science I 3 credits
Prerequisites: determined by nature of topic area. Advance notice of the topics to be covered is given. These seminars examine in depth a special interest area of computer and information science. It emphasizes recent work in area selected for the offering of the course. This course is for master's students and cannot apply toward master's degree credit.

CIS 786
Special Topics in Computer and Information Science 3 credits
Prerequisites: same as for CIS 785. A continuation of CIS 785.

CIS 790
Doctoral Dissertation Credits as designated
Corequisite: CIS 791. Required for all doctoral students in computer science and for doctoral students in the joint NJIT/Rutgers doctoral program in management who major in computer information systems. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation while engaged in doctoral research. After 30 credits (additive to a maximum of 6 credits of CIS 792) are completed, students must register for 3 credits each semester until the dissertation is completed.

CIS 791
Graduate Seminar Non-credit
Corequisite (for doctoral students only): CIS 790. A seminar in which faculty, students, and invited speakers will present summaries of advanced topics in computer and information systems management. In the course students and faculty will discuss research procedures, dissertation organization, and content. Students engaged in research will present their own problems and research progress for discussion and criticism.

CIS 792
Pre-Doctoral Research 3 credits
Prerequisite: permission from department chairperson. For students admitted to the doctoral program in computer and information science who have passed the field exam or the qualifying examination. Research is carried out under the supervision of a designated faculty member. Students identify a research problem and prepare a plan to solve the problem. A maximum of 6 credits of CIS 792 may be applied to the CIS 790 requirement.

CIS 794
Computer Science Colloquium Non-credit
Prerequisite: graduate standing with major in computer science. Colloquium in which national and international experts in the various fields of computer science are invited to present and discuss the results of their recent research.

Ecology and Evolution

Offered by the Department of Ecology and Evolution at Rutgers-New Brunswick

16:215:533
The Behavior of Animal Populations
3 credits
Prerequisite: animal behavior or ecology. Topics in ecological adaptations of behavior; emphasis on the population level. Student research topics.

16:215:565
Community Dynamics 4 credits
Patterns and processes involving sets of two or more coexisting species. Theoretical and empirical studies.

16:215:590
Population Ecology 4 credits
Prerequisite: one ecology course. Population dynamics and demography, natural selection and evolution, life history strategies, population regulatory mechanisms, species interactions and co-evolution, variability among populations and ecological differentiation and island biogeography.

Economics

Offered by the School of Management

Econ 565
Managerial Economics 3 credits
Managerial decision-making for different markets: structure of industry, vertical integration, conglomerate firms, multinational firms, theory of "contestable" markets, entry deterrence, estimating demand and cost functions, price discrimination, agency trade, theory of regulation, market signaling and hiring, and theory of share economy.

Electrical and Computer Engineering

Offered by the Department of Electrical and Computer Engineering

ECE 501
Linear Systems and Random Signals
3 credits
This course, serving as a bridge course for non-electrical and computer engineering department graduate students, provides fundamental coverage of signal and system analysis, including probabilistic methods. Topics include signal models, system properties, Fourier Transform, introduction to probability, random variables, random processes, correlation functions, and spectral density.

ECE 550
Circuit Analysis 3 credits
Introduction to analysis of linear circuits and systems. Techniques used include mesh and nodal analysis, network theorems, steady-state and transient methods, analogs, Fourier series and transforms, and LaPlace transforms. Pole-zero diagrams are developed as an aid in the study of low-order systems. Credits for this course may not be used to fulfill any electrical engineering degree requirement.

ECE 590
Graduate Co-op Work Experience I
3 additive credits
Prerequisites: permission from Department of Electrical and Computer Engineering and Division of Career Development Services. Cooperative education/internship providing on-the-job reinforcement of academic programs in electrical and computer engineering. Assignments and projects are developed by the co-op office in consultation with the electrical and computer engineering department. Work assignments are related to student's major and are evaluated by faculty coordinators in the ECE department. Credits for this course may not be used to fulfill any electrical or computer engineering degree requirement.

ECE 591
Graduate Co-op Work Experience II
3 additive credits
Prerequisites: ECE 590 and permission from Department of Electrical and Computer Engineering and Division of Career Development Services. See ECE 590 course description. Credits for this course may not be used to fulfill any electrical or computer engineering degree requirement.

ECE 592
Graduate Co-op Work Experience III
3 additive credits
Prerequisites: graduate standing and permission from Department of Electrical and Computer Engineering and Division of Career Development Services. See ECE 590 course description. Credits for this course may not be used to fulfill any electrical or computer engineering degree requirement.

ECE 599
Electrical Engineering Laboratory 3 credits
Prerequisites: B.S. in engineering or science, and permission from ECE department. Workshop on fundamental measurements involving instrumentation commonly used in testing electronic and power circuits. Credits for this course may not be used to fulfill any electrical engineering degree requirement.

ECE 601
Linear Systems 3 credits
Methods of linear-system analysis, in both time and frequency domains, are studied. Techniques used in the study of continuous and discrete systems include state-variable representation, matrices, Fourier transforms, LaPlace transforms, inversion theorems, sampling theory, discrete and fast Fourier transforms, and Z-transforms. Computer simulation of linear systems is used, and, where feasible, computer solutions are obtained.

ECE 605
Discrete Event Dynamic Systems 3 credits
Corequisite: Math 630 or ECE 601 or MnE 603 or equivalent. Covers the theory of discrete event dynamic systems with applications in modeling, control, analysis, validation, simulation, and performance evaluation of computer systems, flexible manufacturing systems,

robotic systems, intelligent supervisory control systems, and communication networks. Emphasis on Petri net and automation based approaches.

ECE 609
Artificial Neural Networks 3 credits
Prerequisites: ECE 601 and ECE 673 or consent of instructor. Artificial Neural Networks (ANN) are networks consisting of massively parallel connected simple processing elements arranged in various topology, usually in layers. Various ANN models, learning paradigms, and applications are covered. The course evolves from a simple single-neuron structure to more complex networks.

ECE 610
Power System Steady-State Analysis 3 credits
Prerequisite: B.S. in EE or ME. Steady-state analysis of power system networks, particularly real and reactive power flows under normal conditions and current flows under faulty conditions. Symmetrical components and digital solutions are emphasized.

ECE 611
Transients in Power Systems 3 credits
Prerequisite: ECE 610. Transient performance of power systems with lumped properties, interruption of arcs, restriking voltage, re-ignition inertia effects, switching of rotational systems, magnetic saturation in stationary networks, harmonic oscillations, saturated systems, transient performance of synchronous machines.

ECE 612
Computer Methods Applied to Power Systems 3 credits
Prerequisite: undergraduate computer programming. Digital computer techniques proven successful in the solution of power system problems, particularly in the electric utility industry. Emphasis on short-circuit, load flow, and transient stability problems. Matrix sparsity is considered.

ECE 613
Protection of Power Systems 3 credits
Prerequisite: ECE 610 or equivalent. Coils, condensers, and resistors as protective devices; fundamental principles of protective relaying; relay operating characteristics; power and current directional relays; differential relays; distance and wire pilot relays; heating and harmonic effects.

ECE 614
Dynamics of Electromechanical Energy Conversion 3 credits
Prerequisites: ECE 620 and undergraduate electric machines. Dynamic behavior of lumped parameter systems; study of a continuum electromechanics, such as magnetic diffusion and the stress tensor; and dynamics of electromechanical continua in two- and three-dimensional systems.

ECE 615
Advanced Electromechanical Energy Conversion I 3 credits
Prerequisite: undergraduate electric machines. Steady-state performance of synchronous machines; time constants, sudden reactive loading; sudden short-circuit conditions; dynamic behavior of synchronous machines; speed torque-current control of induction machines; magnetic noise and voltage ripples; and Kron generalized machine theory.

ECE 616
Power Electronics 3 credits
Prerequisite: B.S. in electrical engineering. Principles of thyristor devices, dynamic characteristics of choppers, commutation, protection, voltage-fed and current-fed inverter drives, cycloconverters, pulse width modulation, phase control, and microcomputer control, with case studies.

ECE 618
Power System Design of Alternative Energy Sources 3 credits
Prerequisite: EE 451 or equivalent (see undergraduate catalog for description). System design modeling, economic feasibility, and applications of alternative and renewable energy sources including: fuel cells, storage batteries, bio-electrochemical cells, redox flow cells, ocean thermal energy converters, and magnetohydrodynamic converters. The modes of system interconnections, including linkage to conventional power systems, are also studied.

ECE 620
Electromagnetic Field Theory 3 credits
Prerequisite: undergraduate electromagnetic field theory or equivalent. Maxwell's equations, boundary conditions and formulation of potentials. LaPlace and Poisson equations for electrostatic and magnetostatic problems and the method of images. Dielectric and magnetic materials, force and energy concepts. Quasi-static and time varying fields, plane, cylindrical and spherical waves. Green's functions, transmission lines.

ECE 622
Wave Propagation 3 credits
Prerequisite: ECE 620 or equivalent. Fundamentals of electromagnetics; radiation and scattering; Green's functions; integral equations; numerical methods; ray optics and asymptotics.

ECE 623
Fourier Optics 3 credits
Prerequisite: EE 362 (see undergraduate catalog for description) or equivalent. Theoretical background needed to analyze various optical systems: two-dimensional Fourier transforms, vector and scalar diffractions, Fresnel and Fraunhofer approximations, the properties of lenses, coherence theory, frequency analysis of optical imaging systems, spatial filtering, optical information processing, and wavefront-reconstruction imaging.

ECE 624
Optical Engineering 3 credits
This course covers basic optical concepts, emphasizing those common to many optical instruments, such as light sources and their characteristics, polarization, coherence, and interferometry. The course introduces CAD tools for lenses, optical filters, and instrument design. The course also focuses on topics concerning optical systems, such as flat panel displays and micromechanical optical systems.

ECE 625
Fiber and Integrated Optics 3 credits
Prerequisites: undergraduate electromagnetic field theory and solid-state circuits. Planar dielectric waveguides, step and graded index fibers and dispersion in fibers. The p-n junction and heterostructures, light emitting diodes and semiconductor lasers, p-i-n and avalanche photodetectors, optical transmitter and receiver designs, optical fiber communication system design concepts.

ECE 626
Optoelectronics 3 credits
Prerequisites: undergraduate electromagnetic field theory and solid-state circuits. Optical propagation in anisotropic materials, polarization, birefringence and periodic media. Concepts of electro-optics and acousto-optic devices, optical modulators, switches, active filters for optical communication and optical processing.

ECE 630
Microwave Engineering 3 credits
Prerequisite: undergraduate course in electromagnetic field theory. Review of transmission line theory and the Smith chart; scattering matrix representation, LC and microstrip matching networks; signal flow graph analysis; microwave transistor amplifier design, which includes power gain, stability, noise figure circles; oscillator design.

ECE 632
Antenna Theory 3 credits
Prerequisite: undergraduate course in electromagnetic field theory. Fundamentals of electromagnetic field theory; far field approximation, antenna characteristics (gain, impedance, pattern, etc.); elementary antenna types (dipoles, loops, etc.), antenna array theory, wire antennas; broadband antennas.

ECE 635
Conduction in Plasma 3 credits
Prerequisite: undergraduate course in direct power generation. Maxwellian velocity distribution function, concentration and diffusion gradients, mean free path, methods of ionization, field intensified ionization, drift velocity, plasma temperature methods of deionization, plasma oscillations and plasma sheath, spark breakdown and mechanism of arcs.

ECE 638
Network Management and Security 3 credits
Prerequisites: CIS 652 or ECE 683, and CIS 656. Thorough introduction to current network management technology and techniques, and emerging network management standards. In-depth study of the existing network security technology and the various practical techniques that have been implemented for protecting data from disclosure, for guaranteeing authenticity of messages, and from protecting systems for network-based attacks. SNMP family of standards including SNMP, SNMPv2, and RMON (Remote Monitoring), OSI systems management. Various types of security attacks (such as intruders, viruses, and worms), Conventional Encryption and Public Key Cryptology. Various security services and standards (such as Kerberos, Digital Signature

Standard, Pretty Good Privacy, SNMPv2 security facility). *Same as CIS 696.*

ECE 639
Principles of Broadband ISDN and ATM 3 credits
Prerequisite: CIS 652 or ECE 683 or equivalent. Study of the Broadband Integrated Services Digital Network (B-ISDN) architecture and services. In-depth study of the Asynchronous Transfer Mode (ATM), ATM Adaptation Layer (AAL), ATM switching architectures, SONET/SDH, ATM traffic control, broadband integrated traffic models, Operation Administration and Management (OAM) functions, TCP/IP over ATM, and ATM market. *Same as CIS 697.*

ECE 640
Digital Signal Processing 3 credits
Prerequisite: ECE 601 or equivalent. The theory of digital signals and basic processing techniques: Discrete Fourier Series, Discrete Fourier Transform and FFT, Linear and Circular Convolution, Digital Filter Design Techniques, Discrete Hilbert Transforms, Discrete Random Signals, Chirp-Z and other advanced transforms. Introduction to multivariate signal processing. The typical applications of signal processing tools are discussed and connected to the theoretical foundations.

ECE 642
Communication Systems I 3 credits
Corequisite: ECE 673. Principles of communication theory applied to the representation and transmission of information. Topics include analysis of deterministic and random signals, amplitude modulation, angle modulation, sampling, quantization, PCM, DM, DPCM, geometric representation of signals, error probability, matched filter and correlation receivers and performance analysis of communication systems signal to noise ratio.

ECE 643
Digital Image Processing I 3 credits
Prerequisite: ECE 601. Introductory course in digital image processing. Topics include image models, digitization and quantization, image enhancement in spatial and frequency domains, image restoration, image segmentation and analysis.

ECE 644
Introduction to Wireless and Personal Communications Systems 3 credits
Prerequisite: ECE 642 or equivalent. Introduces emerging personal communications networks (PCN) and envisioned personal communication services (PCS). Discussion of recent history of underlying technologies that are being used to synthesize PCN and delineation of the alternative approaches being considered. Focuses primarily on U.S. technologies, with coverage of wireless technologies in Europe and Japan.

ECE 646
Introduction to Data Communications 3 credits
Prerequisites: ECE 642 and ECE 673, or equivalent. Introduces the theory and technology of data communications over voice-grade and broadband channels. Provides the analytical tools required to understand and design data communication systems. Topics include: an overview of data communication systems, channel capacity, channel coding (block codes, cyclic codes, convolutional codes), data transmission, synchronization, equalization, and an introduction to adaptive equalization.

ECE 648
Digital Microelectronics 3 credits
Prerequisite: undergraduate semiconductor circuits. Topics include: linear wave shaping with RC circuits, clipping and clamping circuits; theory of operation of semiconductor diode, bipolar transistor (BJT), and MOSFET; BJT and MOSFET inverters, gate circuits, and regenerative logic circuits.

ECE 649
Compression in Multimedia Engineering 3 credits
Prerequisite: ECE 640 or instructor's permission. Foundations of information theory, audio/speech and video compression technologies. Detailed discussion of JPEG, image compression, H.261, MPEG-1 and MPEG-2 international video compression standard algorithms. Current status and future directions of very low bit rate MPEG-4 video compression standards activities.

ECE 650
Electronic Circuits 3 credits
Prerequisite: senior undergraduate level semiconductor circuits. Methods of analysis and design of linear and digital semiconductor circuits are studied. Topics include low and high frequency models, passive and active biasing techniques, I-C analysis and design, op-amp circuits, and active filters.

ECE 657
Semiconductor Devices 3 credits
Fundamental principles of solid state materials necessary for understanding semiconductor devices. Topics include crystal structure; energy bands; electron and hole generation, and transport phenomena; generation and recombination processes, and high field effects. P-N junction diode, metal semiconductor contact, and bipolar and metal oxide semiconductor transistors, including switching phenomena and circuit models. Introduction to: photonic devices~light emitting diodes, semiconductor lasers, photodetectors, and solar cells; microwave devices~tunnel and IMPATT diodes, transferred electron devices, and charge-coupled capacitors.

ECE 658
VLSI Design I 3 credits
Prerequisite: ECE 657 or equivalent. Analysis and design of digital integrated circuits; basic building blocks and dependence on circuit parameters of propagation delay; noise margin; fan-out; fan-in; and power dissipation for circuits of different logic families, including NMOS, CMOS and BiCMOS; subsystem designs in combinational and sequential logic; Memory Systems; HSPICE circuit simulation is used for digital characteristics evaluation. Mentor Graphics Layout design tools are used for chip design.

ECE 659
Fabrication Principles of Electronic and Optoelectronic Devices 3 credits
Prerequisite: ECE 657 or equivalent. Overview of all major processing steps in fabrication of integrated circuits such as crystal growth, epitaxy, oxidation, diffusion, ion implantation and etching. Formation of thin film structures along with techniques for defining submicron structures. Emphasizes silicon device technology but also includes processing of compound semiconductors such as gallium arsenide.

ECE 660
Control Systems I 3 credits
Prerequisites: undergraduate course equivalent to EE 333 or ME 305 (see undergraduate catalog for descriptions) and ECE 601 or equivalent or permission from instructor. Introduction to feedback control. Review of state-space analysis. Frequency-domain methods for analysis: Routh-Hurwitz stability algorithms, Root-loci; Nyquist and Bode plots; system "type." Controllability and observability. The separation principle and design by pole placement. Linear observers. Optimization of quadratic performance criteria. Elements of random processes. The Kalman filter as an optimum observer. Robustness considerations.

ECE 661
Control System Components 3 credits
Prerequisite: ECE 660. The theoretical and practical requirements for analog and digital state-of-the-art control system components are covered. Actuators, amplifiers, sensors, encoders, resolvers and other electromagnetic devices are included. A complete system is designed using current vendor catalog data. Problems affecting the system performance are analyzed using measures of functionality, reliability and cost.

ECE 662
Large Power Control Systems 3 credits
Prerequisites: ECE 660, ECE 614, or equivalents. Emphasis on the design and test analysis of servomechanisms and regulation systems involving large power components such as dc machines, induction motors, and alternators. Positioning and velocity servos using rotating amplifiers are covered. A velocity servo for controlling a large induction motor is designed and a typical alternator voltage regulator studied, with regard to its servo characteristics. Methods of determining motor size and gear ratio in large positioning servos are covered.

ECE 664
Real-time Computer Control Systems 3 credits
Prerequisite: EE 486 or equivalent (see undergraduate catalog for description). Emphasizes the practical aspects of modern computer control systems. Topics include: Architecture of digital signal processors (DSP) and microcontrollers, real-time data acquisition devices and interface, programming a DSP, review of sampling theorems and properties of discrete-time systems, introduction of control systems theory, design and implementation of parameter optimized controllers, state variable controllers,

and cancellation controllers. An experimental project using a TMS320C2x DSP-based data acquisition system is an integral part of this course.

ECE 666
Control Systems II 3 credits
Prerequisites: ECE 601 and ECE 660. Properties of nonlinear systems and basic concepts of stability including small-signal linearization. State plane methods are introduced, with emphasis on controller design for systems that can be represented by second-order approximations. Concepts of equivalent gain, describing function, and dual-input describing function as applied to a large class of nonlinear systems. Representation of linear sampled-data systems in discrete state variable form, stability and performance of discrete-event systems. Full-state feedback, pole placement and observer design. Linear quadratic control and Kalman filtering.

ECE 667
Systems Studies in Bioengineering
3 credits
Prerequisite: Undergraduate or graduate course in linear systems. Basic techniques of simulation including digital simulation languages. Physiologic systems of current interest using systems analysis techniques leading to formulation of mathematical, computer, or electric circuit models. Systems examined include the circulatory, respiratory, or hormonal control systems. Basic techniques of signal processing are explored which are necessary to analyze data from physiologic systems. *Same as BME 667.*

ECE 673
Random Signal Analysis I 3 credits
Fundamentals of the theory of random variables. Introduction to the theory of random processes. Topics include functions of random variables, sequences of random variables, central limit theorem, properties of random processes, correlation, spectral analysis and linear systems with random inputs.

ECE 677
Optimization Techniques 3 credits
Prerequisite: undergraduate course in differential equations. Analytical and numerical methods for finding an extremum emphasizing how and when to apply them. Classical differentiation, Lagrange multipliers, the calculus of variations, penalty functions, slack variables, search techniques, and stochastic approximation are covered.

ECE 683
Computer Network Design and Analysis
3 credits
Corequisite: ECE 673. Queueing models and state-transition models are introduced to model, design and analyze computer networks. The OSI model, LANS (including token ring, token bus, and Ethernet), and useful network protocols. Emphasis on the physical, data link and network layers. ALOHA, Stop-and-Wait protocol, Go-Back-N protocol, window-flow-control, and shortest-path routing.

ECE 684
Advanced Microprocessor Systems
3 credits
Prerequisites: undergraduate course in computer architecture and microprocessors, and some experience in assembly language programming. Architecture of advanced microprocessors; CPU architecture, memory management and protection, interrupt and exception facilities, instruction sets, systems aspects including peripheral interfaces, communications ports, and real-time systems.

ECE 685
Network Interface Design 3 credits
Prerequisite: ECE 683 or equivalent. Provides a working knowledge of data communications networking devices, the building blocks upon which networks are constructed. Emphasizes devices and their function in data communication networks. Covers the use of devices in the design, implementation, modification, and optimization of data communications networks.

ECE 686
Instrumentation Systems and Microprocessors 3 credits
Prerequisite: undergraduate course in microprocessors. Principles of instrumentation transducers and the electronic amplifiers and filters needed to process the electrical signals generated by them; types and characteristics of A/D and D/A converters and other circuits necessary for the interfacing of instrumentation data to a computer or digital data transmission system. Emphasis placed on development of stand-alone analog instrumentation systems as well as microprocessor-based systems. Tradeoffs and alternatives for both implementations are emphasized as well as cost effectiveness of each design. Hardware and software are developed as needed.

ECE 687
Design of Medical Instrumentation 3 credits
Prerequisite: undergraduate course in electronics. Principles and practice of medical instrumentation. Instrument components and medical instrument systems design. Examples taken from electrocardiography, clinical chemistry, medical imaging. Microprocessor-based systems emphasized.

ECE 688
Microcontrollers in Instrumentation
3 credits
Prerequisite: undergraduate course in microprocessors. Microcontroller as single chip computer system for diverse applications. System microcontroller real-time design concepts from architecture to interface. Assembly language programs. Real-time facilities of advanced microcontrollers are emphasized.

ECE 689
Digital System Design for Machine Arithmetic 3 credits
Prerequisite: undergraduate course in logic design. Data representation, integers, floating point and residue representation. Bounds on arithmetic speed, algorithms for high speed addition, multiplication, and division. Pipelined arithmetic. Hardware implementation and control issues.

ECE 690
Computer Systems Architecture 3 credits
Prerequisites: ECE 684 and CoE 353 (see undergraduate catalog for description) or CIS 650. Discusses advanced topics in modern computer systems architecture such as pipelined and superscalar processors, parallel computers (vector, SIMD, MIMD), multithreaded and dataflow architectures, cache and memory hierarchy, and system interconnect architectures. Also discusses relevant system software design issues such as shared memory and message-passing communication models, cache coherence and synchronization mechanisms, latency-hiding techniques, virtual memory management, program partitioning and scheduling. Examples are drawn from real systems.

ECE 698
Selected Topics in Electrical and Computer Engineering 3 credits
Special area course given when suitable interest develops. Advance notice of forthcoming topics will be given.

ECE 699
Selected Topics in Electrical and Computer Engineering II 3 credits
See description for ECE 698 above.

ECE 700
Master's Project 3 credits
Prerequisite: written approval of project advisor. An extensive paper involving design, construction, and analysis, or theoretical investigation. Joint projects with industry may be acceptable. Work is carried out under the supervision of a member of the department faculty. A maximum of 3 credits may be applied to the degree.

ECE 701
Master's Thesis 6 credits
Prerequisite: written approval of thesis advisor. Projects involving design, construction, experimental or theoretical investigation. Joint projects with industry or governmental agencies may be acceptable. Work is carried on under the supervision of a designated member of the department faculty. Completed work in the form of a written thesis should be of a quality leading to journal publication. The completed thesis must be defended by the student in an open forum and must be approved by a committee of at least three people. A student must register for a minimum of 3 credits per semester. Only the 6 credits indicated for the thesis will be applied to the degree.

ECE 710
Economic Control of Interconnected Power Systems 3 credits
Prerequisite: ECE 610. Theoretical developments and computer methods in determining economic operation within the boundaries of a given steam-electric operating area. Energy accounting control and economic theories for interconnected steam and hydroelectric power systems.

ECE 711
Power System Dynamics and Stability 3 credits
Prerequisites: ECE 610 and undergraduate course in electric machines. Elements of the stability problem: principal factors affecting stability, ordinary simplified methods of making stability calculations, and illustrations of the application of these methods to studies of power systems, damping, and saturation.

ECE 719
Advanced Electromechanical Energy Conversion II 3 credits
Prerequisites: ECE 615, ECE 622. Derivation of circuit models of rotating systems, based on the cross-sectional space wave method and the study of generalized Maxwell-Lorentz equations, applied to coupled rotational bodies.

ECE 725
Independent Study I 3 credits
Prerequisite: departmental approval. Program of study prescribed and approved by student's faculty coordinator. This special course covers areas of study in which one or more students may be interested but is not of sufficiently broad interest to warrant a regular course offering. Master's degree students cannot count ECE 725 as degree credit but can count these credits to qualify for full-time status.

ECE 726
Independent Study II 3 credits
See description for ECE 725 above. This course is not available to master's students.

ECE 730
Theory of Guided Waves 3 credits
Prerequisite: ECE 620 or equivalent. Modes, rays and beam propagation in guiding structures. Non-uniform waveguides and transitions, excitation of waveguides and optical fibers. Coupled modes theory with applications to resonators and couplers. Wave propagation in anisotropic media.

ECE 739
Laser Systems 3 credits
Prerequisite: ECE 620 or permission of instructor. Optical resonators, laser radiation and oscillation. Laser characteristics: semiconductor lasers, gas and glass lasers; mode-locking, Q-switching. Quantum-well lasers, noise; modulation and detection of laser light, optical systems for communication and computation.

ECE 740
Advanced Digital Signal Processing 3 credits
Prerequisites: ECE 601, ECE 640 and ECE 673. Topics in stationary discrete time stochastic processes; modeling of discrete time processes, Yule-waker equations, aspects of discrete wiener theory; principle of orthogonality, linear predictors; Levinson-Durbin recursion and algorithm, lattice predictors, method of least squares (RLS) algorithm, systolic array implementation of QRD-Ls.

ECE 742
Communication Systems II 3 credits
Prerequisites: ECE 642 and ECE 673 or equivalents. Principles of digital communication. Topics include fundamentals of information theory, digital modulation techniques, optimum detector receivers for digitally modulated signals, the bandlimited gaussian channel and intersymbol interference, equalization, spread spectrum, CDMA.

ECE 746
Adaptive Array Processing and Interference Cancellation 3 credits
Prerequisites: ECE 642 and ECE 673. Principles of array processing, performance criteria used, and adaptive algorithms for realization of these processors; and ideas and principles of array processing in the design of contemporary radar systems.

ECE 747
Signal Decomposition Techniques: Transforms, Sub-bands, and Wavelets 3 credits
Prerequisites: ECE 640 and ECE 673. Multiresolution signal decomposition techniques, transforms, sub-bands, and wavelets. Time-frequency localization properties of multiresolution algorithms. Evaluation and critique of proposed decomposition strategies from compression and performance standpoints. Applications to speech and video compression, and localized feature extraction. These are basic signal processing tools used in diverse applications such as speech and image processing and storage, seismology, machine vision.

ECE 755
Advanced Topics in Digital Communications 3 credits
Prerequisites: ECE 642 and ECE 673 or equivalent. Advanced topics in digital communication systems in the presence of intersymbol interference, noise, and fading: modulation and demodulation in the presence of gaussian noise, efficient signaling with coded modulation, trellis decoding, Viterbi algorithm, digital transmission with intersymbol interference, and digital signaling over imperfect channels.

ECE 757
Wireless Communications 3 credits
Prerequisite: ECE 742 or equivalent. Introduction of digital cellular radio. In-depth analytical characterization of linear, time-variant systems as they apply to wireless channels. Thorough consideration of the principles of the CDMA multiuser system, together with methods for reducing multiple-access interference. Emphasis on general topics such as diversity interleaving.

ECE 758
VLSI Design II 3 credits
Prerequisite: ECE 658 (with ECE 657 suggested). Use of CMOS, biCMOS and bipolar semiconductor technology for VLSI design. Digital techniques are emphasized with minor coverage of analog design. Application areas for full custom, gate arrays, standard cell, and compiled designs are compared. Mentor VLSI design tools running on the HP and Sun workstations are used in the course projects for each enrollee. The course attempts to provide a design environment for projects that is similar to that encountered by VLSI designers in industry.

ECE 759
Principles of Phase Lock and Frequency Feedback 3 credits
Prerequisites: ECE 642 and ECE 673 or equivalents. Principles of operation and design for phase locked and frequency feedback loops, linear equivalent circuit, nonlinear effects, and optimization against noise used in a wide range of applications including low-level signal reception, tracking, phase extraction, filtering, and frequency synchronization. F.M. communication is emphasized.

ECE 760
Solid-State Image Sensors 3 credits
Prerequisites: ECE 657 and ECE 648 or ECE 658. Construction, operation, and performance evaluation of visible and infrared image sensors. Included are a review of the main approaches for photodetectors and readout structures, image sensor architectures, performance evaluation and trade-offs, noise considerations, modulation transfer function, techniques for control of blooming, interlacing, color-coding for visible imagers, HDTV imagers, photo-counting amplifiers, and radiometry and figures of merit for infrared imagers.

ECE 766
Stability Theory of Nonlinear Systems 3 credits
Prerequisite: ECE 666. Concepts of stability in dynamic systems, theory and application of Lyapunov's direct method. Use of functional analysis, and frequency response method of Popov and its extensions including their application to the investigation of stability, boundedness, and damping in a class of unforced and forced nonlinear systems.

ECE 768
Optimal Control Theory 3 credits
Prerequisite: ECE 677. Optimal control for classes of deterministic systems with various constraints using calculus of variations, dynamic programming and the maximum principle, state variable constraints, and application of theory to design problems.

ECE 769
Stochastic Estimation and Control 3 credits
Prerequisites: ECE 660 and ECE 673. Markov processes. The discrete-time Kalman filter as a minimum variance estimator. The continuous-time Kalman-Bucy filter. Relationship to the Wiener filter. Nonlinear systems: the extended Kalman filter and other generalizations. Computational difficulties and methods for avoiding them: separated-bias estimation, "UDU" factorization. Applications in navigation and control.

ECE 773
Random Signal Analysis II 3 credits
Prerequisite: ECE 673. Continuation of ECE 673. Non-stationary stochastic processes, harmonic analysis, the zero crossing problem, Markov processes, the Poisson process, orthogonal expansions, non-Gaussian processes, non-linear operations.

ECE 776
Information Theory 3 credits
Prerequisites: ECE 642 and ECE 673 or equivalents. Classical theory of information developed from Shannon's theory. Information measure, Markov sources and extensions, the adjoint source, uniquely decodable and instantaneous codes and their construction, Shannon's first and second theorems, mutual information, and performance bounds on block and convolutional codes.

ECE 777
Statistical Decision Theory in Communications 3 credits
Prerequisite: ECE 642 or equivalent. Relation between detection theory and statistical hypothesis testing problem. Use of Bayes decision criteria, Neyman-Pearson, and mini-max tests; receiver operating characteristics. Representation of signals in signal space, probability of error calculations. Estimation of random and non-random signal parameters, Cramer-Rao Inequality. The general Gaussian problem and the use of covariance matrices.

ECE 778
Algebraic Coding for Information Transmission 3 credits
Prerequisites: ECE 642 and ECE 673. Coding for reliable digital transmission and storage, error detection and correction codes. Decoding techniques and performance evaluation of block and convolutional codes, including BCH, Reed-Solomon code and Trellis coded modulation.

ECE 783
Computer Communication Networks 3 credits
Prerequisites: ECE 673 and ECE 683. Data link control and communication channels. Delay models in data networks. Queueing analysis techniques are taught in detail. Multi-access communication techniques. Routing in computer communication networks.

ECE 785
Parallel Processing Systems 3 credits
Prerequisite: ECE 684 or equivalent. Parallel computer architectures. General purpose and specialized parallel computers. Shared-memory multiprocessors, message-passing multicomputers, and vector supercomputers. Principles of scalable performance. MPP designs. SIMD and MIMD computers. Design of parallel algorithms (merging and sorting of data, FFT, etc.) and performance evaluation. Load balancing, data decomposition, and scheduling of operations.

ECE 788
Selected Topics in Electrical and Computer Engineering 3 credits
Special-area course given when suitable interest develops. Advance notice of forthcoming topics will be given.

ECE 789
Selected Topics in Electrical and Computer Engineering II 3 credits
See description for ECE 788.

ECE 790
Doctoral Dissertation Credits as designated
Required of all students working toward the Ph.D. in Computer Engineering or in Electrical Engineering. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester; registration for additional credits may be permitted beyond the 6, with the approval of the advisor, up to a maximum of 12 credits per semester. If the student is still actively engaged in the research after completion of 36 credits, continued registration of 3 credits per semester is required.

ECE 791
Graduate Seminar 1/2 credit
Required every semester of all master's students in computer engineering or electrical engineering who receive departmental or research-based support and all doctoral students. To receive a satisfactory grade, students must attend at least five seminars per semester, as approved by the seminar supervisor.

ECE 792
Pre-Doctoral Research 3 credits
Prerequisite: permission of the department. For students admitted to the program leading to the Ph.D. in Computer Engineering or Electrical Engineering. Research carried on under the supervision of a designated member of the department faculty. If the student's research activity culminates in doctoral research in the same area, up to a maximum of 6 credits may be applied toward the 36 credits required under ECE 790 after the student fulfills requirements of doctoral candidacy.

Engineering Management

Offered by the Department of Industrial and Manufacturing Engineering

EM 501
Industrial Management 3 credits
Prerequisite: approval from the engineering management graduate advisor or program director. Operational aspects of management techniques: organization, product design and development, distribution logistics, marketing, plant location and layout, materials handling, production planning and control, inventory control, quality control, work analysis, and incentive plans.

EM 502
Engineering Cost Analysis 3 credits
Prerequisite: approval from the engineering management graduate advisor or program director. Financial, engineering, economic, and cost-control aspects of industrial management; the accounting cycle; cost accounting procedure; and cost-model techniques of making cost comparisons through engineering economic studies.

EM 503
Methods and Applications of Industrial Statistics and Probability 3 credits
Prerequisites: approval from the engineering management graduate advisor or program director, undergraduate course in calculus. An analytical approach to basic engineering probability and statistics, with applications drawn from both manufacturing and process industries. Emphasis is placed upon the utility of statistical inference derived from engineering data.

EM 602
Management Science 3 credits
Prerequisites: undergraduate calculus and probability and statistics. Linear programming: formulation, methodology, and application; the transportation problem; the assignment problem; Markov chains and their applications in decision making; queueing systems; deterministic and stochastic inventory models.

EM 607
Seminar in Contemporary Management Problems 3 credits
Prerequisites: undergraduate courses in economics and management. Readings, discussions, field studies, and reports in areas of contemporary management, behavioral science, management science, economics, and systems planning and control. Course is designed to encourage and give direction to student research for thesis.

EM 617
Environmental Risk Assessment 3 credits
Prerequisites: undergraduate courses in calculus and economics. Application of management technique methodology to recognize, evaluate, and make decisions regarding expenditures for the mitigation of potentially hazardous environmental risks. Basic analytical techniques applicable to social and economic risk assessment; methodology and application to current air and water resources; and rationale for cost-benefit and trade-off analysis. Technical characteristics of materials: half-life, decomposition rates, and temperature sensitivity determining environmental probabilities and expectations.

EM 631
Legal Aspects in Environmental Engineering 3 credits
Control of air, water, and solid waste pollution by federal, state, and local government statutes and international law. Preparation of environmental impact statements and the right of private citizens to bring suit under federal clean air and water pollution legislation are discussed, as well as limitations on these rights.

EM 632
Legal Aspects in Construction 3 credits
Introduction to the legal factors affecting construction activities: contract responsibilities of contractors, engineers, and owners; subcontracts and third-party liability; construction law and code compliance; and insurance and bonds.

EM 633
Legal Aspects of Health and Safety 3 credits
Review of key laws and regulations pertaining to occupational health, safety, and product liability; methods to determine which codes apply in given situations and to prepare operating procedures to be used for internal compliance.

EM 634
Legal, Ethical and Intellectual Property Issues for Engineering Managers 3 credits
Introduction to various environmental, product liability, health and safety, and intellectual property, legal, as well as ethical, issues facing engineering managers. Current New Jersey and federal laws and pending legal actions in these fields. Case studies and advanced multimedia learning tools are used.

EM 635
Management of Engineering Research and Development 3 credits
Prerequisites: principles of management and statistics, or EM 501 and EM 503. A systems approach to management of resources, and tasks needed for engineering research and development. Identification, analysis, and evaluation of the operational characteristics and structure of the research laboratory and engineering office; functions of planning, organizing, staffing, direction, control, innovation, and representation; and planning and control theories, techniques, and current practices in scientific and engineering management.

EM 636
Project Management 3 credits
Prerequisites: IE 492 (see undergraduate catalog for description), IE 603 or equivalents. Introduction to concepts of project management and techniques for planning and controlling of resources to accomplish specific project goals. While the focus is on technically oriented projects, the principles discussed are applicable to the management of any project. Topics include time, cost considerations, cash flow forecasting, financial and performance control, documentation.

EM 637
Project Control 3 credits
Prerequisite: EM 636 or equivalent. Focuses on the methodology that can be employed to plan project implementation and control progress. Topics include work breakdown construction, task and schedule development budgetary control, earned value analysis, and behavioral considerations. Project management software utilization is emphasized.

EM 640
Distribution Logistics 3 credits
Prerequisite: EM 602 or Tran 650 or equivalent. Distribution logistics emphasizing systems engineering techniques used to optimize corporate profit and customer service: transportation modes; inventory policies; warehousing and order processing; and the best logistics gross margin. *Same as Tran 640.*

EM 641
Engineering Procurement and Materials Management 3 credits
Prerequisites: EM 602, EM 640, and EM 674 or equivalents. Study of the logistics life cycle, involving planning, analysis, design, testing, distribution and life cycle support. Make versus buy engineering design decision. Various tools and techniques for an effective life cycle support program. Bench-marking approach to survey available internal and external resources and competitor solutions. Constructing life cycle cost models for acquisitions. Build adequate specification. Application of the latest techniques in supplier chain quality management. Case studies and advanced multimedia learning tools are used.

EM 655
Management Aspects of Information Systems 3 credits
Prerequisite: computer programming experience. Information flow in an organization as an integrated system and management resource: techniques of data analysis, design, and processing; characteristics of computerized information-handling equipment; data acquisition, storage, processing, retrieval, and transmission to decision-makers; and information systems for finance, production, inventory, accounting, marketing, and distribution.

EM 660
Financing an Industrial Enterprise 3 credits
Prerequisites: undergraduate economics, accounting, and engineering economy. Principles of financial practice and management in modern business corporations emphasizing financial planning and control; capital project and working capital needs; internal and external financing; and finance as a major function of the management process.

EM 661
Advanced Engineering Economics 3 credits
Prerequisite: undergraduate engineering economics or equivalent. Economic use of a firm's capital resources. Feasibility studies of potential major capital investments likely to be considered by an enterprise. Risk assessment, cost engineering, effect of financing sources, life cycle, and technologies forecasting models. Case studies are used.

EM 674
Benchmarking and Quality Function Deployment 3 credits
Prerequisite: IE 673 or equivalent. Continuation of IE 673. Benchmarking surveys of competition, process analysis of engineering activities, statistical process control mathematics, Taguchi methods of process and product design, current total quality management innovations, quality functional deployment. Case studies and advanced multimedia learning tools are used.

EM 691
Cost Estimating for Capital Projects 3 credits
Prerequisites: EM 502 and EM 503, or equivalent. Cost estimating techniques and procedures for budgeting used in evaluation, planning, and control of capital investments. Emphasis on updating for change, escalation, and statistical and computer methods.

EM 693
Managerial Economics 3 credits
Prerequisite: undergraduate economics. Internal and external influences on the economic practices of business; classical and current theories of economic behavior; contemporary analytical techniques; behavior of costs, prices, and profits; demand analysis, competition and monopoly; capital expenditure planning; profit theories and business cycles; and econometric models of market strategies, competitive action, and demand behavior.

EM 695
Public Utility Energy Management 3 credits
Prerequisite: EM 602 or equivalent. Managing loads on electric power systems. Influence of variable rate structure and description of several projects currently in progress.

EM 696
Nuclear Power Reactor Management 3 credits
Prerequisites: undergraduate economics and physics. Nuclear power reactor management and power generation alternatives: optimum performance; maximum control; minimum cost; capacity planning; cost estimating; investment requirements; plant location and safety; separation technology for fuel enrichment; transportation and storage of spent fuel; reprocessing and nuclear waste storage; and regulatory aspects of nuclear power.

EM 701
Master's Thesis 6 credits
Prerequisites: matriculation for the M.S. degree, adequate graduate courses in the field of the proposed thesis, and the thesis advisor's approval. Thesis must contribute to the field, and preferably aid the candidate's present or potential career. While original research may not always result, the thesis should provide a new conclusion or application. A student must continuously register for a minimum of 3 credits per semester until the thesis is completed. Total credit will be limited, however, to the 6 credits indicated for the thesis.

EM 714
Multicriteria Decision Making 3 credits
Prerequisite: some background in operations research. Multiobjective programming and conflict analysis to evaluate alternatives in decision making, utility, assessment methodology, interactive and noninteractive multiple mathematical programming methods, and surrogate worth trade-off methods are covered.

EM 715
Design of an Enterprise 3 credits
Prerequisites: undergraduate economics, industrial management accounting, engineering economy, probability and statistics; 9 credits of EM courses at 600-level or above; and advisor's approval. Organization and management of an enterprise, from initial planning through production and distribution of manufactured products. Students choose the industry that they study.

EM 716
Seminar in the Design of an Enterprise 3 credits
Prerequisite: EM 715. Continuation of EM 715. Depending on the student's interest, report on design of the particular enterprise emphasizing either the management of research and development; the management of production; the management of distribution; or the management of manpower.

EM 725
Independent Research 3 credits
Prerequisite: permission from the ME department's industrial and management engineering division advisor. Program of study prescribed and approved by student's advisor. Special

course covers areas of study in which one or more students may be interested, but is not of sufficiently broad interest to warrant regular course offering.

EM 740
Management of Transportation Carriers 3 credits
Prerequisites: Tran 610 or equivalent and Tran 650 or EM 602 or equivalent. Presents theory and practice of managing transportation carriers, including the concepts of costing, pricing, designing and marketing transportation service; the concepts of financial efficiency and resource productivity with application to the selected freight carriers in each mode of transportation. Selected case studies of carriers' operations management practices in various modes. Comparative studies of service characteristics, market share, cost structures both within a particular transportation mode and between the modes. *Same as Tran 740.*

EM 765
Multi-modal Freight Transportation Systems Analysis 3 credits
Prerequisites: Tran 610 or equivalent and Tran 650 or EM 602 or equivalent. Quantitative methods for the analysis and planning of freight transportation services. The supply-performance-demand paradigm for freight transportation systems. Cost and performance as determined by system design and operations. Relationship of traffic and revenue to service levels and pricing. Optimal service design and redesign for transportation enterprises and operations planning. Fleet and facility investment planning. Applications to various modes. *Same as Tran 765 and CE 765.*

EM 771
Operations Cost and Management Control 3 credits
Prerequisites: 6 credits of EM courses at 600-level or above. Analysis and control of cost and other operational aspects of enterprises: manufacturing, distribution and overhead budgets; cost accounting; management information systems; relevant behavioral factors; financial and other management reports. Case studies used.

English

Offered by the Department of Humanities and Social Sciences

Eng 521
Technical Written and Oral Communication 3 credits
Develops skill in oral and written technical communication on a professional level. Three areas are emphasized: 1) analyzing professional and technical communication situations; 2) achieving clear, effective oral and written communication; and 3) developing awareness of variations in professional communication across cultures. For some assignments, students will work on projects from courses in their own fields. The approach is practical; course format is that of a workshop. Non-native speakers of English may take this course.

Eng 601
Advanced Professional and Technical Communication 3 credits
Provides the foundation for all professional and technical communication coursework. Faculty from both academic and corporate communities show the cognitive processes that comprise their expertise as they solve communication problems. Modules include ethics, oral presentations, research, editing, collaboration and interpersonal skills, and rhetorical analysis.

Eng 603
Cultural and Technological Change 3 credits
Examines the complex ways in which technology constructs and is constructed by society, with special emphasis on the interrelationships between technology and communication. Discussions focus on how technological change is expressed in social and political movements, literature, art, architecture, and philosophy and how they, in turn, influence the future direction of technology.

Eng 604
Communication Theory 3 credits
Builds on an understanding of rhetorical theory and explores a range of contemporary communication theories: theories of meaning, discourse, persuasion, cognition, and social contextualism. Emphasis is on exploring theories of communicative action in order to critique communicative practice.

Eng 605
Document Design and Desktop Publishing 3 credits
Provides an understanding of and capability in the visual presentation of information. Integrates theories of design, principles of layout and format, and technology of desktop publishing. Modules include theory and practice in design and information processing, design and visual coherence, visual aspects of documents, tools of design, and production and integration of graphics into documents.

Eng 610
Creating Hypertext: A Task-Oriented Approach 3 credits
Covers the complex tasks needed to create nonlinear material: hypertext theory, task orientation, audience analysis, task list construction, planning and writing documents, obtaining useful reviews, conducting usability tests. Course can be applied to the multimedia communication area of specialization in the information systems master's degree program.

Eng 613
Multimedia Presentations 3 credits
Prerequisite: Eng 605 or equivalent. Builds on the foundational work of Eng 605 and prepares students to work across electronic media in communicating and presenting professional and technical information. Focuses on communication concepts and problem-solving using practical techniques that combine text, audio, graphics, and video.

Eng 620
Proposal Writing 3 credits
Provides an understanding of and practice in proposal writing for corporations, foundations, and government agencies. Builds skills to create a range of persuasive documents including proposals for research grants, responses to requests for proposal, and government proposals.

Eng 622
Collaborative and Interpersonal Communication 3 credits
Uses a case-study approach to give both the theoretical foundations and the hands-on practice needed to work effectively in and among heterogeneous corporate groups. Includes collaborative writing, interviewing, and conflict resolution.

Eng 624
Professional and Technical Editing 3 credits
Presents the theory and practice of editing professional and technical writing. Topics include correctness and conciseness, hard copy and on-line editing, editing graphics, document management, editor-author relationships, and ethical considerations in editing. Students edit writing samples from a variety of technical fields.

Eng 642
Professional Writing 3 credits
Introduction to technical writing and executive communications for corporate and business markets. Includes global communication and modern organizational culture.

Eng 698
Special Topics in Professional and Technical Communication 3 credits
A seminar led by one of the program's faculty. Areas of study include medical communication, hypertext design, scientific writing, legal communication, and the rhetoric of the environment.

Eng 700
Project in Professional and Technical Communication 3 credits
Prerequisites: approval of graduate advisor and completion of core courses and independent study related to project. Demonstrates ability to conceive and execute an extended writing project with professional graphics and to make an oral and visual presentation of the work. Based on experiential research (internship, co-op, work experience). In consultation with graduate advisor, student selects a project committee, which consists of program-approved faculty advisor and external reviewer. Students must register every semester until the project is completed.

Eng 701
Thesis in Professional and Technical Communication 6 credits
Prerequisites: approval of graduate advisor; completion of core courses. Demonstrates ability to conceive and execute an extended writing project with professional graphics and to make an oral and visual presentation of the work. The thesis should be of a quality that would warrant its publication, in full or in part, in a technical journal. The thesis committee consists of program-approved faculty advisor,

one other faculty member, and external reviewer. A student must register every semester for a minimum of 3 credits per semester until the thesis is completed. Total credit awarded is limited to 6 credits.

Eng 725
Independent Study in Professional and Technical Communication 3 credits
Prerequisite: approval of graduate advisor and supervising faculty. Allows development of areas of specialization for master's project or for program. Areas of study in communication in which one or more students may be interested, but which are not of sufficiently broad interest to warrant a regular course offering.

Eng 791
Graduate Seminar Non-credit
Faculty, students, and invited speakers present summaries of advanced topics in technical and professional communication. Discussion of research procedures and thesis/project organization. Required of all students receiving departmental or research-based awards.

English as a Second Language (ESL)

Offered by the Department of Humanities and Social Sciences

Eng 500
English for International Graduate Students I 3 credits
Practice in listening and conversational English for students whose native language is not English.
Level: Low Intermediate

Eng 502
English for International Graduate Students II 3 credits
Practice in writing strengthens sentence structure, grammar, vocabulary, and organization. For technical writing, see Eng 541.
Level: High Intermediate

Eng 503
Advanced English for International Teaching Assistants 3 credits
Practice in public speaking for international TA's and other international students who want to improve their oral presentation skills. Also covers teaching techniques and pronunciation.
Level: Advanced

Eng 505
Advanced Spoken English for International Graduate Students 3 credits
Designed to improve English pronunciation; accent reduction.
Level: Advanced

Eng 507
Advanced Conversation and American Culture 3 credits
Practice in conversation in English at an advanced level. The goal is to help students gain the cultural knowledge and speaking skills for fuller participation in American life.
Level: Advanced

Eng 521
Technical Written and Oral Communication 3 credits
Develops skill in oral and written technical communication on a professional level. Three areas are emphasized: 1) analyzing professional and technical communication situations; 2) achieving clear, effective oral and written communication; and 3) developing awareness of variations in professional communication across cultures. For some assignments, students will work on projects from courses in their own fields. The approach is practical; course format is that of a workshop. Non-native speakers of English may take this course.

Environmental Engineering

Offered by the Department of Civil and Environmental Engineering

EnE 560
Chemistry for Environmental Engineers 3 credits
Prerequisite: undergraduate general chemistry. Basic physical and chemical principles applied to environmental and sanitary engineering.

EnE 610
Hazardous Site Operations 3 credits
Course consists of overview of OSHA regulations and NIOSH standards concerning toxicological hazards and medical surveillance requirements, and recognition and monitoring of site hazards. Site layout, design of engineering control to minimize exposure, risk assessment, and modeling will also be presented. Students will receive a certification for the 40-hour OSHA Hazardous Waste Operation training.

EnE 620
Environmental Chemodynamics 3 credits
The overall objective of this course is to introduce students to concepts, mechanisms, and models used to describe the transport of chemicals in the environment. Concepts and models presented in the first six weeks are applied to the air-water, sediment-water, and soil-air interfaces during the rest of the term.

EnE 660
Introduction to Solid and Hazardous Waste Problems 3 credits
Prerequisite: EnE 560. (May be taken concurrently.) Introduction to solid waste disposal. Industrial and urban sources of solid waste and conventional methods of waste disposal. Application of engineering principles related to these topics.

EnE 661
Microbiology for Environmental Engineers 3 credits
Prerequisite: EnE 560. (May be taken concurrently.) Biological and microbiological principles applied to environmental and sanitary engineering. Bacteriological examinations in the laboratory of water and wastewater.

EnE 662
Site Remediation 3 credits
Prerequisite: EnE 560 or EvSc 610 (May be taken concurrently.) Examines site remediation from start to finish. Includes regulations, cleanup standards, remedial investigations, feasibility studies, risk assessment, and safety. Examines established and innovative cleanup technologies such as incineration, containment, bioremediation, vapor extraction and ground water recovery.

EnE 664
Physical and Chemical Treatment 3 credits
Prerequisite: EnE 560. Physical and chemical operations and processes employed in the treatment of water and wastewater. Topics include gas transfer, coagulation, flocculation, solid-liquid separation, filtration, and disinfection.

EnE 665
Biological Treatment 3 credits
Prerequisites: EnE 560, EnE 661. (May be taken concurrently.) Principles of evaluation and control of water pollution that describe aerobic treatment processes: oxidation ponds, trickling filters, and activated sludge. Anaerobic digestion and sludge handling and disposal as well as biodegradability study techniques for various wastes.

EnE 666
Analysis of Receiving Waters 3 credits
Prerequisites or corequisites: EnE 560 and EnE 661. Ecological responses of various types of receiving waters to municipal and industrial waste loadings. Mathematical models for water quality prediction and planning.

EnE 667
Solid Waste Disposal Systems 3 credits
Prerequisite: EnE 560. Review and evaluation of design criteria, methods, and equipment employed in handling and disposal of industrial and municipal solid wastes. Emphasis is on hazardous toxic waste, resource recovery, and regulatory constraints.

EnE 668
Air Pollution Control 3 credits
Prerequisite: EnE 560 or physical chemistry. The nature of air pollution, its effect on the public, and legal and engineering remedies.

EnE 669
Water and Wastewater Analysis 3 credits
Prerequisite: EnE 560. (May be taken concurrently.) Measurement of parameters of interest in water and wastewater quality studies is performed in the laboratory. Specific project requiring analysis, interpretation, and recommendations will be a major part of the work.

EnE 670
Advanced Processes in Water Pollution Control 3 credits
Prerequisite: EnE 669. Detailed laboratory experiments using unit operations of sedimentation, coagulation and flocculation; chlorination, filtration, aeration, sludge treatment and digestion. Aspects of pilot plant design and layout are considered. Design parameters

discussed in prerequisite courses are developed by advanced bench-scale laboratory procedures. Advanced design and synthesis are considered.

EnE 671
Environmental Impact Analysis 3 credits
Prerequisite or corequisite: EnE 560. A graduate course dealing with physical aspects of the environment. Overview of environmental problems, federal and state standards, methodology for developing impact statements, case studies based on recent experience, basis for assessment and decision making.

EnE 700
Environmental Engineering Project
3 credits
Prerequisite: student must have sufficient experience and/or graduate courses in major field to work on the project. Subject matter to be approved by the department. Permission to register must be obtained from the project advisor. Extensive investigation, analysis, or design of environmental engineering problems not covered by regular graduate course work is required. A student with an exceptional project in EnE may, upon his/her own initiative and with the approval of his/her advisor, substitute the work of this course as the equivalent of the first 3 credits for EnE 701 Master's Thesis.

EnE 701
Master's Thesis 6 credits
The thesis is to be prepared on a subject in the student's major field approved by the department. Approval to register for thesis must be obtained from the thesis advisor. A student must register for a minimum of 3 credits per semester. Credit will be limited, however, to the 6 credits indicated for the thesis.

EnE 702
Special Topics in Environmental Engineering
3 credits
Prerequisite: advisor's approval. Topics of special current interest in environmental engineering.

EnE 725
Independent Study I 3 credits
Prerequisite: written permission from department chairperson plus courses to be prescribed by the supervising faculty member. Covers areas of study in which one or more students may be interested but which is not of sufficiently broad interest to warrant a regular course offering.

EnE 726
Independent Study II 3 credits
Prerequisite: written permission from department chairperson plus courses to be prescribed by the supervising faculty member. Covers areas of study in which one or more students may be interested but which is not of sufficiently broad interest to warrant a regular course offering.

EnE 727
Independent Study III 3 credits
Prerequisite: written permission from department chairperson plus courses to be prescribed by the supervising faculty member. Covers areas of study in which one or more students may be interested but which is not of sufficiently broad interest to warrant a regular-course offering.

EnE 760
Applied Environmental Soil Chemistry
3 credits
Prerequisites: EnE 560, Math 651 or equivalent. Understanding of physical and chemical processes occurring in soils as well as the chemical and physical properties of subsurface soil environments. Emphasizes current research on the subsurface environment.

EnE 790
Doctoral Dissertation
Credits as designated
Required of all students working toward the doctoral degree. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester until 36 credits are reached; registration for additional credits may be permitted beyond the 6, with the approval of the advisor, up to a maximum of 12 credits per semester. If the student has not completed the dissertation after completion of 36 credits, continued registration of 3 credits per semester is required.

EnE 791
Graduate Seminar Non-credit
A seminar in which faculty or others present summaries of advanced topics suitable for research. Students and faculty discuss research procedures, thesis organization, and content. Students present their own research for discussion and criticism. Required of all doctoral students registered for EnE 790 unless requirement is waived, in writing, by the dean of graduate Studies.

Environmental Policy Studies

Offered by the Department of Humanities and Social Sciences

EPS 601
Behavioral Research Methods and Analysis
3 credits
Introduces beginning graduate students to the research tools necessary for specialized study in other environmental policy studies courses. Problem identification, research design and problem solving; methods of data analysis; gathering of original field data.

EPS 602
Research Analysis for the Social and Policy Sciences 3 credits
Prerequisite: EPS 601. Distribution of social, political, economic and health-related data in both samples and populations using a general linear model with residuals. Test hypotheses using both the Fisher and Neyman-Pearson criteria. Use of software such as SPSS, Microsoft Excel and Resampling Stats. to develop and test models using correlation, regression and ANOV techniques.

EPS 606
Technology Forecasting and Management Planning 3 credits
Prerequisite: quantitative background in science, social science, or engineering. Basic forecasting techniques such as regression analysis, scenario generating, Delphi conferencing, and morphological analysis with particular case studies and problems pertaining to the forecasting of technological development. The relation of technological forecasting to the management process and the understanding of the technological development process. Demonstration of techniques and application to the contemporary fields of technological importance such as energy, communications, transportation, housing, and computers.

EPS 609
Environmental Risk Assessment 3 credits
Methodology to assess the social and economic risks to present-day environmental resources of air and water; cost-benefit and trade-off analysis; technical characteristics of materials such as half-life, decomposition rates, and temperature sensitivity; and probabilities of various environmental situations.

EPS 612
Introduction to Environmental Policy Studies 3 credits
Introduction to six areas essential to a comprehensive understanding of environmental policy: concept of environmental policy; tools (law, economics, planning, science, engineering, ethics) for environmental policy; the U.S. perspective (NEPA, clean air and water acts, CERCLA); the international perspective (Club of Rome models, 1972 UNEP, 1992 Rio); industrial perspective (pollution prevention/life cycle engineering, privatization); and the local perspective (New Jersey DEP, NGOs, local industry, shoreline.) *Same as MIP 612.*

EPS 613
Environmental History and Policy 3 credits
Explores the dialogue between humanity and the environment in the United States, as well as its global implications. Surveys fundamental themes of history and policy from an environmental perspective: colonial development, independence, western expansion, industrialization, urbanization, and the rise of a consumer society. Gives special attention to the emergence of an environmental perspective: wilderness appreciation, the conservation movement, public health, the rise of the environmental movement since the 1960s, environmental science, and the legislative and regulatory process.

EPS 614
Environmental Economics 3 credits
Detailed overview of the relationship between political economy and the environment drawing on diverse case studies including global warming, ocean resources, energy policies, and contamination of the nation's water, air and soils. Economic and social policies for the fast-changing relationship between society and nature.

EPS 615
The Politics of Science 3 credits
Geopolitical context in which scientific discovery and governmental science policy have been formulated since World War II: social construction and the constituencies that have a stake in its outcome; military influence on science policy priorities; and legislative obstacles to various science policy objectives.

EPS 616
Global Problem Solving in Science, Technology, and the Environment 3 credits
Developing policy for the global era. Analyses and theories on political concept of sovereign nation states; the earth as one integrated economy, technology, science, politics and ecology; multinational corporations; worldwide patterns of capital and labor migration; energy flows; technology transfer; and impact of modernization and development on ecology.

EPS 630
Technology, Engineering and Civilization 3 credits
Technological development and technical innovation dating from the ancient world, medieval Europe, to the modern era, with emphasis on Western civilization. Comparisons of the United States, Europe, China and Japan. Major themes include the role of the military and war, proto-industrialization and industrial revolution, technology transfer, emergence of engineering as an occupational class, and the place of the United States as the world's premier technological nation.

EPS 634
Professional Ethics 3 credits
Professional ethics: its source, range, and limits. Ethical thought and behavior in Western tradition and culture as they apply to business, engineering, and government. By studying both theoretical arguments and practical, real-life case studies, students learn to recognize, analyze and evaluate the ethics of personal professional decisions about work, careers, and policies.

EPS 642
Urban Environmental Policy Studies 3 credits
Critical evaluation and formulation of environmental policy as it affects urban setting. History and theory of environmental policy. How the U.S. legal structure shapes environmental regulation and its administration. Shifting environmental policy paradigms. Case study analyses focusing on urban settings.

EPS 644
The Rhetoric of Environmental Policy 3 credits
Introduces students to the major types of rhetorical analysis as well as assures that students can analyze and write technology policy that is informed by core rhetorical principles of that analysis.

EPS 651
Introduction to Urban and Environmental Health 3 credits
Health problems associated with the social and psychological factors found in urban areas and health problems stemming from contamination of air, water, food, the work place and other special environments. Policies required to promote healthful living behavior and those required to regulate negative externalities.

EPS 660
Ethics and Environmental Policy 3 credits
Contemporary environmental problems from the perspective of ethics or moral philosophy. Is there a moral obligation to preserve or protect the natural environment? What are the ethical presumptions and values underlying environmental policy? Are traditional theories of moral philosophy applicable to contemporary environmental problems, or is a new conception of the relationship between humanity and nature needed?

EPS 698/EPS 699
Special Topics in Environmental Policy 3 credits each
Prerequisite: advisor's approval. Topics of special or current interest.

EPS 701
Master's Thesis 6 credits
Prerequisite: matriculation for the master's degree, advisor's and departmental approval. Projects involving fieldwork, experimental, or theoretical investigation carried out under the supervision of a designated member of the departmental faculty. The completed thesis should be of a quality as to warrant publication, in whole or in part, in a professional journal. A minimum of 3 credits per semester is required until completion.

EPS 711
Environmental Policy: Corporate Approach and Organization 3 credits
Explores corporate and business advocacy approaches to influencing and responding to environmental policy and regulation from organizational, historic and strategic perspectives.

EPS 712
Advanced Studies in Environmental Policy 3 credits
Analysis of environmental policy development and implementation by studying current issues such as the shift from command and control to pollution prevention, brownfields, clean air from local, regional and national perspectives, and environmental policy priority setting.

EPS 714
Environmental and Natural Resources Economics 3 credits
Examines environmental regulation of firms and natural resource use with emphasis on the theoretical foundations required for public policy. Students focus primarily on the application of economic tools to improve environmental quality.

EPS 725
Independent Study I 3 credits
Prerequisite: matriculation for the master's degree, advisor's and departmental approval. Projects not within the scope of existing courses are carried out under the supervision of a designated member of the departmental faculty.

EPS 726
Independent Study II 3 credits
Prerequisite: matriculation for the master's degree, advisor's and departmental approval. Projects not within the scope of existing courses are carried out under the supervision of a designated member of the departmental faculty.

EPS 761
Ethics and Environmental Policy II 3 credits
Presents a detailed investigation of the ethical bases of environmental policy decisions. Examines both theoretical philosophical arguments and practical case studies.

Environmental Science

Offered by the Department of Chemical Engineering, Chemistry and Environmental Science

EvSc 592
Graduate Work Experience 3 additive credits
Prerequisite: permission of the associate chairperson for environmental science and the Division of Career Development Services. Provides on-the-job reinforcement of environmental science assignments. Projects are developed by the co-op office in consultation with the associate chairperson for environmental science. Cannot be used for degree credit.

EvSc 600
Environmental Science Seminar Non-credit
Prerequisite: graduate standing. Current environmental topics of interest to the environmental professional are presented. Required every semester for environmental science graduate students receiving departmental or research-based awards and for all doctoral students.

EvSc 602
Special Topics in Environmental Science I 3 credits
Prerequisite: approval of graduate advisor in environmental science. Topics of current interest in the environmental field.

EvSc 603
Hazardous Waste Operations and Emergency Response 3 credits
Explores the safe operation of hazardous waste sites as well as emergency responses to hazardous releases. Overview of OSHA regulations and NIOSH standards concerning toxicological hazards and medical surveillance requirements. Emphasis on recognition and monitoring of site hazards. A written health and safety plan, and participation in a group problem involving a simulated hazardous site entry

using actual protective equipment is required. Course satisfies the regulatory compliance mandates to meet 29 CFR 1910.120 for OSHA, with certification valid for one year.

EvSc 610
Environmental Chemical Science 3 credits
Prerequisite: graduate standing. Principles of physical, inorganic and organic chemistry are applied to understanding the origins of environmental pollutants, their transport, distribution and decomposition pathways.

EvSc 611
Hazardous Waste Management 3 credits
Prerequisite: graduate standing. An overview of hazardous waste management; case histories; legislation and regulations; treatment, disposal and cleanup technologies; sampling and analysis methodology; persistence and fate in the environment; emergency response procedures.

EvSc 612
Environmental Analysis 3 credits
Prerequisite: graduate standing. The analysis of environmental samples is studied from the acquisition of representative samples, through sample handling, chain of custody, sample storage, analytical method selection, analysis, and data treatment.

EvSc 613
Environmental Problem Solving 3 credits
Prerequisite: graduate standing. This course is designed to study solutions for current environmental problems. Students are asked to respond to an imaginary Request for Proposal (RFP) in writing and before a team of technical experts at an oral presentation. Solutions proposed in student RFPs must reflect knowledge of environmental science and technology in current use.

EvSc 614
Quantitative Environmental Risk Assessment 3 credits
Prerequisite: graduate standing. Applications of quantitative risk assessment concepts to the management of environmental problems.

EvSc 615
Global Environmental Problems 3 credits
Prerequisite: graduate standing. With an understanding that environmental problems are not restricted by geographical boundaries, relationships of the earth's temperature balance, global air circulation patterns, global energy needs, and control and remediation technologies are studied.

EvSc 616
Toxicology for Engineers and Scientists 3 credits
Prerequisite: graduate standing. The general principles of toxicology are presented and applied to the assessment of acute, subacute and chronic effects of hazardous and toxic chemicals. Qualitative and quantitative measures of toxicity and testing protocols are addressed. The role of toxicology in risk assessment and risk management is discussed.

EvSc 700
Master's Project 3 credits
Prerequisite: graduate standing and approval of the graduate advisor in environmental science. Written report requiring experimental or theoretical research, or an extensive literature analysis. Registration must be approved by an advisor. Students must continue to register for 3 credits each semester until completion and a written report is accepted. Only a total of 3 credits will count toward the degree.

EvSc 701
Master's Thesis 6 credits
Prerequisite: matriculation for a master's degree in environmental science. Approval to register for the thesis must be obtained from the advisor. Original research under the supervision of a designated faculty member. The final product must be a written thesis approved by three faculty members: the student's primary advisor, another from the program and one other faculty member. Once registration for thesis has begun, a student must continue to register for a minimum 3 credits per semester until at least 6 credits have been completed and a written thesis is approved. Only a total of 6 credits will count toward the degree.

EvSc 702
Special Topics in Environmental Science II 3 credits
Prerequisite: approval of graduate advisor in environmental science. Topics of current interest in the environmental field.

EvSc 711
Advanced Environmental Analysis 3 credits
Prerequisite: EvSc 612 or equivalent. Analysis of complex environmental samples is studied, from the acquisition of representative samples, through sample handling, chain of custody, sample storage, analytical method selection, analysis and data handling. Collection and analysis of samples from air, water, soil, and biological systems will be discussed. Emphasis on the study of current literature.

EvSc 725
Independent Study I 3 credits
Prerequisite: written permission from the Associate Chairperson for Environmental Science plus courses prescribed by the supervising faculty member (who is not the student's thesis advisor). This special course covers areas of study in which one or more students may be interested, but which are not sufficiently broad to warrant a regular course offering. Students may not register for this course more than once with the same supervising faculty member.

EvSc 726
Independent Study II 3 credits
See description for EvSc 725.

EvSc 790
Doctoral Dissertation Credits as designated
Required of all students working toward the degree of Doctor of Philosophy. A minimum of 36 credits is required. Approval of dissertation advisor is necessary for registration. Candidates must register for at least 6 credits of dissertation per semester until 36 credits are reached, and 3 credits per semester thereafter until a written dissertation is approved.

Epidemiology

Offered by the UMDNJ–New Jersey Medical School

EPI 615
Introduction to Epidemiology and Control of Chronic and Infectious Diseases 3 credits
Prerequisites: epidemiology core courses. Terminology; major causes; occurrence, distribution and dynamic behavior; epidemiologic concepts; epidemiology of selected diseases; investigation of outbreaks and epidemics; application to medicine (individual basis) and public health (community and population basis); implement levels of prevention and control.

EPI 616
Advanced Topics in Infectious and Chronic Diseases Epidemiology 3 credits
Prerequisites: epidemiology core courses, EPI 615. Utilizing practical and detailed examples, explores topically important issues in epidemiology to provide a framework for future self-learning and field research experiences. Applies principles to critically analyze relevant literature. Presents advanced, selected topics in depth with an emphasis on infectious disease epidemiology.

EPI 621
Survey Research Methods/Questionnaire Design 3 credits
Prerequisites: biostatistics, epidemiology, health information systems core courses. Introduces basics of survey research; provides skills necessary to conduct research. Conduct a one-page survey and present the results to the class as a final project.

EPI 625
Community-Based Epidemiological Research 3 credits
Prerequisites: epidemiology and biostatistic core courses. Investigate the epidemiology of a disease or an outbreak or risk factor(s) or any of the current public health issues. The investigation must warrant publication upon successful completion of the study; include detailed study in primary and secondary prevention of the selected topic; and requires review of relevant literature.

EPI 626
Emerging and Re-emerging Infections 3 credits
Covers the problem organisms and the various approaches to the problems from immunization and surveillance to attacking the societal variables that provide the setting in which these epidemics arise and flourish. Includes deliberately initiated infections (bioterrorism) and controversial partial solutions such as food irradiation.

EPI 627
Innovations in Public Health 3 credits
Includes some of the major historical approaches, current concepts (including control of illicit drug use, unusual community-based projects, use of large national cohorts) and potential future approaches; marketing of public

health; appropriate, fiscally responsible screening; nutrition; and changes that will be created in public health innovations related to deciphering the genome.

EPI 628
Pharmacoepidemiology 3 credits
Prerequisites: epidemiology core courses, required track courses. Familiarization with methodological issues in pharmacoepidemiology; commonly used designs (e.g. cohort, case-referent); identification of main sources of bias in these designs; familiarization with tactics to deal with these biases. Students present for discussion proposals for pharmacoepidemiologic research.

EPI 629
Oral Epidemiology of Chronic and Infectious Diseases 3 credits
Provides an epidemiological overview of oral diseases. Topics include: clinical-decision analyses for the diagnosis, treatment, prevention and prognosis; research protocol; epidemiological data sources and clinical measurements; scientific papers; sampling techniques and research designs; descriptive and inferential statistics.

Financial Management

Offered by the School of Management

Fin 516
Principles of Financial Management 3 credits
Fundamentals of financial management divided into two segments: investment and corporation finance.

Fin 600
Financial and Economic Environment 3 credits
Intended for public and private organizations. Issues related to interest rates, extraordinary rates of inflation, fiscal and monetary policy, and regulatory policy are integrated with market structure, cost and production technology, pricing policy, cash flow, risk-return opportunities, capital budgeting techiques, and decision making in companies.

Fin 618
Public and Private Financing of Urban Areas 3 credits
Ties government's budget, tax policy, allocation of resources between public and private sectors, with the structure, development, and growth needs of urban metropolitan areas. Focuses on problems of poverty, transportation, land-use, economic base, relation between central cities and suburban areas, and alternative engineering and economic solutions. *Same as MIP 618 and Tran 604.*

Fin 624
Financial Management 3 credits
Prerequisite: Fin 516. The management of assets, liabilities and equity in a domestic framework. Includes: goals of the firm, time value of money, financial statement analysis, financial ratio analysis, financial planning and forecasting, capital budgeting, cost of capital, capital structure, dividend policy, working capital management, mergers and acquisitions, and pricing of options.

Fin 626
Financial Investment Institutions 3 credits
Prerequisite: Fin 516. Introduces the role of banking institutions and investment banks in the domestic and international money market and capital environment to the financial managers. Covers instruments and services of financial intermediaries that are crucial to business management. Discussions range from the financial services and facilities of regional banks to money-center banking institutions. Alternatives of project financing, lending requirements and regulations, project financing, and role of intermediaries in local and international transactions. Focuses on the private placement procedures of all types of securities in the capital market and the unique role undertaken by the investment banking firms. Provides an insight about the public offering process for existing and venture capitalized firms.

Fin 627
International Finance 3 credits
Prerequisite: Fin 516. Examines financing of exports and imports, managing multicurrency working capital, international aspects of capital budgeting, cost of capital and their relationship with political, economic, and financial risk. Explores financial innovations and their impact on the firm's financial strategy and performance of overall productivity. Discusses the tax consequences and principal-subsidiary relationship of the multinational enterprise. Introduces international money and capital markets, instruments, derivatives, and institutions.

Fin 630
Applied Business Econometrics 3 credits
Introduces methodological development of quantitative tools essential to modern managers. Includes sampling distribution, hypothesis testing, nonparametric statistics, and simultaneous regression models. Centers on application setting with statistical results providing insights into management decisions.

Fin 631
Working Capital Management and Credit Analysis 3 credits
Prerequisite: Fin 516. Optimal management of a firm's working capital, such as cash, marketable securities, receivables, and inventories with an emphasis on the institutional background and environmental modeling. Deals with cash flow analysis, the assessment of financial needs, and selecting the appropriate domestic and international sources for meeting a firm's credit needs.

Fin 632
Financial Valuation of Technology-Based Companies 3 credits
Prerequisite: Fin 516. Concentrates on techniques and procedures of assessing, managing, and forecasting value of alternative corporate and business level strategies of companies with emphasis on technology-based companies. These strategies include new product introduction, joint venture agreements, new market entries, and capital expenditures.

Fin 634
Mergers, Acquisitions, and Restructuring 3 credits
Prerequisite: Fin 516. Focuses on identifying and evaluating potential and international companies for mergers and acquisitions as well as structuring of deals. The financial, social and managerial implications of these changes in corporate ownership will be examined. Topics are: financing M&As, deal structuring, tax implications, valuation, broker/finder agreements, merger negotiations, and post-merger integration.

Fin 660
Financial Planning and Decision Making 3 credits
Prerequisite: Fin 624. This course introduces the in-depth qualitative and quantitative analysis of the short-term and long-term investment and financing decisions in an uncertain environment. The course emphasizes a quantitative analysis (simulation model) and case studies that deal with actual business decisions and challenges. Students are assigned to competing financial management teams in order to develop financial planning and decision making expertise.

Fin 700
Seminar in Theory and Research in Financial Management 3 credits
Prerequisites: Fin 624 or Fin 626. Only open to those students who do not do a thesis. The theory and applied tools of financial management. Presented in seminar format with several students working as a team to analyze and resolve an issue in financial management.

Fin 701
Thesis in Financial Management 6 credits
Prerequisites: Fin 624 or Fin 626; waived with approval of the assistant dean for graduate programs. Examines: What is research? Why do research? What are the objectives of research? Covers the need for research, criteria for good research and research design, concept of measurement, sampling design, primary data collection, experimentation and simulation, statistical and other types of analysis, and reporting of research findings.

Geology

Offered by the Department of Geological Sciences at Rutgers-Newark

26:460:577
Seminar in Environmental Geology 3 credits
Human interaction with the geological environment. Case histories involving geological hazards to engineering works, transportation, land use, water, mineral and energy resources, disposal of wastes, and public health.

History

Offered by the Federated History Department of Rutgers-Newark and NJIT. Courses in the history of technology, environment and medicine are listed below and are taught at NJIT. Courses in American history and global history are listed under Rutgers-Newark History Courses and are taught at Rutgers-Newark.

Hist 620
City and Disease in History 3 credits
Explores the dynamic interaction between the growth of cities and changes in the experience and location of disease. Presumes the intertwining of these two historical developments in the birth of a distinctly urban identity, one predicated on the notion that the modern city is somehow inherently diseased. Focuses on the New York and Newark metropolitan areas in the nineteenth and twentieth centuries. Among the topics considered are epidemic outbreaks, quarantines, the technology and organization of sanitation and hygiene, the professional formation of public, industrial and occupational medicine, and medical and popular responses to immigration.

Hist 622
Culture and Science in the History of American Medicine 3 credits
Provides an overview of American medical history and a familiarity with the theoretical and practical ramifications of different approaches to the complex relationships between medicine, science, and culture. Topics include: the extent to which medicine is or has been scientific; reasons why science has been considered so important to medicine's professional culture; and the degree to which medicine's professional culture has been shaped by science as well as other factors, such as economic and political self-interest, technology, class, race, gender, and other kinds of cultural values.

Hist 624
Technology, Environment and Medicine in World History, 1500-1900 3 credits
Examines the interrelationship between the emerging modern world system and changes in technology, environment, and medicine, with particular emphasis on European overseas expansion and its impact in non-Western regions.

Hist 626
Social History of American Medicine Since 1800 3 credits
Topics include the practices of 19th-century "regular" medicine; the relation between medical concepts and mainstream social thought; the treatment of women's health; antebellum alternative healers and alternative politics; the triumphs of late 19th- and early 20th-century medical therapeutics; the emergence of medicine as big business; medicine and racism; the emergence of nursing as a profession; modern medicine in an international perspective; New Age healing; the AIDS crisis and AIDS activism; and contemporary debates on the future of health care in the United States.

Hist 628
Gender, Science and Technology in the Modern World 3 credits
Introduction to a wide range of political and cultural analyses of science and technology, with an emphasis on recent feminist critiques of science. Explores the questions of scientific neutrality; the gendering of scientific knowledge; the relationship between science, technology, and capitalism; the role of science in international politics; and why science has not freed women.

Hist 630
History of the Body in Modern Western Culture 3 credits
Considers medical or scientific history primarily in terms of implications for bodily experience in everyday life. Begins with grand narratives of historical shifts in bodily perceptions and practices, and proceeds to more focused narratives of changing bodily experience, engaging key distinctions between genders, classes, and species as well as perceptions of pain and internal bodily structure. Materials will be drawn from early modern and modern Europe, as well as more recent bodily experience in the United States.

Hist 632
Technology, Culture and History 3 credits
Treats the relationship between technology and cultural values in a variety of historical and geographical settings, from early modern Japan to twentieth-century America. Examines the ways in which cultural ideals, conceptions, and preconceptions serve to influence the rate and manner of technological change, as well as the ways in which technology affects social and cultural life.

Hist 634
Environmental History of North America 3 credits
Explores the dialogue between humankind and the environment in North America over the course of the last four centuries. Examines the latest and most interesting work done in the new field of environmental history to see what such a perspective has to offer.

Hist 635
History of Technology, Environment and Medicine: Theory and Method 3 credits
A team-taught course which surveys the methods employed in the three fields. Explores the interdisciplinary nature of each field, and the value of interdisciplinary scholarship.

Hist 638
Social History of Communication 3 credits
Treats selected themes in the history of communication in different social and cultural contexts, from the ancient world to the twentieth century. Topics include: orality, proto-literacy, and literacy in ancient and medieval cultures; printing and the development of print culture in the early modern world; the "communication revolution" of the late 19th and early 20th centuries; and historiographical debates over the role of communication technologies in society.

Hist 640
The Urban Environment 3 credits
Examines the role of the economy, culture, and technology in shaping the urban environment. Makes extensive use of Newark and the New York metropolitan area, including field observations and local research. In addition to other topics, explores in detail spatial relationships, the role of transportation, and the development of suburbia.

Hist 644
War, Technology and Society, 1500-1914 3 credits
Examines key themes in the interrelationship between warfare, technology and society from the beginnings of modern warfare until World War I. Primary emphasis placed on the historical connections between violent conflict, the technical means by which it is carried out, and the socio-political environment within which wars take place. The effect of technology upon war and considerations of the effect of war on technological change and development. Samples the rich tradition of thought and ideas produced by philosophers and theorists on these themes.

Hist 701
Master's Thesis 6 credits
Prerequisite: permission of graduate history advisor. For students writing a master's thesis in the history of technology, environment and medicine.

Hist 725, Hist 726, Hist 727
Independent Study in History 3 credits
Prerequisites: permission of graduate history advisor and course instructor.

Hist 791
Seminar in History of Technology, Environment and Medicine Non-credit
Faculty, students and invited speakers present and discuss current topics of research in history, technology and medicine.

Rutgers-Newark History Courses

26:510:520
Topics in the History of Technology 3 credits
Selected topics in the history of technology.

26:510:525
Colloquium in the History of Women 3 credits
Readings and discussion on the history of women in the United States and Western Europe.

26:510:526
Problems and Readings in Afro-American History 3 credits
An introduction to the major historiographical problems and recent literature in the history of Afro-Americans in the U.S.

26:510:527,528
Selected Topics in European Political and Diplomatic History 3 credits each
An examination of issues and methods in European political and diplomatic history, with a consideration of some leading problems in the field.

26:510:529,530
Selected Topics in European Intellectual and Cultural History 3 credits each
An examination of issues and methods in European intellectual and cultural history, with a consideration of some leading problems in the field.

26:510:531,532
Problems and Directed Readings in the History of U.S. Foreign Policy and Diplomacy 3 credits each
An examination of issues and methods in American diplomatic history, with a consideration of some leading problems in the field.

26:510:533,534
Selected Topics in American Social and Economic History 3 credits each
An examination of issues and methods in American social and economic history, with a consideration of some leading problems in the field.

26:510:537,538
Problems and Readings in the Ancient World 3 credits each
An introduction to the major historiographical problems and recent literature of the ancient world.

26:510:539,540
Problems and Readings in Medieval History 3 credits each
An introduction to the major historiographical problems and recent literature in medieval European history.

26:510:541,542
Problems and Readings in European History, 1350-1650 3 credits each
An introduction to the major historiographical problems and recent literature in European history from 1350 to 1650.

26:510:543,544
Problems and Readings in European History, 1650-1850 3 credits each
An introduction to the major historiographical problems and recent literature in European history from 1650 to 1850.

26:510:545,546
Problems and Readings in European History Since 1850 3 credits each
An introduction to the major historiographical problems and recent literature in European history since 1850.

26:510:547
Comparative World Colonialism 3 credits
Examines interactions of Europeans and non-Europeans after 1500. Emphasis is on comparative analysis of the colonial experience in Asia, Africa, and Latin America.

26:510:548
Topics in the History of the American Environment 3 credits
Selected topics in the history of the interaction between humans and the environment in North America.

26:510:551,552
Selected Topics in American Intellectual and Cultural History 3 credits each
An examination of issues and methods in American intellectual and cultural history, with a consideration of some leading problems in the field.

26:510:553,554
Selected Topics in American Political and Legal History 3 credits each
An examination of issues and methods in American political and legal history, with a consideration of some leading problems in the field.

26:510:555,556
Selected Topics in American Urban and Ethnic History 3 credits each
An examination of issues and methods in American urban and ethnic history, with a consideration of some leading problems in the field.

26:510:557,558
Selected Topics in European Social and Economic History 3 credits each
An examination of issues and methods in European social and economic history, with a consideration of some leading problems in the field.

26:510:559
Cities in Change I 3 credits
The process of urbanization as seen in the growth of historic European and North American cities and in the underdeveloped world: the revival of towns in the Middle Ages, the royal capital as center of power, rise of an urban way of life, nineteenth-century industrial cities, changing city forms and functions of the twentieth century, urban values in politics, business, and material culture.

26:510:560
Cities in Change II 3 credits
The process of urbanization as seen in the growth, decline, and revival efforts of Newark, N.J. Examination of the economic, political, geographical, and social factors that helped develop Newark as New Jersey's most important city and as one of the most troubled urban communities in the U.S. Attention to the origins of Newark's decline; its relationship with suburban communities in northern New Jersey; the settlement of European immigrants and rural Afro-Americans in the late nineteenth and twentieth centuries; and recent efforts to revive the city's political, economic, and cultural life.

26:510:566
American Historiography 3 credits
Examines the major historiographical disputes among American historians, including such topics as Jacksonian Democracy, the Civil War, foreign policy, the Progressive Era, and the New Deal.

26:510:567,568
Modern Russia 3 credits each
Major themes of post-Petrine Imperial Russia and the Soviet Union.

26:510:569
American Legal History to 1860 3 credits
Readings and discussion of the legacy of common law after the Revolution, the emergence of legal instrumentalism, and the evolution of tort, contract, and damages in the context of industrialism and economic growth.

26:510:570
Topics in American Legal History 3 credits
Readings and discussion of the growth of legal formalism, the evolution of substantive due process, changes in legal education and the legal profession, and the evolution of private law.

26:510:571
Introduction to Historical Method 3 credits
Examines major theoretical approaches that have been used by historians and some of the works that have employed those approaches.

26:510:572
Philosophy of History 3 credits
A general survey of major trends in historiography and of leading issues in the philosophy of history.

26:510:573,574
Problems in Central European History 3 credits each
Topics in the nineteenth- and twentieth-century political, social, and intellectual history of Germany. The Hapsburg monarchy and its successor states.

26:510:576
Problems and Readings in American History, 1492-1789 3 credits
An introduction to the major historiographical problems and recent literature in American history from 1492 to 1789.

26:510:577
Problems and Readings in American History, 1789-1865 3 credits
An introduction to the major historiographical problems and recent literature in American history from 1789 to 1865.

26:510:581
Problems and Readings in American History, 1865-1912 3 credits
An introduction to the major historiographical problems and recent literature in American history from 1865 to 1912.

26:510:583
Problems and Readings in American History, 1912-1945 3 credits
An introduction to the major historiographical problems and recent literature in American history from 1912 to 1945.

26:510:585
Problems and Readings in American History, 1945 to Present 3 credits
An introduction to the major historiographical problems and recent literature in American history since 1945.

26:510:589,590
Problems and Readings in African History 3 credits each
Various problems in African history, from the ancient African civilizations to the present day. Topics vary from year to year; contact the instructor for current topics.

26:510:618
Seminar: Teaching of History 3 credits
Experience in the planning of a course, leading discussions, and lecturing under the supervision of the student's major professor. Critiques are made by both the professor and the seminar participants.

26:510:669
Business and Government in the Twentieth Century I 3 credits
An exploration through selected readings of industrial and financial concentration in the U.S. and attempts at resolution of the dilemma through overhead management (the New Deal), associationalism (the trade association), and decentralism (antitrust).

26:510:670
Business and Government in the Twentieth Century II 3 credits
Examines the history of the relationship of federal government policies, presumptions, and practices to American business activity—financial, industrial, and commercial—outside the United States.

26:510:695
Individual Studies in History 3 credits
Prerequisite: permission of the director of graduate programs. Offered both terms.

26:510:696
Advanced Individual Studies in History 3 credits
Prerequisite: permission of the director of graduate programs. Offered both terms.

26:510:697,698
Research in History 3 credits each
Normally reserved for master of arts thesis credit.

Human Resource Management

Offered by the School of Management

HRM 601
Organizational Behavior 3 credits
Analysis of key organizational components; individual perception; learning ability; conflict resolution models; group processes in decision making; motivation; problem diagnosis, and the organization as the mechanism for joining into a coherent productive system. Organizational assessment for innovation, leadership styles, and environmental interaction.

HRM 606
Human Resource Management 3 credits
Management of human resources in business, industry, and government; developing personnel programs including wage and job classification, training, employee and labor relations, and accident prevention. Particular attention is directed to cases and roles involving both line and staff managers.

HRM 607
Personnel and Evaluation Research 3 credits
Focuses on the assessment and improvement of personnel systems. Emphasis is on the use of diagnostic tools in problem identification, developing action plans, and assessing outcomes of HRM interventions. Special attention is given to survey methodology and to the use of assessment tools in conducting personnel research. Databases and statistical software packages are used in project work.

HRM 608
Behavioral Issues in Transportation Studies 3 credits
Behavioral science concepts and principles such as perception, learning, motivation, and information processing as they relate to: transportation, consumer use of mass transit, automobiles, ridesharing and intelligent transportation systems. *Same as Tran 608.*

HRM 609
Employee Development and Training 3 credits
Key concepts in training including needs analysis, curriculum design and delivery, managing external consultants, and the evaluation of offsite training programs are introduced to gain understanding of the training function in organizations. Emphasis is on the impact of technological changes on employee skills utilization and development; training as a means of sustained competitive advantage for technology-based organizations; and the effects of technological advances on the design and delivery of training programs.

HRM 616
Job Analysis and Design 3 credits
Analyzing and designing jobs in work organizations, particularly technology-based organizations. Principles of job analysis and job design are applied to the allocation of tasks in organizations. Draws upon theory and research from industrial and organizational psychology, organizational sociology, social psychology, industrial engineering and occupational medicine.

HRM 630
Managing Technological and Organizational Change 3 credits
Prerequisite: HRM 601. Managing planned and unplanned change in organizations. The change process is studied in relation to technology-driven changes in the workplace and to other environmental factors. Focuses on planned and unplanned systemic change, such as downsizing, re-engineering, mergers, and acquisitions.

HRM 640
Cultures in Organizations 3 credits
Prerequisite: HRM 601. Cultures and subcultures in organizations are studied from an ethnographic perspective. Managerial and professional cultures are studied as are engineering and R&D cultures. Organizational cultures are also studied in detail using case studies, with an emphasis on understanding culture as a control mechanism in modern organizations.

HRM 650
Human Resource Information Systems 3 credits
Information systems as a tool in improving human resource functions in organizations. Emphasis is on the design of information systems and their applications to HRM problems. The course is applications oriented. A technical MIS background is not required.

HRM 655
Theory and Research in Organizational Behavior 3 credits
Prerequisite: permission of the instructor. Survey of theory and empirical research on the behavior of individuals in organizations. Foundation in theories and concepts of organizational behavior, organizational psychology, and social and individual psychology. Read critically and evaluate classic works in these areas.

HRM 660
HRM Issues in Technology-Based Organizations 3 credits
Prerequisite: HRM 606. An interactive course that emphasizes the special problems faced by organizations that include a high percentage of technically trained professional employees. Linkages between HRM functions are examined and then built upon to develop a strategic plan for the firm's human resources. Special attention is directed toward the needs of technology-based organizations such as building technical skills aimed at maintaining competitive advantage; managing innovation; assessing employee skills bases company-wide; cross training; and fostering organizational learning. Case studies and comparative analyses are used extensively.

HRM 662
Organizational Diagnosis and Development 3 credits
A problem-oriented approach to organizational development with a focus on improving work group and organizational performance. Diagnostic tools are introduced as a means of problem definition. Attention then turns to structural and process issues in organizational development. Issues with respect to technology and structure are also examined. Emphasis is primarily on the internal organization. Representative topic areas include self-managed work teams, empowerment strategies, work group structures and technologies, and conflict resolution strategies. Development also covers quality of work life issues.

HRM 670
Advanced Issues in Resource Management 3 credits
Prerequisite: permission of the instructor. A research-based course that studies current issues in HRM. Course is designed for students in the Rutgers-Newark Ph.D. program.

HRM 685
Cross Cultural Management Studies
3 credits
Provides insight into the institutional fabric and social and communication behavior of other cultures to better understand problems arising from cultural aspects of managing and doing business in various countries. Focus will be with the manager acting in various cultural environments, not restricted to the traditional human resource function at corporate headquarters. Cultural differences and technologies are also examined.

HRM 693
Employment Relationships and the Law
3 credits
Legal issues in government regulation of labor-management relations: selection and designation of bargaining agents; administration and enforcement of collective bargaining agreements; activities of unions and employers in labor disputes; and laws regulating wages, hours, and benefits.

HRM 700
Project in Human Resource Management
3 credits
Prerequisites: matriculation and advisor's approval. Comprehensive proposal for a program of human resource management; or a major component of a management program applied to an organization chosen by the student, including a design for recruitment, selection, OSHA, benefits services, and/or training program with an evaluation procedure. Another alternative is a comprehensive evaluation of existing human resource programs, including human resource plans and personnel operations requiring cost-benefit analysis. Students select an acceptable organization on which to base their proposal plans.

HRM 701
Thesis in Human Resource Management
6 credits
Prerequisites: matriculation for the master's degree, adequate graduate courses in the field of proposed research, and research advisor's approval. Thesis may be developmental experience at an appropriate professional level, or a scholarly research paper providing useful data and/or conclusions for other professionals interested in further study. A student must register for a minimum of 3 credits per semester. Credit will be limited, however, to the 6 credits indicated.

Industrial Engineering

Offered by the Department of Industrial and Manufacturing Engineering

IE 501
Fundamentals of Industrial Engineering
3 credits
Basic concepts of industrial engineering for students who lack an undergraduate degree in the discipline, including: manufacturing processes, work methods and measurement concepts, basics of human factors, quality control, facilities design, production planning, operations research tools, and simulation models.

IE 590
Graduate Co-op Work Experience I
3 additive credits
Prerequisites: permission from the industrial engineering program director and the Division of Career Development Services. Cooperative education internship providing on-the-job reinforcement of academic programs in industrial engineering. Work assignments and projects are developed by the co-op office in consultation with the industrial engineering program director. Work assignments are related to student's major and are evaluated by faculty coordinators in the IE department. Course cannot be applied toward degree credit.

IE 591
Graduate Co-op Work Experience II
3 additive credits
Prerequisite: permission from the industrial engineering program director and the Division of Career Development Services. Course cannot be applied toward degree credit.

IE 592
Graduate Co-op Work Experience III
3 additive credits
Prerequisites: graduate standing and permission from the industrial engineering program director, and the Division of Career Development Services. Course cannot be applied toward degree credit.

IE 601
Measurement Methods for Performance Analysis of Operations 3 credits
Prerequisite: undergraduate mathematics for management science, or EM 602. Quantitative study of various analytical methods for designing and evaluating systems employed in the management of complex enterprises such as decision-making, efficiency measurement, and methods for obtaining optimal system performance.

IE 603
Behavioral Science in Engineering Organization 3 credits
Prerequisite: undergraduate probability and statistics, or EM 503. A study of scientific research on human behavior in organizations. Processes and problems of communication in engineering activities; line-staff and supervisor-subordinate relationships; formal and informal organizations; organization models; and technical and social structure of organizations.

IE 604
Advanced Engineering Statistics 3 credits
Prerequisite: IE 331 (see undergraduate catalog for description) or equivalent. The foundations of modern quality improvement, scientific basis of quality engineering, probability, statistical inference, statistical experimental design issues such as randomized blocks, factorial design at different levels, application to factorial design, building models, and implementation and critique of Taguchi's contributions. Statistical software is used in the data analysis.

IE 605
Engineering Reliability 3 credits
Prerequisite: statistics. Concepts of modern reliability applied to practical industrial problems: statistical concepts, reliability through design, reliability through testing, analysis of reliability data, and the organization and management of a reliability program. Offered alternate years.

IE 606
Maintainability Engineering 3 credits
Prerequisite: statistics. Factors affecting maintainability design applied to military and industrial problems: statistical concepts; maintainability prediction, allocation, and demonstration; availability, system and costeffectiveness; provisioning; optimal maintenance policies; and management of a maintainability program.

IE 608
Product Liability Control 3 credits
Product liability and the effect of legal doctrines on minimizing hazards of design and manufacture. Use of actuarial techniques and legal precedents applicable to design, manufacturing, advertising, and marketing problems: warranties, notices, disclaimers, definition of liability, use of expert witnesses, reliability prediction and analysis methods, safety engineering concepts, and design review. A review of government regulations for safety and protection, as well as mandatory and voluntary standards will also be included.

IE 609
Advanced Analytical Engineering Statistics
3 credits
Prerequisite: IE 604. An extension of the techniques of engineering statistical analysis to industrial applications. Emphasis is placed on the design of experiments and analysis of tests for multivariate level problems.

IE 610
Transportion Economics 3 credits
Prerequisite: undergraduate course in economics. Principles of engineering economy. Costs of highway and public transportation facilities. Economic comparisons and evaluations. Financing approaches, tax allocation theory. Programming highway and public transit improvements. *Same as Tran 610.*

IE 614
Safety Engineering Methods 3 credits
Prerequisites: introductory course in statistics and industrial or construction management. Application of selected safety engineering methods to detect, correct, and prevent unsafe conditions and procedures in future practice. Methods selected are from safety management and programs; loss prevention; fire protection; systems safety; the design of buildings and other facilities; and the design of products, machinery, and equipment. Engineering problems in designing and constructing a hazard-free environment.

IE 615
Industrial Hygiene and Occupational Health
3 credits
Prerequisites: one year of college physics and one semester of college chemistry or biology. Introduction to industrial hygiene. Recognition, evaluation and control of human exposure to

noise, heat, bio-hazards, chemicals, radiation, and improper lighting. Government standards, field measurements, work practices, engineering designs, and the effects of excessive exposure on worker health and productivity.

IE 618
Engineering Cost and Production Economics 3 credits
Prerequisite: IE 502 or equivalent. Cost management of operational activities. Focuses on capital investment decision making and efficient resource utilization to achieve cost-effective operations. Topics include alternative investment evaluation, budgeting activity based costing, quality costs, life cycle management and relevant behavioral science. These are considered in the context of manufacturing and service industry application.

IE 621
Systems Analysis and Simulation 3 credits
Prerequisites: IE 331, IE 466 (see undergraduate catalog for descriptions), or equivalent or department approval. The application of well-integrated systems approach, systems and systems engineering in the system life cycle, system design process, mathematical tools and techniques applied to systems analysis, design for operational feasibility, systems engineering management, modeling techniques including simulation, application of discrete simulation techniques to model industrial systems, design of simulation experiments using software, output data analysis.

IE 622
Simulation and Risk Analysis in Operations Management 3 credits
Prerequsites: IE 331 (see undergraduate catalog for description) or equivalent. Introduction to the concepts, methodologies and applications of simulation in operations management. Foundations of simulation, Monte Carlo approaches, simulation models using spreadsheets, generating probabilistic outcomes using random number generation techniques, applying risk analysis software to spreadsheets for various decisions making. Variety of applications in operations management, finance and marketing. Software to develop models of practical operations management applications, is provided.

IE 623
Linear Programming 3 credits
Prerequisite: EM 602 or introductory course in operations research. Principles, methodology, and practical applications of linear programming to complex problems in production and marketing, simplex techniques, duality theory, parametric analysis, Wolfe and Dantzig's decomposition methods, ellipsoid method, and Karmakar's method.

IE 624
Heuristic Methods 3 credits
Prerequisites: EM 503 or equivalent. Techniques and concepts used to develop "intelligent" decision support systems. Application of rules called heuristics and models of reasoning to solve problems in engineering design and manufacturing. Topics include set theory, fuzzy subset theory, decision theory, logic, inference expert systems and single and multi-fault diagnostics.

IE 641
Operations Analysis 3 credits
Prerequisites: EM 602 and computer programming experience. Management systems and business behavior using industrial models. Special attention is given to the interaction of individual elements that make up the total system.

IE 642
Network Flows and Applications 3 credits
Prerequisite: EM 602 or equivalent. Theories, algorithms, computation complexity, and application of networks, shortest path, network flow, and minimum cost flow problems. Models of industrial service systems as network problems.

IE 643
Transportation Finance 3 credits
Prerequisite: undergraduate course in economics. Balance sheets and income statements. Asset and liability management, sources and costs of debt and equity financing. Financial performance measures in the private sector (airlines, railroads, trucking and bus companies). Financing issues associated with the public sector (highways and mass transit). Equity and efficiency in pricing. Subsidy allocation formulae. Innovative financing schemes in the public sector. *Same as Tran 643.*

IE 644
Application of Stochastic Modeling in Systems Control 3 credits
Stochastic processes applied to control of various types of systems: Markov chains, queueing theory, storage theory applications to measure performance of flexible manufacturing systems, telecommunication and distributions networks and similar service systems. Knowledge of probability theory and linear algebra is essential.

IE 650
Advanced Topics in Operations Research 3 credits
Prerequisite: introductory course in operations research or equivalent. Current topics in deterministic models of operations research: linear programming, large scale decomposition, integer programming, dynamic programming, and nonlinear programming. Emphasis on optimization techniques for solving mathematical programming problems.

IE 651
Industrial Simulation 3 credits
Prerequisite: introductory course in statistics/simulation or instructor's permission. Statistical design and analysis of Monte Carlo simulation experiments from an engineering view. Examples are provided with emphasis on industrial and manufacturing applications of simulation modeling. Markovian processes simulation, random number generation, mathematical programming, heuristics and decision theory.

IE 652
Facilities Location and Plant Layout 3 credits
Prerequisite: introductory course in operations research or instructor's approval. Basic concepts of facilities location and plant layout. Quantitative and qualitative tools needed in industrial engineering, including single and multiple facilities location problems, site selections and allocation models, use of Duality theory in location and plant layout problem, and computerized layout planning.

IE 653
Facility Maintenance 3 credits
Prerequisite: EM 501 or equivalent. Intended for those individuals who manage the functioning and maintenance of physical facilities. Emphasis on planning and control of facilities use, maintenance, utility management, managerial control, budgets and costs, personnel administration, legal and safety, flexibility measurement, and design.

IE 661
Man-Machine Systems 3 credits
Prerequisite: human factors engineering. Analysis of integrated man-machine systems: physical and psychological effects of systems of deterministic and conditional responses of individuals and groups, and the resulting interaction between individuals, groups, and machine systems; also current research and development pertaining to man-machine systems.

IE 665
Applied Industrial Ergonomics
Prerequisites: IE 355 (see undergraduate catalog for description) or IE 669. Introduces the fundamentals and applications of industrial ergonomics for improving equipment, tool, workplace, and job design. Engineers, as well as safety and health professionals, will benefit from the course by understanding the design principles for human operators and current issues in industrial ergonomics, and a variety of evaluating methodologies for the design.

IE 669
Human Design Factors in Engineering 3 credits
Prerequisite: engineering statistics. Human factors research related to workplace and equipment design and development. Capabilities and limitations of the human sensory-motor system. Design of displays and resulting interaction between individuals, groups, environments and machine systems. Current research in engineering pertaining to the man-machine interface. Not for IE students who have had an undergraduate course in human factors.

IE 670
Industrial Work Physiology 3 credits
Prerequisite: IE 669 or equivalent. A study of human physiological responses to industrial environmental factors emphasizing knowledge of human anatomy and physiological tolerances: skeletal, muscle, and neuromuscular systems, evaluation of physical work capacity and performance, changes in circulation and respiration during work. Semester project under the instructor's supervision is also required.

IE 672
Industrial Quality Control 3 credits
Prerequisite: engineering statistics. The management of quality assurance: operational and statistical principles of acceptance sampling and process control; quality problems in production lines, and introduction to total quality management concepts.

IE 673
Total Quality Management 3 credits
Introduces the concept of total quality management as applicable to industrial systems. Presents methods for product quality improvement. Emphasis is on prevention through quality engineering and design, and goes beyond traditional statistical process quality control. Presentation of recent methods in supplier management, quality assurance, process control, and competitor analysis. Includes Taguchi methods and quality function deployment. Description of ISO 9000 and Baldridge Award.

IE 674
Quality Maintenance and Support Systems 3 credits
Prerequisites: probability and statistics, IE 331 (see undergraduate catalog for description) or equivalent. Consideration of factors necessary for cost effective maintenance and support of technical operating systems. Topics discussed include service organization and management, spare parts and logistics, quality assurance, ISO9003 training. Examples from automation, computer systems, clinical engineering, power, and transportation will be used to illustrate application areas.

IE 675
Safety in Facility and Product Design 3 credits
Prerequisite: IE 614 or equivalent. Application of safety principles to minimize the health and safety hazards in the design and manufacture of various products. Practical techniques for, and economic ramifications of, conformance with the many statutes enacted to assure safe workplaces and products.

IE 677
Applied Statistics and Epidemiology for Hazard Analysis 3 credits
Prerequisite: IE 604 or equivalent. Application of statistical concepts to the field of hazard analysis including: investigation of root causes of accidents, their patterns and trends; rules for systematic data analysis; determination of commonality factors; availability and use of customized computer software.

IE 685
Systems Safety 3 credits
Prerequisites: applied probability/statistics and introductory safety. Safety decision making and systems engineering applications to safety, including planning, managing and conducting system safety programs.

IE 699
Special Topics in Industrial Engineering 3 credits
Prerequisite: approval from the industrial engineering graduate advisor. Special course given when interest in a subject area develops. Advanced notice of topics will be given before registration.

IE 701
Master's Thesis 6 credits
Prerequisites: matriculation for the master of science degree, thesis advisor's approval, and adequate graduate courses in the field of the proposed thesis. Candidates for the degree who choose this option must submit an acceptable thesis on an approved subject that contributes to the literature of the field, and preferably aids the candidate's present or potential, career. While original research may not always result, the thesis should provide a new conclusion or application. Approval to register for the thesis must be obtained from the thesis advisor. A student must continuously register for a minimum of 3 credits per semester until the thesis is completed. Total credit will be limited, however, to the 6 credits indicated for the thesis.

IE 704
Sequencing and Scheduling 3 credits
Prerequisite: IE 650 or equivalent. Advanced sequencing and scheduling for job shops, flow lines, and other general manufacturing and production systems are discussed in this course. Both deterministic and stochastic scheduling models are covered in detail. Heuristics and worst case analysis for "unsolvable" hard scheduling problems (NP-C problem) are introduced.

IE 705
Mathematical Programming in Management Science 3 credits
Prerequisites: IE 623 and IE 650. An advanced study of various mathematical programming techniques such as linear and non-linear, parametric, integer, stochastic and dynamic programming. Readings and discussions emphasize mathematical advances and applications in operations research.

IE 706
A Queueing Approach to Performance Analysis 3 credits
Prerequisite: IE 644 or equivalent. Newly developed techniques in the area of queueing networks that play a critical role in studying several aspects of discrete event stochastic systems such as FMS, computer-aided communication systems, transportation systems and service systems.

IE 725
Independent Research 3 credits
Prerequisite: approval from the industrial engineering program director. Program of study prescribed and approved by student's advisor. This special course covers areas in which one or more students may be interested but is not of sufficiently broad interest to warrant a regular course.

IE 753
Airport Design and Planning 3 credits
Prerequisite or corequisite: Tran 610 or EM 693. Planning of individual airports and statewide airport systems. Functional decision of air and landside facilities. Orientation, number and length of runways. Concepts of airport capacity. Passenger and freight terminal facility requirements. Airport access systems. FAA operating requirements. Financial, safety and security issues. *Same as CE 753 and Tran 753.*

IE 754
Port Design and Planning 3 credits
Prerequisite: Tran 610 or EM 693. Functional design of the water and landsides for general cargo, liquid and dry bulk, and container operations. Yard and storage systems. Port capacity in an intermodal network. Economic, regulatory, and environmental issues. *Same as CE 754 and Tran 754.*

IE 760
Quantitative Methods in Human Factors 3 credits
Prerequisite: IE 661. More advanced human factors engineering concepts analyzed quantitatively: systems modeling, control theory, human error, and decision making. Discussion of human factors, research design and data analysis. Operator/computer interaction is also emphasized.

IE 761
Advanced Studies in Human Factors 3 credits
Prerequisite: one year of graduate work in human factors or the equivalent. The course integrates various areas of graduate studies in human factors such as: work physiology, occupational safety, environment and human-machine systems. Detailed discussion of selected current papers covering theoretical review, experimental design, results, applications, and future research. Completion of semester project under instructor's guidance is mandatory.

IE 762
Psychophysical Methods in Human Factors 3 credits
Prerequisite: one year of graduate work in human factors or instructor's approval. This course considers various classical and modern psychophysical methods, signal detection theory, information theory, and human information processing applicable to advanced human factors/occupational safety research measurement and normative modeling.

IE 791
Graduate Seminar Non-credit
A seminar in which faculty or others present summaries of advanced topics suitable for research. Discussion of research procedures, thesis organization, and content. Students engaged in research will present their own research for discussion and criticism.

Infrastructure Planning

Offered by the School of Architecture

MIP 601
Interdisciplinary Infrastructure Studio I 6 credits
Collaborative work on realistic infrastructure projects by teams of students with different professional backgrounds under the supervision of interdisciplinary faculty. A project manager coordinates and ensures that working conditions in practice are simulated in the studio. Projects include analytical, financial and design components and emphasize planning

strategies and the coordinating function of the design process. Studio products are presented orally in reviews and documented in written and illustrated reports.

MIP 602
Interdisciplinary Infrastructure Studio II
6 credits
A comprehensive planning and design project emphasizing infrastructure technologies and information management. CAD and other computer applications are used to produce computer-generated graphics and multimedia presentations. Although subjects and approaches will vary, the work of the studio is intended to develop the students' ability to deal with all facets of infrastructure planning regardless of previous academic background. The final products must include a full written and illustrated report on the project and the research on which it is based.

MIP 612
Introduction to Environmental Policy Studies 3 credits
Introduction to six areas essential to a comprehensive understanding of environmental policy: concepts of environmental policy; tools (law, economics, planning, science, engineering, ethics) for environmental policy; the U.S. perspective (NEPA, clean air and water acts, CERCLA, etc.); the international perspective (Club of Rome models, 1972 UNEP, 1992 Rio, etc.); industrial perspective (pollution prevention/life cycle engineering, privatization, etc.); and the local perspective (New Jersey DEP, NGOs, local industry, shoreline, etc.). *Same as EPS 612.*

MIP 615
Introduction to Transportation Studies
3 credits
Prerequisite: elementary probability and statistics. Presentation of the characteristics of the traffic stream, road users, and of vehicles, and a review of traffic flow relationships. Students are exposed to the principal methodologies followed by transportation practices to perform volume, speed, travel time, delay, accident, parking, pedestrian, transit and goods movement studies. Presentation of the principal methodologies used to perform transportation facility capacity analyses for: basic freeway sections, weaving areas, ramps and ramp junctions, multi-lane and two lane roadways, signalized and unsignalized intersections. Students get hands on experience using the highway capacity software (HCS) and SiDRA. *Same as CE 660 and Tran 615.*

MIP 618
Public and Private Financing of Urban Areas 3 credits
Ties government's budget, tax, policy, allocation of resources between public and private sectors, with the structure, development, and growth needs of urban metropolitan areas. Focuses on problems of poverty, transportation, land-use, economic base, relation between central cities and suburban areas, and alternative engineering and economic solutions. *Same as Fin 618 and Tran 604.*

MIP 631
History and Theory of Infrastructure
3 credits
The historical role of infrastructure in the formation of cities and the relation of planning theories to urban culture. Case studies are used to develop effective ways of learning urban design; method and substance are equally emphasized. Concentration on the social, economic, political, technological and topographic factors that affect urban form; analysis of urban design schemata and their relation to patterns of use; and the critical appraisal of planning ideologies and strategies. *Same as Arch 631H.*

MIP 652
Geographic Information Systems 3 credits
Prerequisite: course or working knowledge of CADD or permission of instructor. Geographical/Land Information System (GIS/LIS) is a computerized system capable of storing, manipulating and using spatial data describing location and significant properties of the earth's surface. GIS is an interdisciplinary technology used for studying and managing land uses, land resource assessment, environmental monitoring and hazard/toxic waste control, etc. Introduces this emerging technology and its applications. *Same as CE 602 and Tran 602.*

MIP 655
Land Use Planning 3 credits
Spatial relations of human behavior patterns to land use: methods of employment and population studies are evaluated; location and spatial requirements are related to land use plans; and concepts of urban renewal and recreational planning are investigated by case studies. *Same as Tran 655 and CE 655.*

MIP 673
Infrastructure Planning in Practice 3 credits
Infrastructure planning principles, methods and tools. Through selected examples, acquaintance with infrastructure planning theories and models, quantitative methods of research and analysis, information management, decision making, and implementation techniques. *Same as Arch 673.*

MIP 674
Infrastructure and Architecture 3 credits
Examination of areas of overlap and continuity between architecture, landscape architecture, urban design, building science and infrastructure. Topics include the typology, programming and design of public facilities; the housing fabric; the relation between built form, urban space and infrastructure. *Same as Arch 674.*

MIP 675
Elements of Infrastructure Planning
3 credits
Introductory survey of the basic principles, operation and design of physical infrastructure systems including roads, public transportation, community facilities, public open space, surface drainage, and electric, gas, water, waste disposal, and telecommunications services. *Same as Arch 675.*

International Studies

Administered by the Office of International Students and Faculty

MR INTL
Study Abroad
12 maintenance-of-registration credits
Prerequisite: permission from the Office of International Students and Faculty. NJIT, through direct exchange agreements and through membership in an engineering educational exchange consortium, offers students the opportunity to study abroad for a semester or an academic year. Students may select any of the courses that meet their degree requirements with written approval from the academic advisor. Transfer credits will be awarded for preapproved courses successfully completed at the end of the exchange period. Open to all degree programs.

Management

Offered by the School of Management

Mgmt 580
Managerial Science 3 credits
Introduction to methods of operations research and systems analysis of managerial problems: objective functions and constraints, theories of values, optimization and simulation modeling with emphasis on models of production systems, decision analysis, inventory systems, project planning, and transportation systems. Deterministic and stochastic approaches to these topics are covered.

Mgmt 610
Foundations of Management in Organizations 3 credits
Presented during the residence week for the Executive Program. Includes management accounting, managerial economics, statistics, operations research, marketing, MIS, and finance.

Mgmt 620
Management of Technology 3 credits
Technology as a main component of an organizational entity. Generation, development, and implementation of technology are outlined. Influence of technology on global competitiveness is also discussed.

Mgmt 625*
Distribution Logistics 3 credits
Distribution logistics emphasizing techniques used to optimize corporate profit and customer service; transportation modes; inventory policies; warehousing and order processing; and the best logistics gross margin. Same as EM 640 and Tran 640.

Mgmt 630
Decision Analysis 3 credits
Introduction to the methodology of decision analysis using computer based techniques and systems analysis. Introduces concepts of modeling, probability, and choice. Addresses the philosophy and detailed methods involved in decision analysis. Methods are applied to address routine and special business decisions.

*Same as EM 640 and Tran 640 course designations pending

Mgmt 635
Management Research Methods 3 credits
Prerequisite: Mgmt 630. Introduction to the application of research methodologies and quantitative methods to typical problems in business and organizations, including the areas of manufacturing, transportation/logistics, MIS, and organizational research. Covers framing research questions to selecting the appropriate method and analytical technique to be used, and interpreting the analysis output. Business software tools such as Excel, SPSS, SAS, Minitab and Statbox are used for data analysis. Topics include experimental, quasi-experimental, correlational, and survey research designs and descriptive and differential data analysis using a variety of procedures. All topics use management case studies and illustrations.

Mgmt 640
New Venture Management 3 credits
Prerequisite: Fin 516. For the student who is considering starting or managing a new business. The course combines classroom instruction in business management and a term project involving the analysis of a business case. The course is designed to build upon and integrate the student's previously acquired business knowledge and skills into an understanding of how to start and run a new business.

Mgmt 645
New Venture Finance 3 credits
Prerequisite: Fin 516. This course is designed to provide students with understanding of the problems and opportunities posed by the financing of a new and growing technology-based business. Students will study the financial conditions of new businesses and examine the effect of growth upon cash flow while exploring optimal sources of capital.

Mgmt 650
Leadership in Total Quality Management 3 credits
Presents an integrative approach to total quality management as it relates to achieving competitive and global advantage. Specific emphasis is placed on coordinating the marketing, production, service, and human resource function in TQM programs. The role of senior management in building organizations committed to TQM is then addressed.

Mgmt 655
Global Competitiveness 3 credits
Improves knowledge of the issues involved in international business operations and their management. Develops skills in selecting key issues and familiarization with emerging methods for organizing and managing international operations. Emphasis will be on companies with technological, product, production, or design focus.

Mgmt 657
Import/Export Processes 3 credits
Prerequisite: Mgmt 670 or Mgmt 655. Discusses key elements of import/export planning processes with an emphasis on the technology-based firm. International environment, market analysis, export strategy, and transactions are studied. Covers trade regulations and policies, financial advantage of foreign trade zones, and international standards for technology-based products. Factors underlying trade encouragement and restrictions between nations are also considered.

Mgmt 660
Global Communications 3 credits
Communications within a company, with its customers, and between its suppliers, is essential to business operations. Internationalization of suppliers and customers requires changes in traditional corporate communication systems. Models for design and management of global communication systems are presented and discussed. Emphasis is on improving the socio-technical operations interface. Topics include: use of telecommunications and related technologies for communications; new patterns of global business communications; and means to manage technological and cultural communication gaps.

Mgmt 665
International Product Development 3 credits
Prerequisite: Mgmt 670 or Mgmt 655. Students will learn about product development processes as part of international business development operations. Examines differences in developing products for: national and international customers, production and service industries, and static and dynamic client needs. Examines methods of design management, means to integrate product design, production, and marketing functions, and measures for product life-cycle accounting. Term projects examine national differences in product development.

Mgmt 670
International Business 3 credits
Covers the scope and the essential characteristics of international business in the world economy; MNEs as economic, political, and social institutions; national and international control; functional management and operations; country evaluation; and regional market analysis.

Mgmt 675
Legal Environment of International Business 3 credits
Focuses on the legal aspects of international business activities. Topics include: international trade practices and government regulations; legal aspects of international joint ventures, mergers, and acquisitions; and the legal component of intellectual property rights and its relation to trade disputes.

Mgmt 680
Entrepreneurial Strategy 3 credits
For the student who is considering starting and/or managing a new business. Integrates knowledge of the different aspects of business that have been learned as separate subjects. Provides an understanding of the decisions that guide the overall operations of an entrepreneurial business organization and how it interacts with its markets, competitors, and suppliers. Combines classroom instruction in business strategy along with case analysis of small firms. Should be taken in the last semester of the program, unless prior arrangement has been made with the instructor or the graduate advisor.

Mgmt 685
Operations Research and Decision Making 3 credits
Introduces the concepts of objective functions and constraints, concepts of value and utilities, optimization algorithms, networks, and game theory. Covers models of linear programming, inventory systems, multi-criteria decision-making, project management, and transportation planning. Topics discussed from probabilistic and deterministic approaches.

Mgmt 691
Legal and Ethical Issues 3 credits
Explores the legal and ethical responsibilities of managers. Analyzes extent to which shareholders should be allowed to exercise their legitimate economic, legal, and ethical claims on corporate managers; extent of regulation of a particular industry, individual rights of the employee and various corporate interests, and corporate responsibility to consumers, society, and conservation of natural resources and the environment.

Mgmt 692
Business Strategy 3 credits
Prerequisites: Mgmt 691, HRM 601. Integration of the functional areas in management providing a top management perspective to the role of chief executive in an organization; strategy formulation and implementation; and ethical issues related to corporate strategies.

Mgmt 695
Business Strategy for Environmental Management 3 credits
This is a capstone course integrating the functional areas in management to provide a top management perspective to potential managers. The course deals with the role of the chief executive in environmental management and how strategies are formulated and implemented.

Mgmt 701
Master's Thesis 6 credits
Prerequisite: approval of the assistant dean for graduate programs. For students who desire to complete a thesis in management. Students must register every semester until the thesis is completed. Only 6 credits indicated for the thesis is applied to degree credit.

Mgmt 710
Business Forecasting Methods 3 credits
Covers the application of forecasting techniques to various phases of business and management decision making. Topics include forecasting with cyclical and seasonal series; Box-Jenkins modeling; regression modeling; use of stochastic models; and the linkage of management forecasts to macro forecasts. Actual models in use will be reviewed and evaluated.

Mgmt 791
Graduate Seminar Non-credit
Faculty, students and invited speakers present and discuss current topics of research in management.

Rutgers-Newark Management Courses
Offered by the Department of Management at Rutgers-Newark

26:620:555
Seminar in Organizational Behavior
3 Credits
Survey of theory and empirical research about the behavior of individuals and groups in organizations. Typical topics include motivation, socialization, job design, satisfaction, performance, leadership, group norms, and decision-making processes.

26:620:556
Seminar in Organizational Theory 3 credits
Survey of theory and empirical research about the behavior of individuals and groups in organizations. Typical topics include models or organizations such as theories of bureaucracy and closed, open, and natural systems; effects of technology including environment, power and decision-making, and organizational culture.

26:620:671
Management of Innovation and Technology
3 credits by arrangement
Examines individual, structural, and contextual factors that facilitate and inhibit the generation and implementation of new technology. Emphasizes the management of innovation in organizations.

26:620:677
Culture and Organizations
3 credits by arrangement
Draws on the cross-cultural psychology literature on national and ethnic cultures and on the management literature on culture in organizations. Major topics include the content and manifestations of culture, cultural similarities and differences, the transmission of culture, culture and subculture, culture change, leadership and culture, and managing organizational culture.

Management Information Systems

Offered by the School of Management

MIS 545
Management Information Systems 3 credits
Tools and techniques of management information systems and how they can be used to improve the quality of management decisions. Includes computer-based solutions to management problems in office automation, budgeting, communications, and decision support, major features of hardware and software computer system components and how to design a system, and technical tools ranging from flowcharts and decision tables to automated design.

MIS 620
Computing Concepts for Managers
3 credits
The manipulation of relational databases. Normally the main language will be SQL, which facilitates the use of personal computer-based database management software.

MIS 625
Internet for Managers 3 credits
Prepares students for effective management of internet-based businesses and electronic commerce and oversight of global business activities in an increasingly competitive environment. Introduces Internet concepts and infrastructure. Examines current and proposed Internet services forming the basis of Internet commerce. Covers corporate intranets and extranets and their applications to corporate computing, seamless e-commerce, and other emerging services such as VPN. Issues are discussed, with special emphasis on security.

MIS 635
Management of Telecommunications
3 credits
A comprehensive review of current trends in telecommunications with an emphasis on the techniques required by non-technically trained managers to deal with hardware, software, and human interfaces. Specific areas to be covered include the types of telecommunication networks, common network operating systems, and network design strategies.

MIS 636*
Telecommunications: Policies and Regulations
Familiarization with government regulations for all forms of telecommunications, including video and audio. Covers such aspects as the ways in which corporations manage and provide security for telecommunications. Covers briefly: major telecommunications policies and regulations that have made a major impact on the current environment; telecommunications regulations in a global environment.

MIS 645
Operations Management, Planning and Control 3 credits
Prerequisite: MIS 545. The management of information processing resources, including: role of information processing, estimates of personnel resources and budgets, integration of corporate and MIS plans, organizational alternatives for MIS departments and support staffs, management of computer operations, equipment and general software acquisitions, intermediate and long-range MIS plans, integration of personal computers, minicomputers, and mainframes, and security and controls.

MIS 648
Decision Support Systems 3 credits
Prerequisites: MIS 545, Mgmt 580. Covers the use of decision support systems to support management decision making in a real world environment. Topics include: establishing and measuring decision support systems success criteria, software tools, model management, elements of artificial intelligence, and statistics. Justification, design, and use of decision support systems.

MIS 654
Design of Accounting Information Systems
3 credits
Management's need for information and design of systems to provide this information. Emphasis on designing controls to ensure that the system meets management's objectives. Comparison of management and technical aspects of information systems. Accounting information systems will be used as models, but the course will incorporate all functions within the organization and provide the student with tools needed to manage the system and safeguard the assets of the organization.

MIS 655
Information Systems Audit, Control and Security 3 credits
Emphasizes controls and how an auditor or a manager verifies that controls are in existence and are effective. Security and controls are complementary and should be included in an MIS system environment. Covers the internal controls that should be present in an information system given its environment.

MIS 680
PC Tools for Managers 3 credits
Presents a cross section of the personal computer tools available to most managers. Builds on traditional spread sheets, word processors, and databases and may include presentation graphics, project management, and others.

MIS 690
Executive Information Systems 3 credits
Provides decision makers a framework for designing and building systems to gain competitive advantage. Covers executive support systems, executive information systems, and group support systems.

MIS 701
Thesis in Information Systems Management
6 credits
Prerequisites: MIS 645, MIS 648, CIS 675, CIS 679 or waived with approval of the Dean. Examines what is research? Why do research? What are the objectives of research? Covers need for research, criteria for good research and research design, concept of measurement, sampling design, primary data collection, experimentation and simulation, statistical and other types of analysis, and reporting of research findings.

Manufacturing Systems Engineering

Offered by the Department of Industrial and Manufacturing Engineering

MnE 601
Manufacturing Systems 3 credits
Modeling and control of large-scale systems with application to complex manufacturing systems including mathematically based modeling and control, and artificial intelligence-based methods.

MnE 602
Flexible and Computer Integrated Manufacturing 3 credits
Prerequisites: EM 602 and MnE 601, or instructor's approval. Integrated manufacturing as a decision and information network, with appropriate automation; manufacturing LANs, MAP, PDES, programmable controllers, and MRP-II are discussed in technical detail; group

*pending

technology, cellular manufacturing and relevant process planning approaches; mathematical techniques for CIM and FMS scheduling and control.

MnE 603
Management of Manufacturing Systems
3 credits
Methods of planning and control of manufacturing organization, processes and facilities including demand forecasting, product development, capacity planning, inventory control, site selection, finance development, decision processes, personnel development and training, and manufacturing policy formulation.

MnE 612
Robotic Manufacturing Systems 3 credits
Industrial robotic programming and control. Robotic end effectors and sensors, tactile and vision. Cell design and control. Artificial intelligence. Robotic project using one of twenty industrial robots. Economic analysis and productivity. Material transfer, machine loading, assembly, inspection, welding, painting, and safety aspects. Hardware/software interfacing.

MnE 654
Design for Manufacturability 3 credits
Prerequisite: MnE 601 or instructor's approval. Methodologies used in the synthesis and analysis of product design to optimize manufacturability. The relationship of design to production processes, product material, material handling, quality costs, and CAD/CAM are presented. Emphasis is on both formed products and assembled products. Simulation and other design analysis tools are employed.

MnE 655
Concurrent Engineering 3 credits
Concurrent/simultaneous engineering methods and tools such as system analysis, system modelling and system integration, market oriented, integrated design for manufacturing, assembly, quality and maintenance, product design analysis, integrated product design and manufacturing innovation methods, QFD (Quality Function Deployment) — applied to concurrent engineering, FMEA (Failure Mode and Effect Analysis), POKA-YOKE, KANZEI, waste reduction, quality circles, rapid prototyping of designed objects and various other advanced processing methods.

MnE 700
Master's Project 3 credits
An interdisciplinary team project performed in collaboration with industry. The project must reflect proficiency in the student's selected area of specialization.

MnE 701
Master's Thesis 6 credits
In special cases, a thesis based on an important industrial problem will be substituted for the master's project. Research for the thesis should be performed with industrial sponsorship and collaboration.

MnE 715
Selected Topics 3 credits
Prerequisite: approval of the program director. Topics in various areas of specialization.

MnE 725
Independent Study in Manufacturing
3 credits
Prerequisites: written permission from the director of manufacturing systems engineering programs, and courses prescribed by the supervising faculty member. Areas of study in manufacturing computer systems analysis and design in which one or more students may be interested, but that are not of sufficiently broad interest to warrant a regular course offering.

MnE 791
Manufacturing Engineering Seminar
1 credit
A series of invited speakers, primarily from industry, will discuss current manufacturing problems and methods. Attendance at these seminars is required for all students enrolled in the manufacturing systems engineering program.

Marketing

Offered by the Department of Management at Rutgers-Newark

26:630:576
Quantitative Methods in Marketing
Credits by arrangement
Emphasis on quantitative approach to marketing decision making and model building in particular.

26:630:625
Clustering Analysis 3 credits by arrangement
Prerequisites: calculus, intermediate statistics, optimization theory, and graph theory. Emphasizes such methods of data analysis as: clustering, including formal underpinnings, measures of association or dissimilarity coefficients, overlapping clustering, partitioning, constrained clustering, consensus clustering, cluster validity, computational advances, and substantive developments, with emphasis on market segmentation and product positioning.

26:630:660
Qualitative Research Methods 3 credits
Emphasizes issues of eliciting, analyzing, and representing verbal data in qualitative research. The topics considered are definition and evaluation of qualitative research; methods of eliciting data from individuals and groups; methods of analyzing verbal data; issues of representing narratives; and new research directions using feminist, historical, and aesthetic methods.

26:630:668
Causal Modeling 3 credits
Prerequisite: 26:960:577. In-depth analysis of recent advances in the statistical analysis of causal models. Topics include structural equation methods, log-linear modeling, and Bayesian methods.

Marketing Management

Offered by the School of Management

Mrkt 530
Principles of Marketing 3 credits
Examination of the factors relating to marketing process. The nature and significance of consumer and organization buying behaviors, competition, government regulations, consumerism, and social responsibility are analyzed. Covers decision making in market research, product development, pricing, distribution, advertising, promotion, selling, and marketing strategy.

Mrkt 620
Competing in Global Markets 3 credits
Designed to help prepare students to become effective managers overseeing global market activities in an increasingly competitive environment. It will examine the impact of global economic, financial, cultural, political, and legal factors on the development of marketing programs and on the marketing/R&D and marketing/manufacturing interfaces.

Mrkt 630
Models of Consumer Behavior 3 credits
Provides students a framework, the buyer decision process model, to analyze how and why products and services are selected and purchased. Impact of consumer decisions on the marketing strategies of organizations is emphasized. Focus on quality management of the marketing function to determine customer needs; provide the appropriate products, prices, distribution systems, and promotion messages; and measure customer satisfaction after purchase and use.

Mrkt 631
Market Planning and Analysis 3 credits
Provides a research and managerial perspective on advanced marketing research methods and analytical techniques. Topics include problem formulation, research design, data collection and analysis, managerial report writing. Students will acquire experience by developing and executing their own marketing research project using sophisticated computerized analytical techniques.

Mrkt 632
Marketing Strategy for Technology-Based Organizations 3 credits
Students combine the knowledge and skills learned in other marketing courses and develop strategic marketing plans that focus on quality management, productivity improvement, and international competitiveness. Buyer decision making, market segmentation and targeting, product positioning, market response, and competitive actions are analyzed. Case studies and student projects add realism and practical experience to the course.

Mrkt 636
Design and Development of High Technology Products 3 credits
Focus on analysis of needs of buyers and consumers for specific product characteristics and the development of appropriate products to

satisfy such needs. The process of identifying new product opportunities, screening new product concepts, product testing and test marketing, product positioning, and development of the marketing strategy and implementation plans.

Mrkt 637
Marketing Communications and Promotions 3 credits
Communications, sales promotion, and public relations are examined from the perspective of the manager. Topics include advertising and promotion research, media selection, creative production of electronic and print materials, and the budgeting and control of their use. Field research will be stressed as part of the course project requirement.

Mrkt 638
Sales Management for Technical Professionals 3 credits
Focuses on the promotion and sales of products in the business-to-organization market. All elements of the marketing communications mix are covered according to their importance in that market: selling, sales promotion, trade advertising, and publicity. The latest techniques are reviewed and discussed using case histories and student projects. Issues of global competitiveness, high technology products, and the role of total quality management in marketing communications are emphasized.

Mrkt 640
Industrial Marketing Management 3 credits
Stresses the role of the manager in all aspects of marketing. Managerial decision-making techniques and strategies for product development, product pricing, distribution channels, personal selling, advertising and promotion. Strategic and operational marketing plans are developed based on student field research.

Mrkt 642
International Marketing Management 3 credits
Focus on multinational enterprise in the global market, emphasizing special managerial skills required to adapt sound marketing practices to foreign cultural, political, economic and financial environments. Foreign opportunities and marketing strategies are examined. Students prepare a marketing plan for entry into an international market after conducting appropriate research.

Mrkt 701
Thesis in Marketing Management 3 credits
Prerequisites: Mrkt 630, Mrkt 631, Mrkt 632 or waived with approval of the Dean. For students who do a thesis in marketing. State-of-the-art marketing research methods: importance in marketing decision making, research objectives, research design, measurement concepts, reliability and validity, primary and secondary data collection, sampling design, qualitative and quantitative research and analytical methods, field studies and survey research, multivariate analytical models. Also covers planning, preparation and submission of the thesis.

Mrkt 731
Advanced Market Planning and Analysis 3 credits
Prerequisite: Mrkt 631. Covers advanced topics in the design and analysis of market research studies. Focus on the development of statistical sampling methods and techniques to develop estimates for complex marketing problems. Also focuses on advanced multivariate analysis and estimation techniques needed in the interpretation of complex marketing problems.

Mrkt 753
Marketing Science 3 credits
Prerequisite: Mrkt 631. Emphasizes quantitative model building approach to the complex problems of marketing decision making using the principles of quantitative decisions to management problems and econometrics to the understanding of large amounts of data, which lead to improvements in marketing decision effectiveness. Such areas of marketing as buyer behavior, pricing, promotion, advertising, sales force management, and new product planning will be analyzed.

Materials Science and Engineering

Offered by the Committee for the Interdisciplinary Program in Materials Science and Engineering

MtSE 605
Fundamentals of Engineering Materials 3 credits
Prerequisite: graduate standing. The effect of structure on the properties and behavior of engineering materials. Topics include atomic structure, bonding, crystallography, and defects in solids; properties of metals, semiconductors, ceramics, and polymers and their behavioral response to mechanical, chemical, optical, electrical, and magnetic stimuli.

MtSE 610
Mechanical Properties of Materials 3 credits
Prerequisite: graduate standing. Elements of elasticity and plasticity theory, deformation and fracture behavior of materials, the concept of dislocations and their interaction with other lattice defects, strengthening mechanisms in solids, and principles of failure analysis. Materials to be studied include metals, polymers, ceramics, glasses, and composites.

MtSE 615
Composite Materials 3 credits
Prerequisites: MtSE 605 and MtSE 610. Introduction to fundamental principles of design and technology of composite materials. Materials based on polymer, ceramic, and metal matrices are discussed. Properties of the constitutive materials, their structure, methods of structural arrangements, as well as properties and characterization of the final products are described. The different perspectives, examples, and problems in composite applications are outlined.

MtSE 625
Introduction to Ceramics 3 credits
Prerequisite: MtSE 605. Mechanical, thermal, electrical, magnetic, and optical properties of crystalline and glassy ceramics are discussed from a structural viewpoint. Important processing methods, design and evaluation of properties, and modern applications of ceramic materials are emphasized.

MtSE 627
Glass Science and Engineering 3 credits
Prerequisites: MtSE 605 and MtSE 630. Formation and structure of inorganic, polymeric, and metallic glasses. Transport phenomena, kinetics of crystallization, glass transition, and phase separation; chemical, mechanical and optical properties of glasses.

MtSE 630
Thermodynamics of Materials 3 credits
Prerequisite: undergraduate thermodyamics. Review of first, second, and third laws of thermodynamics and their applications to materials. Stability criteria, simultaneous chemical reactions, binary and multicomponent solutions, phase diagrams, surfaces, adsorption phenomena, thermochemistry of homogeneous and heterogeneous reactions are covered.

MtSE 650
Physical Metallurgy 3 credits
Prerequisite: MtSE 605. Processing-structure-property relationships in metallic alloys. Alloy systems covered include carbon steels, stainless steels, aluminum and titanium alloys, and super alloys. Topics to be presented include elementary theory of metals, defects and related phenomena, solidification, phase phenomena, solid state diffusion, nucleation and growth kinetics, as well as transformation and deformation processes.

MtSE 655
Diffusion and Solid State Kinetics 3 credits
Prerequisite: MtSE 630. The atomic theory of diffusion and mathematical derivation of the diffusion equations. Diffusion phenomena in dilute alloys as well as in ionic and covalent solids are considered. High atom mobility effects at defect sites and surfaces are examined. Chemical kinetics and kinetics of phase transformations including nucleation, growth, and spinodal decomposition are discussed.

MtSE 700
Master's Project 3 credits
Prerequisites: sufficient experience and/or graduate courses to work on the project and approval of project advisor. An extensive report involving an experimental, theoretical, or literature investigation is required. The literature investigation should result in a critical review of a specific area. Students may extend the master's project into a master's thesis.

MtSE 701
Master's Thesis 6 credits
Prerequisites: sufficient experience and/or graduate courses to work on the thesis and approval of thesis advisor. Research involving experimental or theoretical investigations or collaborative projects with industry or governmental agencies may be accepted. Completed work in the form of a written thesis should merit publication in a technical journal and must be

approved by a committee consisting of three faculty members. A student must register for 3 credits per semester. Only the 6 credits indicated for the thesis will be applied to the degree.

MtSE 702
Characterization of Solids 3 credits
Current methods for characterizing the chemical composition, crystallographic structure, electrical mapping, and morphology of solid materials. Principles and application of Auger Electron Spectroscopy (AES), Secondary Ion Mass Spectroscopy (SIMS), X-ray Photoelectron Spectroscopy (XPS), X-ray Emission Spectroscopy (XES), and Rutherford Backscattering Spectroscopy (RBS) for chemical analysis, X-ray Diffraction (XRD) and electron diffraction for crystallographic analysis, Electron Beam Induced Current (EBIC) microscopy, voltage contrast microscopy, Cathodoluminescence for electrical mapping, and Atomic Force Microscopy (AFM), Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM) and Nomarski interference contrast microscopy (DIC) for morphology.

MtSE 725
Crystallography and Diffraction 3 credits
Prerequisite: graduate standing. The atomic arrangement of crystalline materials including treatment of crystalline defects and diffraction phenomena. Lattices, crystal systems, symmetry operations are covered as well as the fundamentals of electron and X-ray diffraction.

MtSE 737
Transport of Electrons and Phonons in Solids 3 credits
Prerequisite: Phys 687/26:755:687. Basic transport processes involving electrons and phonons in solids. Topics inlcude transport-related phenomena such as Hall effect, quantum Hall effect, magneto-resistance, size effects, thermal conductivity, thermoelectric effects, phonon drag, ballistic phonons, and ballistic electrons. Applications of transport to the characterization of new electronic materials including thin films are stressed.

MtSE 757
Defects in Solids 3 credits
Prerequisites: MtSE 605 and MtSE 725. Crystallographic defects in solids, namely point defects such as vacancies and interstitial, line defects such as dislocations, and planar defects such as grain boundaries. Correlation of these defects to the mechanical, electrical and optical behavior of materials is examined in particular. Experimental methods for observation and characterization of defects including TEM, EBIC, DLTS are described.

MtSE 765
Science and Technology of Thin Films 3 credits
Prerequisite: graduate standing. Methods of preparing thin films by physical and chemical means are examined. Topics pertinent to nucleation and growth mechanism of single and polycrystalline films, structure determination, film thickness and compositional evaluation properties are discussed. The electrical, magnetic, optical, and mechanical properties of metallic, semiconductor, and insulating thin films are studied with particular relevance to integrated circuit applications.

MtSE 790
Doctoral Dissertation Credits as designated
Required of all candidates for the degree of Doctor of Philosophy. A minimum of 36 credits is required. Students must register for 6 credits each semester until 36 credits are reached. If the dissertation is not yet complete, registration for an additional 3 credits is required each semester thereafter.

MtSE 791
Graduate Seminar Non-credit
Required of all students enrolled in the M.S. or Ph.D. Program in Materials Science and Engineering. Faculty, students, and invited speakers will present and discuss current topics of research in materials science and engineering.

MtSE 792
Pre-Doctoral Research 3 credits
Prerequisite: permission of the program director. For students enrolled in the Ph.D. program before passing the Ph.D. qualifying examinations. Research is carried out under the supervision of a faculty member of the student's choice. A maximum of 6 credits may be applied to MtSE 790.

Mathematics

Offered by the Department of Mathematical Sciences

Math 515
Introduction to Advanced Calculus I
3 credits
Prerequisite: undergraduate calculus. Explores the conceptual foundations of calculus and the applications motivating the study of calculus. Some advanced concepts involving limits and integration are discussed, and connections to high school mathematics are made. Topcis include induction, limits, continuity, the derivative and integration.

Math 516
Introduction to Advanced Calculus II
3 credits
Prerequisite: Math 515. A continuation of Math 515. Topics include series and sequences, functions of several variables, vector analysis, partial derivatives and applications.

Math 545
Advanced Calculus I 3 credits
Prerequisite: undergraduate calculus. Rigorous treatment of the calculus of real-valued functions of one real variable: the real number system, Epsilon-Delta theory of limit, continuity, derivative, and the Riemann integral. The fundamental theory of calculus. Series and sequences including Taylor series and uniform convergence. The inverse and implicit function theorems.

Math 546
Advanced Calculus II 3 credits
Prerequisite: Math 545 or equivalent. Rigorous treatment of the calculus of real-valued functions of several real variables: the geometry and algebra of n-dimensional Euclidean space. Limit, continuity, derivative, and the Riemann integral of functions of several variables. The inverse and implicit function theorems. Series, including Taylor series. Optimization problems. Integration on curves and surfaces, the divergence and related theorems.

Math 551
Engineering Mathematics 3 credits
Prerequisite: undergraduate differential equations. Mathematical methods useful in the analysis of problems arising in applied mathematics and engineering. Topics include Fourier series, general orthogonal systems, Laplace and Fourier transforms, boundary-value problems, generalized functions, linear algebra and systems of ordinary differential equations.

Math 573
Intermediate Differential Equations
3 credits
Prerequisites: undergraduate differential equations and linear algebra. Methods and applications for systems of ordinary differential equations: existence and uniqueness for solutions of ODEs, linear systems, and stability analysis. Phase plane and geometrical methods. Sturm-Liouville eigenvalue problems.

Math 590
Graduate Co-op Work Experience I
3 additive credits
Prerequisites: permission from mathematical sciences department and Division of Career Development Services. Cooperative education/internship providing on-the-job complement to academic programs in mathematics. Work assignments and projects are developed by the co-op office in consultation with the mathematics department.

Math 591
Graduate Co-op Work Experience II
3 additive credits
Prerequisites: permission from mathematical sciences department and Division of Career Development Services.

Math 592
Graduate Co-op Work Experience III
3 additive credits
Prerequisites: graduate status and permission from mathematical sciences department and Division of Career Development Services.

Math 599
Teaching in Mathematics 3 credits
Prerequisite: full-time status in a graduate program. Provides TA's in mathematics with the skills and practice necessary for the effective performance of teaching and related duties. Students are exposed to strategies and methods for teaching undergraduate mathematics, and are required to demonstrate their capability for teaching using techniques. Not counted toward degree credit.

Math 611
Numerical Methods for Computation
3 credits
Prerequisites: undergraduate differential equations, linear algebra and familiarity with a computer language (FORTRAN, C, or equivalent). A practical introduction to the numerical methods of science and engineering. Numerical solution of linear systems. Interpolation and quadrature. Iterative solution of nonlinear systems. Computation of eigenvalues and eigenvectors. Numerical solution of initial and boundary value problems for ODEs. Introduction to numerical solution of PDEs. Includes examples requiring student use of a computer with some use of software packages.

Math 613
Advanced Applied Mathematics I: Modeling
3 credits
Prerequisites: undergraduate differential equations and linear algebra. Concepts and strategies of mathematical modeling are developed by investigation of case studies in a selection of areas. Consistency of a model, nondimensionalization and scaling, regular and singular effects are discussed. Possible topics include continuum mechanics (heat and mass transfer, fluid dynamics, elasticity), vibrating strings, population dynamics, traffic flow, and the Sommerfeld problem.

Math 614
Numerical Methods I 3 credits
Prerequisites: undergraduate differential equations, linear algebra and familiarity with a computer language (FORTRAN, C, or equivalent). Theory and techniques of scientific computation, with more emphasis on accuracy and rigor than Math 611. Machine arithmetic. Numerical solution of a linear system and pivoting. Interpolation and quadrature. Iterative solution of nonlinear systems. Computation of eigenvalues and eigenvectors. Numerical solution of initial and boundary value problems for systems of ODEs. Applications. The class includes examples requiring student use of a computer.

Math 620
Topics in Discrete Analysis 3 credits
Examines applications of various topics in discrete analysis including sets, modular arithmetic, graph theory and combinatorics.

Math 621
Applied Exterior Calculus 3 credits
Prerequisites: undergraduate calculus and linear algebra. Development of exterior calculus: the method of characteristics, first order linear and quasilinear PDEs and systems of PDEs. Lie subalgebras and reduction to Jacobi normal form. Theorems of Froebenius, Darboux, and Cartan. Antiexact forms and solution of exterior differential equations. Applications to nonlinear second order PDEs, calculus of variations, and examples from physics.

Math 630
Linear Algebra and Applications 3 credits
Prerequisites: undergraduate calculus and differential equations. Development of the concepts needed to study applications of linear algebra and matrix theory to science and engineering. Topics include linear systems of equations, matrix algebra, orthogonality, eigenvalues and eigenvectors, diagonalization, and matrix decomposition.

Math 631
Linear Algebra 3 credits
Prerequisites: undergraduate calculus and differential equations. Similar in aim and content to Math 630 but with more emphasis on mathematical rigor. Linear systems of equations, matrix algebra, linear spaces, orthogonality, eigenvalues and eigenvectors, diagonalization, and matrix decomposition. Applications.

Math 644
Regression Analysis Methods 3 credits
Prerequisite: Math 661 or equivalent. Regression models and the least squares criterion. Simple and multiple linear regression. Regression diagnostics. Confidence intervals and tests of parameters, regression and analysis of variance. Variable selection and model building. Dummy variables and transformations, growth models. Other regression models such as logistic regression. Using statistical software for regression analysis.

Math 645
Analysis I 3 credits
Prerequisite: a background in advanced calculus. Review and extension of the fundamental concepts of advanced calculus: the real number system, limit, continuity, differentiation, the Riemann integral, sequences and series. Point set topology in metric spaces. Uniform convergence and its applications.

Math 646
Time Series Analysis 3 credits
Prerequisite: Math 661 or, permission of instructor. Time series models, smoothing, trend and removal of seasonality. Naive forecasting models, stationarity and ARMA models. Estimation and forecasting for ARMA models. Estimation, model selection and forecasting of nonseasonal and seasonal ARIMA models.

Math 651
Applied Mathematics I 3 credits
Prerequisite: undergraduate ordinary differential equations. A survey of mathematical methods for the solution of problems in the applied sciences and engineering. Topics include: ordinary differential equations, Fourier series, Fourier and Laplace transforms, and eigenfunction expansion.

Math 652
Applied Mathematics II 3 credits
Prerequisite: Math 651 or equivalent. Continuation of Math 651. Topics include: partial differential equations, functions of a complex variable, and the calculus of variations.

Math 656
Complex Variables I 3 credits
Prerequisite: Advanced calculus. The theory and applications of analytic functions of one complex variable: elementary properties of complex numbers, analytic functions, elementary complex functions, conformal mapping, Cauchy integral formula, maximum modulus principle, Laurent series, classification of isolated singularities, residue theorem and applications.

Math 660
Differential Geometry of Curves and Surfaces II 3 credits
Prerequisites: Math 460 or equivalent. Differential forms, the Euler characteristic, the Gauss-Bonnet theorem, and the fundamental group. Outline of the topological classification of compact surfaces, vector fields, geodesics, and Jacobi fields. Calculus of variations. The global differential geometry of surfaces and the elementary theory of Riemann surfaces.

Math 661
Applied Statistics 3 credits
Prerequisite: undergraduate calculus. Role and purpose of applied statistics. Data visualization and use of statistical software used in course. Descriptive statistics, summary measures for quantitative and qualitative data, data displays. Modeling random behavior: elementary probability and some simple probability distribution models. Normal distribution. Computational statistical inference: confidence intervals and tests for means, variances, and proportions. Linear regression analysis and inference. Control charts for statistical quality control. Introduction to design of experiments and ANOVA, simple factorial design and their analysis.

Math 662
Probability Distributions 3 credits
Prerequisite: a background in undergraduate statistics or permission of instructor. Probability, conditional probability, random variables and distributions, independence, expectation, moment generating functions, useful parametric families of distributions, transformation of random variables, order statistics, sampling distributions under normality, the central limit theorem, convergence concepts and illustrative applications.

Math 664
Methods for Statistical Consulting 3 credits
Prerequisite: Math 661, or permission of instructor. Communicating with scientists in other disciplines. Statistical tools for consulting. Using statistical software such as JMP, SAS and Splus. Case studies which illustrate using statistical methodology and tools are presented by the instructor and guest speakers from academia and industry. Assignments based on case studies with use of statistical software is required.

Math 668
Probability Theory 3 credits
Prerequisite: Math 662 or equivalent. Introduction to measure theory and integration, axiomatic probability, random variables, distribution function, expectation, independence, modes of convergence, characteristic functions, Laplace-Stieltjes transforms, sums of identically distributed random variables, conditional expectation, martingales.

Math 671
Asymptotic Methods I 3 credits
Prerequisite: Math 545 or Math 645, Math 656, or equivalent. Asymptotic sequences and series. Use of asymptotic series. Regular and singular perturbation methods. Asymptotic methods for the solution of ODEs, including: boundary layer methods and asymptotic matching, multiple scales, the method of

averaging, and simple WKB theory. Asymptotic expansion of integrals, including: Watson's lemma, stationary phase, Laplace's method, and the method of steepest descent.

Math 672
Biomathematics I: Biological Waves and Oscillations 3 credits
Prerequisites: differential equations and linear algebra, or permission of the instructor. Models of wave propagation and oscillatory phenomena in nerve, muscle, and arteries: Hodgkin-Huxley theory of nerve conduction, synchronization of the cardiac pacemaker, conduction and rhythm abnormalities of the heart, excitation-contraction coupling, and calcium induced waves, wave propagation in elastic arteries, models of periodic human locomotion.

Math 673
Biomathematics II: Pattern Formation in Biological Systems 3 credits
Prerequisites: differential equations and linear algebra, or permission of the instructor. Emergence of spatial and temporal order in biological and ecological systems: Hopf and Turing bifurcation in reaction-diffusion systems, how do zebras get their stripes, patterns on snake skins and butterfly wings, spatial organization in the visual cortex, symmetry breaking in hormonal interactions, how do the ovaries count. Basic techniques of mathematics are introduced and applied to significant biological phenomena that cannot be fully understood without their use.

Math 675
Partial Differential Equations 3 credits
Prerequisite: Math 690 or equivalent. A survey of the mathematical theory of partial differential equations: first order equations, classification of second order equations, the Cauchy-Kovalevsky theorem, properties of harmonic functions, the Dirichlet principle. Initial and boundary value problems for hyperbolic, elliptic, and parabolic equations. Systems of equations.

Math 676
Advanced Ordinary Differential Equations 3 credits
Prerequisites: undergraduate differential equations, linear algebra, and Math 545 or equivalent. A rigorous treatment of the theory of systems of differential equations: existence and uniqueness of solutions, dependence on initial conditions and parameters. Linear systems, stability, and asymptotic behavior of solutions. Nonlinear systems, perturbation of periodic solutions, and geometric theory of systems of ODEs.

Math 677
Calculus of Variations 3 credits
Prerequisite: Math 676 or equivalent. Necessary conditions for existence of extrema. Variation of a functional, Euler's equation, constrained extrema, first integrals, Hamilton-Jacobi equation, quadratic functionals. Sufficient conditions for the existence of extrema. Applications to mechanics.

Math 683
Functional Analysis 3 credits
Prerequisite: Math 645 or equivalent. Principles of linear analysis: Hahn-Banach, uniform boundedness and closed graph theorems. Riesz representation theorem; weak topologies; Riesz theory of compact operators. Spectral theory of operators on Hilbert space. Applications to differential and integral equations.

Math 685
Combinatorics 3 credits
Prerequisite: Math 545 or equivalent. Generating functions, principle of inclusion-exclusion, pigeonhole principle, partitions. Polya's theory of counting, graph theory and applications.

Math 687
Quantitative Analysis for Environmental Design Research 3 credits
Prerequisites: college level statistics course and permission of instructor. Fundamental concepts in the theory of probability and statistics including descriptive data analysis, inferential statistics, sampling theory, linear regression and correlation, and analysis of variance. Also includes an introduction to linear programming and nonlinear models concluding with some discussion of optimization theory.

Math 689
Advanced Applied Mathematics II: ODEs 3 credits
Prerequisites: Math 545 and Math 631, or equivalent. A practical and theoretical treatment of boundary value problems for ordinary differential equations: generalized functions, Green's functions, spectral theory, variational principles, and allied numerical procedures. Examples will be drawn from applications in science and engineering.

Math 690
Advanced Applied Mathematics III: PDEs 3 credits
Prerequisite: Math 689 or equivalent. A practical and theoretical treatment of initial and boundary value problems for partial differential equations: Green's functions, spectral theory, variational principles, transform methods, and allied numerical procedures. Examples will be drawn from applications in science and engineering.

Math 691
Stochastic Processes with Applications 3 credits
Prerequisite: Math 662 or equivalent. Renewal theory, renewal reward processes and applications. Homogeneous, non-homogeneous and compound Poisson processes with illustrative applications. Introduction to Markov chains in discrete and continuous time with selected applications.

Math 698
Sampling Theory 3 credits
Prerequisite: Math 662 or equivalent. Role of sample surveys. Sampling from finite populations. Sampling designs, the Horowitz-Thompson estimator of the population mean. Different sampling methods, simple random sampling, stratified sampling, ratio and regression estimates, cluster sampling, systematic sampling.

Math 699
Design and Analysis of Experiments 3 credits
Prerequisite: Math 662 or equivalent. Statistically designed experiments and their importance in data analysis, industrial experiments. Role of randomization. Fixed and random effect models and ANOVA, block design, latin square design, factorial and fractional factorial designs and their analysis.

Math 700
Master's Project 3 credits
Prerequisites: matriculation for the master's degree and departmental approval. Work must be initiated with the approval of a faculty member, who will be the student's project advisor. Work of sufficient quality may qualify for extension into a master's thesis, see Math 701.

Math 701
Master's Thesis 6 credits
Prerequisite: matriculation for the master's degree and departmental approval. Students must register for a minimum of 3 credits per semester until completion. The work is carried out under the supervision of a designated member of the faculty.

Math 707
Advanced Applied Mathematics IV: Special Topics 3 credits
Prerequisite: permission of the instructor. A current research topic of interest to departmental faculty. Typical topics include: computational fluid dynamics, theoretical fluid dynamics, acoustics, wave propagation, dynamical systems, numerical analysis and scientific computation, theoretical and numerical aspects of combustion, and various topics in statistics.

Math 710
Graduate Research Methods 3 credits
Prerequisite: Math 614, Math 671, Math 690. Acquaints second-year graduate students with the techniques and vocabulary of a field in applied mathematics. Each student contacts a designated faculty member and gives several basic papers or books on a research topic of current interest. The student prepares two lectures on his/her topic to be given at the end of the semester. A sample list of active fields of research includes acoustics, electromagnetic theory, elasticity, fluid dynamics, combustion and biomathematics.

Math 711
Logic and Set Theory 3 credits
Prerequisite: permission of the instructor. Propositional calculus, predicate calculus, first-order theories and concepts of consistency, completeness and decidability. Theorems of Church, Kleene, Godel, Mostowski and Turing. Axiomatic set theory according to von Neumann, Bernays, Godel, and others. Recursive functions, effective computability and Turing machines.

Math 712
Numerical Methods II 3 credits
Prerequisites: Math 614 and introductory partial differential equations, or equivalent. Numerical methods for the solution of initial and boundary value problems for partial differential equations, with emphasis on finite difference methods. Consistency, stability, convergence, and implementation are considered.

Math 720
Tensor Analysis 3 credits
Prerequisite: permission of the instructor. Review of vector analysis in general curvilinear coordinates. Algebra and differential calculus of tensors. Applications to differential geometry, analytical mechanics and mechanics of continuous media. The choice of applications will be determined by the interests of the class.

Math 730
Applied Algebra 3 credits
Prerequisite: Math 631 or equivalent. An introduction to groups, rings, fields and their applications in science and engineering. Topics that are usually emphasized include permutation groups, cyclic groups, polynomial algebras and finite fields.

Math 745
Analysis II 3 credits
Prerequisite: Math 645 or equivalent. Lebesgue measure and integration, including the Lebesgue dominated convergence theorem and Riesz-Fischer theorem. Elements of Hilbert spaces and Lp-spaces. Fourier series and harmonic analysis. Multivariate calculus.

Math 756
Complex Variables II 3 credits
Prerequisite: Math 656 or equivalent. Selected topics from: conformal mapping and applications of the Schwarz-Christoffel transformation; applications of calculus of residues; singularities, principle of the argument, Rouch's theorem, Mittag-Lefler's theorem, Casorati-Weierstrass theorem; analytic continuation and applications, Schwarz reflection principle, monodromy theorem, Wiener-Hopf technique; asymptotic expansion of integrals; integral transform techniques; special functions.

Math 761
Statistical Reliability Theory and Applications 3 credits
Prerequisite: Math 662 or permission of instructor. Survival distributions, failure rate and hazard functions, residual life. Common parametric families used in modeling life data. Introduction to nonparametric aging classes. Coherent structures, fault tree analysis, redundancy and standby systems, system availability, repairable systems, selected applications such as software reliability.

Math 762
Statistical Inference 3 credits
Prerequisite: Math 662 or permission of instructor. Review of sampling distributions. Data reduction principles : sufficiency and likelihood. Theory and methods of point estimation and hypothesis testing, interval estimation, nonparametric tests, introduction to linear models.

Math 771
Asymptotic Methods II 3 credits
Prerequisite: Math 671 or equivalent. Continuation of Math 671. Asymptotic methods for the solution of PDEs, including: matched asymptotic expansions, multiple scales, the WKB method or geometrical optics, and near-field far-field expansions. Applications to elliptic, parabolic, and hyperbolic problems. Further topics in the asymptotic expansion of integrals and the WKB method. Emphasis on examples drawn from applications in science and engineering.

Math 790
Doctoral Dissertation Credits as designated
Prerequisite: passage of the doctoral qualifying examination. A minimum of 36 credits is required of all candidates for the Ph.D. degree. Registration between a minimum of 6 credits per semester and a maximum of 12 credits per semester is determined by a designated dissertation advisor. When 36 credits are reached, students must continue to register for 3 credits each semester until degree completion.

Math 791
Graduate Seminar 1 credit
Required each semester of all doctoral students and master's students receiving departmental or research-based awards.

Math 792
Pre-Doctoral Research 3 credits
Prerequisite: departmental approval. For students admitted to the program leading to the degree of Ph.D. in the mathematical sciences. Research is performed under the supervision of a designated faculty member. If the work culminates in doctoral research in the same area, up to 6 credits may be counted toward Math 790. See Math 790.

Mechanical Engineering

Offered by the Department of Mechanical Engineering

ME 590
Graduate Co-op Work Experience I
3 additive credits
Prerequisites: permission from Department of Mechanical Engineering and Division of Career Development Services. Cooperative education internship providing on-the-job reinforcement of academic programs in mechanical engineering. Work assignments and projects are developed by the co-op office in consultation with the mechanical engineering department. Work assignments are related to student's major and are evaluated by faculty coordinators in mechanical engineering. Course cannot be used for mechanical engineering degree credit.

ME 591
Graduate Co-op Work Experience II
3 additive credits
Prerequisites: permission from Department of Mechanical Engineering and Division of Career Development Services. Course cannot be used for mechanical engineering degree credit.

ME 592
Graduate Co-op Work Experience III
3 additive credits
Prerequisites: permission from Department of Mechanical Engineering and Division of Career Development Services. Course cannot be used for mechanical engineering degree credit.

ME 607
Advanced Thermodynamics 3 credits
Prerequisite: undergraduate thermodynamics. Basic laws of thermodynamics are applied to various thermodynamic systems. Topics include: availability, stability requirements, equation of state, property relations, properties of homogeneous mixtures, optimization applied to power generation and refrigeration cycles, and thermodynamic design of system components.

ME 608
Non-Equilibrium Thermodynamics 3 credits
Prerequisites: undergraduate thermodynamics and heat transfer, and ME 616. (May be taken concurrently.) Principles and mathematical techniques of non-equilibrium thermodynamics applied to mechanical engineering problems. Topics include field theory, energy and entropy balances, variational principles, and applications to fluid flow, heat exchangers and combustion.

ME 609
Dynamics of Compressible Fluids 3 credits
Prerequisites: undergraduate differential equations, fluid mechanics, and thermodynamics. One-dimensional reversible and irreversible compressible fluid flow, including effects of variable area, friction, mass addition, heat addition, and normal shock; two-dimensional reversible subsonic and supersonic flows, and an introduction to the method of characteristics and two-dimensional oblique shock.

ME 610
Applied Heat Transfer 3 credits
Prerequisites: undegraduate fluid mechanics, heat transfer, and ME 616. (May be taken concurrently.) Fundamentals of conduction, convection and radiation heat transfer. Practical engineering applications of heat exchangers including the design approaches by Mean Temperature Difference and Effectiveness-NTU methods, fins, convection fouling factors, and variable property analysis.

ME 611
Dynamics of Incompressible Fluids
3 credits
Prerequisites: undergraduate fluid mechanics and ME 616. (May be taken concurrently.) An introduction to the hydrodynamics of ideal fluids; two-dimensional potential flow and stream functions; conformal mapping; and differential equations of viscous flow. Boundary layer theory and dimensional analysis are introduced.

ME 612
Gas Dynamics 3 credits
Prerequisite: ME 616. (May be taken concurrently.) Physical phenomena of gas dynamics and mathematical methods and techniques needed for analysis. Dynamic and thermodynamic relations for common flow situations are described through vector calculus. The

nonlinearity of resulting equations and solutions such as numerical analysis, linearization or small perturbation theory, transformation of variables, and successive approximations are discussed. The method of characteristics is reviewed in detail for shock flows.

ME 613
Radiation Heat Transfer 3 credits
Prerequisites: undergraduate differential equations, thermodynamics, heat transfer and ME 616. (May be taken concurrently.) Heat radiation of solid bodies, gases and flames; angle factors; radiative properties of electrical conductors and non-conductors; application of radiative networks to multi-body problems; diffuse specular reflectors: artificial satellites and space vehicles; analogy between heat transfer by radiation and electrical networks; and combined conduction and radiation problems.

ME 615
Advanced Mechanical Vibrations 3 credits
Prerequisites: differential equations and ME 616. (May be taken concurrently.) One-, Two- and Multiple degree of freedom systems, Lagrange's equation of motion, Runge-Kutta computation, Finite Element Method and classical methods for normal mode analysis, matrix notation and iteration procedure, and Fourier series representation for the solution of vibration problems.

ME 616
Matrix Methods in Mechanical Engineering 3 credits
Prerequisite: undergraduate differential equations. Applications of matrix algebra and matrix calculus to engineering analysis; matrix methods in solid and fluid mechanics; vibration, elasticity, viscous fluids, and heat transfer. Matrix theory is used to show the basic unity in engineering analysis.

ME 618
Selected Topics in Mechanical Engineering 3 credits
Prerequisite: departmental approval. Given when interest develops. Topics may include analysis and/or design of energy or mechanical systems of current interest to mechanical engineers.

ME 620
Stress Methods in Mechanical Design 3 credits
Prerequisites: undergraduate differential equations, strength of materials and ME 616. (May be taken concurrently.) Governing equations and solutions for analysis and design of structural and machine elements; appropriate boundary conditions to investigate pipes and rods subjected to shrink and force fits; rotating disks of uniform and variable thickness; beam and plate elements; and thermal stresses and stress concentrations in mechanical design.

ME 621
Energy Methods in Mechanical Design 3 credits
Prerequisites: undergraduate differential equations, strength of materials and ME 616. (May be taken concurrently.) Use of energy methods to design structural and machine elements. Includes approximate solutions for problems using conservation of energy and several variational approaches; the role of energy in failure criteria; combined loads; and the relationship of variational methods to the development of finite element solutions.

ME 622
Finite Element Methods in Mechanical Engineering 3 credits
Prerequisites: undergraduate differential equations, strength of materials and ME 616. (May be taken concurrently.) Using variational formulation and Ritz approximation, element equations for bar, beam, potential flow, heat transfer, torsion of a solid bar and plane elasticity problems are derived and solved with computer programs.

ME 624
Microlevel Modeling in Particle Technology 3 credits
Presents methodologies for analyzing the macroscopic properties of particulate systems in terms of the underlying microlevel processes. Significant components are the mathematical modeling of particulate systems at the microlevel, analytical and numerical methods for predicting macroscopic properties from microlevel models, and comparison of theoretical predictions with experimental results. Demonstrates the importance of the interaction of these three components in the scientific process. The first part concerns the flow of dry particles where any interstitial fluid can be ignored. The second part considers the flow of particles suspended in an interstitial fluid. Also includes a class project involving development of simulations. *Same as ChE 625.*

ME 625
Introduction to Robotics 3 credits
Prerequisites: undergraduate differential equations, kinematics and demonstrated competence in computer programming and ME 616. (May be taken concurrently.) Introduction to robotics, and computer-controlled programmable robotic manipulators; robot geometries; kinematics of manipulators; differential motion; work space planning and trajectory control; dynamics; robot sensing, and robot programming.

ME 628
Machine Vision Principles and Applications 3 credits
Prerequisites: undergraduate differential equations and demonstrated competence in computer programming. Fundamentals of machine vision as applied to inspection, recognition, and guidance in mechanical and manufacturing processes. Emphasis on real-time machine vision algorithms for machine parts inspection and identification. Topics include lighting and optics, camera selection and calibration, image segmentation, edge detection, feature extraction, and pattern classification.

ME 630
Analytical Methods in Machine Design 3 credits
Prerequisites: undergraduate differential equations, machine design, and ME 616. (May be taken concurrently.) Theory and analytical methods used in machine design. Comparisons are made between approximate and exact engineering methods for evaluation of the range of applicability of solutions. Topics include advanced analysis of threaded members; keyed, splined, and shrink fits when subjected to torque; preloaded bearings; surging, presetting and buckling of coiled springs; and accurate analysis of impact stresses and stresses beyond the yield point.

ME 631
Bearings and Bearing Lubrication 3 credits
Prerequisites: undergraduate differential equations, machine design and ME 616. (May be taken concurrently.) The theoretical and physical aspects of lubrication: hydrostatic and hydrodynamic problems. Reynold's differential equation for pressure distribution applied to slider bearing and journal bearing problems with and without end leakage.

ME 633
Dynamics of Machinery 3 credits
Prerequisites: undergraduate differential equations and matrix analysis. Consideration of kinematics, constraints and Jacobians, linear and angular momentum and potential energy and conservative forces of mechanical systems. Application of principle of virtual work, D'Alembert's principle, method of virtual power and Lagrange's equation to systems of particles and systems of rigid bodies.

ME 635
Computer-Aided Design 3 credits
Prerequisites: demonstrated competence in computer programming, ME 616 or equivalent and ME 622. (ME 622 may be taken concurrently.) Adaptation of computer for solving engineering design problems; design morphology; simulation and modeling; algorithms; problem-oriented languages; use of available software; computer graphics, and automated design.

ME 636
Mechanism Design: Analysis and Synthesis 3 credits
Prerequisites: undergraduate kinematics, dynamics and demonstrated competence in computer programming and ME 616. (May be taken concurrently.) Kinematic principles combined with computer-assisted methods for designing mechanisms; complex polar notation; and dynamic and kinetostatic analysis of mechanisms. Kinematic synthesis of planar mechanisms; graphical Burmester theory for plane linkage synthesis; and planar linkage synthesis for function and path generation.

ME 637
Kinematics of Spatial Mechanisms 3 credits
Prerequisites: undergraduate kinematics, dynamics, knowledge of matrices and ME 616. (May be taken concurrently.) Advanced techniques for the dual-number coordinate-transformation matrix modeling to perform the displacement, velocity, static and dynamic force analysis of spatial mechanisms. Applications considered will include shaft couplings, skew four-bars, wobble plates, generalized slider-cranks and robotic manipulators.

ME 638
Computer-Aided Machining 3 credits
Prerequisites: demonstrated competence in computer programming, ME 305, ME 616 and ME 635 or equivalent. Introduction of computer applications to understand integrated

computer-aided machining process. Included in the course are the fundamentals of motion control and NC/CNC/DNC machining, part programming and post-processors, and advances in CAM. Student projects are carried out using appropriate manufacturing software.

ME 641
Refrigeration and Air Conditioning 3 credits
Prerequisites: undergraduate differential equations, fluid mechanics and thermodynamics. Refrigeration and air conditioning cycles; comfort analysis, psychometric chart analysis, heat and mass transfer steady and transient processes, heating and cooling design loads, energy loads and standards requirements.

ME 644
Building Environmental Control Principles 3 credits
Prerequisites: undergraduate thermodynamics, fluid mechanics, heat transfer and differential equations. Control systems for buildings including control of temperature, moisture and air quality. Optimization of systems for control of building energy use. Modern microprocessor-based control systems, including direct digital control, proportional and integral controllers, predictive control, adaptive control, optimum start controllers and optimal control.

ME 653
Control of Electro-Mechanical Networks 3 credits
Prerequisites: undergraduate electrical circuits and mechanical vibrations or equivalent. Electro-mechanical systems; control loops; use of mechanical networks in dynamic systems; and stability and response to various inputs in electro-mechanical networks.

ME 655
Introduction to Modern Control Methods 3 credits
Prerequisites: undergraduate system dynamics and automatic controls. Introduction to modern control methods applied to mechanical and manufacturing systems. Topics include state variable feedback, observer theory, nonlinear control, optimal control, and adaptive control for both continuous and discrete systems.

ME 660
Noise Control 3 credits
Prerequisites: undergraduate differential equations and physics. Engineering methods for reducing noise pollution; reduction of intensity at the source; limitation of transmission paths and absorption; application to structures, machinery, ground transportation, aircraft, and noise measurement.

ME 664
Experiments and Simulations in Particle Technology 3 credits
Prerequisites: gradute standing and consent of the instructor. Covers a particle size analysis using sieves as well as laser diffraction technique, size reduction with ball mill, measurement of powder flow properties and internal angle of friction, measurement of angle of repose, design of mass flow hoppers using Jenike direct shear tester, measurement of minimum sintering temperature of powders, particle sedimentation, powder mixing, dry particle coating, and fluidized beds. Simulations involve various dry and fluid based particle systems, focusing on particle-particle and fluid-particle interactions. *Same as ChE 664.*

ME 670
Introduction to Biomechanical Engineering 3 credits
Prerequisites: undergraduate thermodynamics, statics, and dynamics. Introduction to biomechanical engineering of physiological systems; fluid flow, structural, motion, transport, and material aspects; energy balance of the body, and the overall interaction of the body with the environment.

ME 671
Biomechanics of Human Structure and Motion 3 credits
Prerequisites: undergraduate statics, kinematics, and dynamics. Principles of engineering mechanics and materials science applied to human structural and kinematic systems and to the design of prosthetic devices. Topics include anatomy; human force systems; human motion; bioengineering materials; and design of implants, supports, braces, and replacements limbs.

ME 672
Biomaterials-Characterization 3 credits
Prerequisites: mechanics of materials, principles of materials science and engineering. Engineering physiology, stress analysis and mechanical laboratory. Fundamental concepts on the methods and rationales used in characterization of metal, ceramic, polymeric, and biologic materials used in biomedical implant fabrication including survey of various techniques and engineering design aspects on biomaterials.

ME 675
Mechanics of Fiber Composites 3 credits
Prerequisites: ME 315 (see undergraduate catalog for course description) and demonstrated competence in computer programming. Introduces various design problems using fiber composites. Analysis of general fiber composite laminate and short fiber composites, fracture mechanics, fatigue, creep and viscoelasticity, thermal stresses, special layups and associated optimization problems.

ME 676
Applied Plasticity 3 credits
Prerequisite: ME 620 or equivalent. Fundamentals of plasticity applied to mechanical and manufacturing engineering problems. Topics include elastic-plastic analysis for beams, rings and plates. Plastic instability and slip-line fields are considered.

ME 678
Engineering Design of Plastic Products 3 credits
Prerequisite: ME 316 (see undergraduate catalog for description) or equivalent. Structure and properties of plastics including stress-strain behavior and the effect of fillers and reinforcements. Designing for impact, flexure, shear, friction, puncture, creep and fatigue. Case studies of structural, electrical, and optical applications.

ME 679
Polymer Processing Techniques 3 credits
Prerequisites: undergraduate courses in fluid dynamics and heat transfer. Techniques for processing of plastics: extrusion, injection molding, compression molding, thermoforming, casting.

ME 680
Polymer Processing Equipment 3 credits
Prerequisites: ChE 645 or equivalent and undergraduate heat transfer. Application of heat transfer, fluid mechanics, and thermodynamics to the design and control of polymer processing equipment. Detailed consideration of extrusion, collandering, rotational molding, stamping, and injection molding.

ME 700
Master's Project 3 credits
Prerequisite: department approval. An extensive paper involving design, construction, and analysis, or theoretical investigation. Further information may be obtained from the graduate advisor.

ME 701
Master's Thesis 6 credits
Prerequisite: department approval. Projects involving design, construction, experimental, or theoretical investigation carried out under the supervision of a designated member of the mechanical engineering faculty. The completed written thesis must be defended in a publicly announced oral defense. A student must register for a minimum of 3 credits per semester until completion, although degree credit will be limited to the 6 credits indicated for the thesis.

ME 710
Conduction Heat Transfer 3 credits
Prerequisite: ME 610 and ME 616 or equivalent. Heat transfer by conduction: differential and integral forms of the energy equation for isotropic and anisotropic material. Analytical and numerical studies of transient and steady one-, two-, and three-dimensional heat transfer problems for a variety of boundary conditions including phase change. In addition, variational and boundary element methods are applied to heat conduction problems.

ME 711
Convection Heat Transfer 3 credits
Prerequisites: ME 610 and ME 616 or equivalent. Development of convective heat transfer theory: currently available methods, analytical and numerical, for predicting heat rates in forced, natural, and mixed convection in laminar and turbulent flow regimes are thoroughly studied. Studied techniques are applied to the thermal design of complex systems.

ME 712
Mechanics of Viscous Fluids 3 credits
Prerequisite: ME 611 and ME 616. (May be taken concurrently.) Properties and behavior of real fluids in laminar and turbulent motion. Review of tensor analysis; current mathematical and empirical laws and methods; flows in ducts; exact solutions of Navier-Stokes equations; boundary layers over surfaces and flow past bodies.

ME 713*
Non-Newtonian Fluid Dynamics 3 credits
Prerequisites: ME 611 and ME 616. Properties and behavior of non-Newtonian fluids. Topics include discussion on experimental methods used to quantify flow behavior, and continuum and micromechanical modeling for non-Newtonian flows; constitutive equations and their solutions.

ME 717
Selected Topics in Mechanical Engineering I 3 credits
Prerequisite: department approval. Given when interest develops. Topics may include advanced mechanisms, aerodynamics, analysis of ME systems, design optimization, and case studies in design.

ME 721
Thermal Stresses 3 credits
Prerequisites: vector analysis or ME 616 or equivalent and theory of elasticity or ME 785. Thermoelasticity; reduction of thermoelastic problems to constant temperature equivalents; fundamentals of heat transfer; and elastic and inelastic stress analysis.

ME 725, ME 726, ME 727
Independent Study I, II, III 3 credits
Prerequisites: written permission from department chairperson plus prerequisite courses prescribed by a supervising faculty member. Areas of study in which one or more students may be interested but which is not of sufficiently broad interest to warrant a regular course offering. A maximum of two independent studies courses may be applied to a degree.

ME 734
Analysis and Synthesis for Design 3 credits
Prerequisites: ME 616 and ME 620 or ME 610. Fundamental concepts of advanced mathematics and their application to analysis and synthesis of mechanics, electricity, thermodynamics, fluid mechanics, and heat transfer systems and their components.

ME 735
Advanced Topics in Robotics 3 credits
Prerequisite: ME 625. Introduction to advanced topics and techniques in robotics. Subjects covered include differential kinematics, calibration and accuracy, trajectory control, and compliant motion control as well as an in-depth treatment of topics discussed in ME 625.

ME 736
Advanced Mechanism Design 3 credits
Prerequisite: ME 636 and ME 616. Advanced methods for the synthesis of mechanisms. Topics include synthesis of planar mechanisms for three, four and five positions, multiloop linages, change of branch and order problems, and optimal synthesis of mechanisms. Synthesis of linkages for special types of motion including straight line motion, cusp points on coupler curves and adjustable mechanisms.

*pending

ME 752
Design of Plates and Shells 3 credits
Prerequisites: ME 616 or equivalent and ME 620. A study of plates and shells. Mechanical engineering design solutions for typical loading and boundary conditions through analytical and numerical methods. Plate and shell interfaces and vibration are also considered.

ME 754
Pressure Vessel Design 3 credits
Prerequisites: ME 616 or equivalent and ME 620. Theories in designing pressure vessels; analysis of circular plates; cylindrical and spherical shells; pressure vessel heads; pipe bends; and attachments. Consideration is also given to pressure vessel materials in fatigue and creep designs.

ME 755
Adaptive Control Systems 3 credits
Prerequisite: ME 655. Theory and application of self-tuning and model reference adaptive control for continuous and discrete-time deterministic systems. Topics include model-based methods for estimation and control, stability of nonlinear systems and adaptive laws. Applications of adaptive control in mechanical systems and manufacturing processes.

ME 776
Dynamics of Polymeric Liquids 3 credits
Prerequisites: ME 610 and ME 611. An advanced course in fluid dynamics which concentrates on the behavior of polymeric liquids. Topics include constitutive equations of polymeric liquids, fluid dynamics of rheometry and kinetic theory of polymeric fluid dynamics.

ME 785
Theory of Deformable Solids in Mechanical Engineering I 3 credits
Prerequisites: ME 616 or equivalent and ME 620. Measure of strain; strain tensor; stress tensor; equilibrium equations; constitutive relations; compatibility conditions; conditions for and formulation of three-dimensional problems; and the relationship of engineering theories for beams, plates, and shells to the equations of elasticity.

ME 786
Theory of Deformable Solids in Mechanical Engineering II 3 credits
Prerequisite: ME 785. Solutions for problems formulated in ME 785: eigenfunction solutions; operational methods; complex variables theory; three-dimensional problems; contact problems; wave propagation; and non-linear problems.

ME 790
Doctoral Dissertation Credits as designated
Required of all students working toward the Doctor of Philosophy in Mechanical Engineering. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester until 36 credits are reached and for 3 credits each semester thereafter.

ME 792
Pre-Doctoral Research 3 credits
Prerequisite: permission of department chairperson. For students admitted to the doctor of philosophy program in mechanical engineering who have not yet passed the qualifying examination. Research is carried out under the supervision of designated mechanical engineering faculty. If the student's research activity culminates in doctoral research in the same area, up to a maximum of 6 credits may be applied toward the 36 credits required under ME 790.

ME 794
Mechanical Engineering Colloquium
Non-credit
Prerequisite: graduate standing and major in mechanical engineering. National and international experts in mechanical engineering discuss their recent research. Required of all students enrolled in mechanical engineering graduate degree programs. Students must register in this course for at least two semesters and attend at least four lectures in each semester. All doctoral students and students with assistantships must register in this course each semester and attend regularly.

Mechanics

Offered by the Department of Civil and Environmental Engineering

Mech 540
Advanced Strength of Materials 3 credits
Prerequisite: mechanics of deformable bodies. Topics beyond the scope of elementary mechanics of deformable bodies are studied with particular emphasis on the assumptions, limitations, and applications to actual problems.

Mech 630
Theory of Elasticity 3 credits
Prerequisite: differential equations. Theory of elasticity as basis for both advanced stress analysis and for a critical examination of elementary stress analysis.

Nursing

Offered by the College of Nursing at Rutgers-Newark

26:705:504
Human Diversity and Social Issues in the Community 3 credits
Advanced nursing practice examined from epidemiological perspective in the context of cultural and social pluralism. Emphasis on multiple dimensions of human diversity with identification and assessment of vulnerable and undeserved populations and ethical issues.

26:705:534
Community Health Nursing Theory II
3 credits
Prerequisites: 26:705:524, 525. Advanced specialized knowledge relevant to the design, implementation, and evaluation of programs that address health promotion and prevention in populations, groups, and the individual/family in the community examined. Focus on planning, implementation, evaluation of programs, and services.

Occupational Safety and Industrial Hygiene

Offered by the Department of Chemical Engineering, Chemistry and Environmental Science

OSIH 601
Environmental, Safety and Health Program Management 3 credits
Prerequisite: graduate standing or permission of the instructor. For students in the occupational safety and industrial hygiene master's program and other students enrolled in environmental and safety programs. Considers various management techniques, roles, history, program elements and current trends in environmental, safety and health, in industrial and governmental settings.

OSIH 602
Worker Compensation and Risk Management 3 credits
Prerequisite: graduate standing or permission of the instructor. For students majoring in the OSIH master's program, and other students enrolled in environmental and safety programs. Considers worker compensation and risk management in industrial and government settings.

OSIH 603
Transportation of Hazardous Materials
3 credits
Prerequisite: graduate standing or permission of the instructor. Considers regulatory compliance, basic knowledge of hazard identification, controls, safety management principles, and regulations for the transportation industry.

OSIH 604
Construction Safety 3 credits
Prerequisite: graduate standing or permission of the instructor. Considers regulatory compliance, basic knowledge of hazard identification, controls, safety management principles, and regulations for the construction industry. Satisfies OSHA 30-Hour Construction Safety and Health Certification.

OSIH 605
Principles of Radiation Safety 3 credits
Prerequisite: graduate standing or permission of the instructor. Considers the principles of radiation safety, recognition, evaluation, and control of routine radiation sources in the workplace. Topics include, radioactivity, interactions with matter, radiation dosimetry, biological effects, instrumentation, non-ionizing radiation safety, laser safety, X-ray machine safety, and regulatory requirements.

OSIH 606
Health Care/Hospital Health and Safety
3 credits
Prerequisite: graduate standing or permission of the instructor. Provides understanding of the health care environment and its potential hazards. Covers standards of the Joint Commission for Accreditation of Healthcare Organizations (JCAHO), College of American Pathologies (CAP) requirements, and applicable OSHA standards.

OSIH 607
Industrial Issues in Occupational Safety and Industrial Hygiene 3 credits
Prerequisite: graduate standing or permission of the instructor. A series of lectures by experts from the private sector, in areas such as worker compensation, electrical safety, occupational medical services, and risk management.

OSIH 608
Safety Training Program Development
3 credits
Prerequisite: graduate standing or permission of the instructor. Evaluating and identifying training program needs, and reviewing critical safety training elements using 29 CFR 1910. Experience in outlining, organizing and presenting safety programs.

OSIH 609
Food Process Safety and Clean Design
3 credits
Prerequisite: graduate standing or permission of the instructor. Introduction to FDA requirements for food safety and process system control.

OSIH 610
Sampling and Testing Methods for Industrial Hygiene I 3 credits
Prerequisites: graduate standing or permission of the instructor. Introduction and familiarization with methods to test and sample the workplace environment. Industrial hygiene equipment is used.

OSIH 611
Sampling and Testing Methods for Industrial Hygiene II 3 credits
Prerequisite: graduate standing or permission of the instructor. Continuation of OSIH 610.

OSIH 612
Fundamentals of Controls 3 credits
Prerequisite: graduate standing in OSIH program or equivalent. Introduction for non-engineering students to the fundamentals of control technologies for mitigation of air and workplace exposures (focusing on ventilation), noise and vibration, electrical hazards, and fire protection.

OSIH 698
Special Topics in Occupational Safety and Industrial Hygiene 3 credits
Prerequisite: graduate standing or permission of the instructor. Topics of current interest in occupational safety and industrial hygiene.

OSIH 700
Master's Project 3 credits
Prerequisite: matriculation for the master's degree. An extensive report involving an experimental, theoretical, or literature investigation is required. The literature investigation should result in a critical review of a specific area. Approval to register for the master's project must be obtained from the project advisor. Students must continue to register for at least 3 credits every semester until the project is completed and a written report is accepted. Only a total of 3 credits will count toward the degree.

OSIH 725
Independent Study 3 credits
Prerequisites: written permission from the associate chairperson for environmental science and courses prescribed by the supervising faculty member. Covers areas of study in which one or more students may be interested, but which are not sufficiently broad to warrant a regular course offering. Students may not register for this course more than once with the same supervising faculty member.

Operations Management

Offered by the Department of Management at Rutgers-Newark

26:711:585
Control Models 3 credits
Project control scheduling theory as it relates to the control function, manpower scheduling. Discusses model formulation, solution techniques, and system dynamics. Applies model formulation and computer simulation to dynamic systems.

Optical Science and Engineering

Offered by the Federated Physics Departments of NJIT and Rutgers-Newark

OPSE 601
Advanced Topics in Optical Science and Engineering 3 credits
In small groups or as an individual, students conduct three complete research experiments in the available topics of interest, from preliminary background research through data analysis. Use of modern optical research tools under close guidance of faculty and associated research team members in the faculty member's lab.

Physics

Offered by the Federated Physics Departments of NJIT and Rutgers-Newark

Phys 601
Mechanics I 3 credits
Concepts and basic methods for the treatment of equilibrium and accelerated motion; Newton's Laws and the Free Body Diagram applied to problems in statics and dynamics; vectors, vector quantities, and their application in mechanics.

Phys 602
Mechanics II 3 credits
Prerequisite: Phys 601 or equivalent. Laws of conservation of energy and conservation of momentum in work and energy, power, impulse and momentum, collisions, recoil, and rocket propulsion. Angular motion, torque, moment of inertia, work and energy in rotational motion, and the application of Newton's laws and the law of conservation of angular momentum to problems in rotational dynamics are studied.

Phys 603
Electricity and Magnetism I 3 credits
Prerequisite: Phys 602 or equivalent. Electric charge, electric field, Gauss's law, electric potential, potential energy difference, current, resistance, and emf are studied. Also considers the law of conservation of charge and Kirchoff's laws, direct current circuits and instrumentation. Class includes demonstration lectures, related supervised computation problems, and recitations.

Phys 604
Electricity and Magnetism II 3 credits
Prerequisite: Phys 603 or equivalent. Magnetic field, force on moving charges, force on current-carrying conductor, and torque on a current-carrying coil; the Hall effect, magnetic field due to moving changes, induced emf, Faraday's and Lenz's laws, mutual and self-inductance, R-L, L-C, and R-L-C circuits, ferromagnetism and permanent magnets. Also considers alternating currents, circuits with resistance, inductance, and capacitance, average and RMS values, phasors, power, resonance, and transformers. Class includes demonstration lectures, supervised computation problems, and recitation.

Phys 607
Topics in Astronomy and Cosmology
3 credits
Prerequisites: college-level physics and mathematics. A survey of recent progress in astronomy, the physical principles involved, and the impact these new discoveries have on our understanding of the universe. Includes results from recent and ongoing planetary probes of our solar system, discovery of planetary systems around other stars, the evolution of stars, exotic objects such as neutron stars and black holes, the formation of galaxies, and current understanding of the birth and final fate of the universe. Observing sessions familiarize students with the sun, moon, and night sky.

Phys 611/26:755:611
Advanced Classical Mechanics 3 credits
Prerequisite: undergraduate advanced mechanics or equivalent. Newton's laws of motion; mechanics of a system of particles; D'Alembert's principle and Lagrange's equations; derivation of Lagrange's equations from variational principle; conservation theorems and symmetry properties; the Hamilton equations of motion; canonical transformation, Poisson brackets; Hamilton-Jacobi theory; the rigid body equations of motion; small oscillations.

Phys 621/26:755:621
Classical Electrodynamics 3 credits
Prerequisites: undergraduate electromagnetism and working knowledge of ordinary and partial differential equations, special functions, complex variable functions, and vector analysis. Electrostatics; magnetostatics; and boundary value problems; time-varying fields, Maxwell equations, conservation laws; plane and spherical electromagnetic waves; wave propogation in dielectric and conducting media; waveguides and resonant cavities.

Phys 631/26:755:631
Quantum Mechanics 3 credits
Prerequisite: Phys 611/26:755:611. Limits to classical physics; wave mechanics and the Schrodinger equation; uncertainty principle; eigenvalues and eigenfunctions of simple systems including quantum well, potential barrier, harmonic oscillator, and hydrogen atom; matrix mechanics, Hilbert space and operator method; approximation methods; scattering theory; time-dependent perturbation theory; quantization of electromagnetic radiation; quantum theory of angular momentum, spin.

Phys 641/26:755:641
Statistical Mechanics 3 credits
Prerequisite: Phys 631/26:755:631. Review of thermodynamic laws; ensemble theory; thermodynamic functions; classical ideal gas and imperfect gas; chemical reactions; Boltzmann, Bose-Einstein, and Fermi-Dirac statistics; quantum statistical theory of solids, magnetism and phase transitions.

Phys 651/26:755:651
Atomic and Molecular Physics 3 credits
Prerequisite: Phys 441 (see undergraduate catalog for description). Fundamentals of quantum mechanics; one-electron atoms; orbital angular momentum, spin, and total angular momentum; transition rates and selection rules; multi-electron atoms, LS coupling and JJ coupling; optical properties of atoms, the lasers; H2 molecules; molecular bonding; molecular spectra; the Raman effect.

Phys 654/26:755:654
Nuclear and Particle Physics 3 credits
Prerequisite: Phys 441 (see undergraduate catalog for description). Nuclear stability; saturation of nuclear forces; two nucleon potentials for finite nuclei, the deutron; nucleon-nucleon scattering; effective interactions; nuclear matter; models of nuclear structure; nuclear excitations; description of elementary particle phenomena; applications of scattering theory; conservation laws and symmetrical properties of interactions; structure of nucleons.

Phys 661/26:755:661
Solid-State Physics 3 credits
A brief review of basic concepts of quantum mechanics; free electron theories of metals; lattices in real and momentum space; electron levels in a periodic potential; the tight-binding method for calculating band structures; classification of solids; electrical and optical properties of semiconductors; cohesive energy; phonons; dielectric properties of insulators; magnetism; superconductivity.

Phys 667/26:755:667
Modern Experimental Techniques for Materials Processing and Characterization
3 credits
Prerequisite: Phys 441 (see undergraduate catalog for description) or equivalent. Bonding and material classification, phase transitions and phase diagrams, basic material structures and properties. Materials processing: various techniques for crystal growth and thin film fabrication. Materials modification: diffusion, ion implantation, and wet and dry etching. Materials and characterization: chemical and structural, electrical, optical and mechanical techniques.

Phys 671/26:755:671
Applied Optics 3 credits
Maxwell's theory, linear and elliptical polarized light, Fresnel's equations, electromagnetic waves in crystals, dielectric functions, optical constants. Ellipsometry, interference, amplitude and wavefront dividing interferometry, Fabry-Perot interferometer, modes in layered structures. Fraunhofer and Fresnel diffraction, spatial coherence, Zernike's theorem. Symmetric and asymmetric Fourier transform spectroscopy. Fourier optics, imaging with quasi-monochromatic and monochromatic light, holography. Scattering of light. Geometrical optics of thin and thick lenses, aberration. Radiometry, blackbody, synchrotron, and laser radiation. Radiometric quantities.

Phys 675/26:755:675
Cellular Biophysics 3 credits
Prerequisites: differential and integral calculus and introductory physics. Lecture and lab covers the basis for cell membrane voltages, both static and dynamic. Basic biochemistry pertinent to biological systems, bioelectricity of the cell membrane, electrophysiology, and relevant microscopy. Laboratory sessions include electronics, bioelectric measurements both in artificial and biological cells, and microscopy.

Phys 687/26:755:687
Physics of Materials 3 credits
Prerequisite: Phys 441 or equivalent (see undergraduate catalog for description). Fundamentals of quantum mechanics; energy bands in crystals; electrical conduction in metals and alloys, semiconductors; optical properties of materials; quantum mechanical treatment of optical properties; magnetic properties of materials; thermal properties, heat capacity, and thermal expansion in solids.

Phys 689/26:755:689
Simulations of Electronic Device Structures 3 credits
Prerequisite: EE 657 or equivalent. Extensive introduction to the modeling programs used to stimulate devices and the processes used to build them. Standard software such as SIMION (for electron optics and vacuum microelectronic device physics), SUPREM (for process modeling), PISCES (for device modeling), and ANSYSM and ANSYST (for finite element mechanical and thermal modeling) will be used. Each student will be assigned a final modeling project.

Phys 690/26:755:690
Directed Study of Applied Physics 3 credits
Directed study under the guidance of a physics faculty member on a topic of applied physics.

Phys 700/26:755:700
Master's Project 3 credits
Prerequisite: Written approval from graduate advisor. For students admitted to the Master of Science program in applied physics who do not take Phys 701/26:755:701 Master's Thesis. An extensive paper involving experimental or theoretical investigation of a topic in microelectronics or other applied physics area is required. Cooperative projects with industry or government agencies may be acceptable. The project is carried out under the supervision of a designated physics graduate faculty member.

Phys 701/26:755:701
Master's Thesis 6 credits
Prerequisite: written approval from graduate advisor. For students admitted to the Master of Science program in applied physics. Experimental or theoretical investigation of a topic in microelectronics or other applied physics area. The thesis is written under the supervision of a designated physics graduate faculty member. A paper based on the completed written thesis should be of sufficient merit to warrant publication in a scientific or technical journal. The student must register for a minimum of 3 credits per semester. Degree credit is limited to 6 credits indicated for the thesis.

Phys 721/26:755:721
Classical Electrodynamics II 3 credits
Prerequisites: Phys 621 or equivalent, and basic knowledge of tensor analysis. Simple radiating systems, scattering and diffraction; special theory of relativity; dynamics of relativistic particles and electromagnetic fields; collisions between charged particles, energy loss, and scattering; radiation from an accelerated charge, synchrotron radiation, and bremsstrahlung.

Phys 731/26:755:731
Quantum Mechanics II 3 credits
Prerequisite: Phys 631/26:755:631 or equivalent. Review of quantum mechanics and theory of special relativity; second quantization; relativistic one-particle problem: Klein-Gordon equation and Dirac equation; canonical field theory; relativistic scattering theory; introduction to quantum electrodynamics and quantum field theory; Feynman diagrams, and applications.

Phys 732/26:755:732
General Relativity and Gravitation 3 credits
Prerequisites: Phys 611/26:755:611, Phys 621/26:755:621, and Phys 631/26:755:631, or equivalents. Review of special relativity; principles of equivalence and the metric tensor; tensor analysis; effects of gravitation; Einstein's field equations; the Schwarzschild singularity; gravitational radiation and cosmology.

Phys 761/26:755:761
Solid-State Theory 3 credits
Prerequisite: Phys 661/26:755:661 or equivalent. Fundamentals of group theory; symmetry of solids; application of group theory in solid-state physics; density functional theory; the one-electron approximation and energy bands; thermodynamic and transport properties; pseudopotentials and other methods of band structure calculation; Fermi liquid theory, collective excitation and mean field theory of superconductivity and magnetism; lattice vibrations, the electron-phonon interaction, and the BCS theory of superconductivity.

Phys 762/26:755:762
Electronic Structure of Solids 3 credits
Prerequisite: Phys 631/26:755:631 or equivalent. Tight binding theory; bond orbitals and the electronic structure of covalent solids; universal tight-binding parameters and the prediction of the bonding and dielectric properties of semiconductors; ionic solids and the bonding and dielectric properties of insulators. Theory of silicon dioxide and related compounds and their properties; transition metals and their compounds.

Phys 763/26:755:763
Surface and Interface Physics 3 credits
Prerequisite: Phys 661/26:755:661 or equivalent. Introduction to UHV (Ultra High Vacuum) technique; clean surface preparation; surface symmetry and LEED (Low Energy Electron Diffraction); surface and interface electronic structure and electron spectroscopy; XPS, UPS, AES and ESCA; surface compositional and geometric structure and EXAFS; STM (Scanning Tunneling Microscopy) and STS (Scanning Tunneling Spectroscopy).

Phys 771/26:755:771
Quantum Electronics 3 credits
Prerequisites: Phys 631/26:755:631 and Phys 651/26:755:651, or equivalents. Physics of lasers and the interaction of radiation with matter. Semiclassical and quantum theory of the interaction of the laser with single and multiple electromagnetic fields, and with homogeneously and Doppler-broadened media.

Phys 772/26:755:772
Applied Plasma Physics 3 credits
Prerequisites: Phys 621/26:755:621 and Phys 631/26:755:631, or equivalents. Properties of ionized systems, electromagnetic interactions, experimental techniques and selected topics on discharges and thermonuclear plasmas.

Phys 773/26:755:773
Particle-Solid Interactions 3 credits
Prerequisites: Phys 631/26:755:631 and Phys 661/26:755:661, or equivalent. The particle-solid interactions that form the basis for ion implantation, sputter deposition, reactive ion etching, and other microelectronic processing technology. Ion beam interactions with solids and solid state materials and structures. Rutherford backscattering experiments, and ion channeling. Methods for observing defect distributions in materials, surfaces, and surface layer interfaces using ion scattering techniques.

Phys 774/26:755:774
Principles of Spectroscopy 3 credits
Prerequisites: Phys 651/26:755:651 and Phys 761/26:755:761, or equivalents. Theoretical and experimental principles of spectroscopy. Atomic absorption, emission, IR (infrared), Raman, fluorescence, NMR, X-ray spectroscopies. Fourier transformation techniques. Coherent and incoherent sources.

Phys 775/26:755:775
Electrical Properties of Polymers 3 credits
Prerequisite: Phys 631 or equivalent. The course is intended for graduate students in applied physics, chemical engineering, materials science, and electrical engineering. Topics include introduction to polymers, electronic properties of polymers, theory of dielectric conduction, dielectric properties of polymers, dielectric values, and experimental techniques.

Phys 780/26:755:780
Current Topics of Applied Physics 3 credits
Current research interests in applied physics. Emphasis is on research work related to microelectronics, optoelectronics, optical physics, materials science, surface science, free electron laser and solar physics.

Phys 781/26:755:781
Physics of Advanced Semiconductor Devices 3 credits
Prerequisites: Phys 687/26:755:687 and EE 657, or equivalents. Physical principles and operational characteristics of the most important semiconductor devices for advanced electronics systems that process data at rates higher than 1 Gb/s, or handle analog signals at frequencies above 1 GHz. Devices addressed include: submicron MOSFET, MESFET, heterostructure MESFET, heterostructure bipolar transistors, quantum-effect devices, microwave devices, and photonic devices.

Phys 787/26:755:787
Physics of Sensors and Actuators 3 credits
Prerequisites: EE 657 and Phys 687/26:755:687, or equivalents. Fundamentals of sensors: optical, thermal, chemical, mechanical and electrical. Study of noise, phase-sensitive detection and other low-level measurement techniques. Semiconductor surface microstructures, including temperature, pressure, strain, acceleration, humidity, mass flow, and gas sensors. Actuators, including micro-motors, microrobots, and other micro-mechanisms. Semiconductor vacuum microelectronic devices.

Phys 789/26:755:789
Physics of Advanced Semiconductor Device Processing 3 credits
Prerequisites: EE 657 and Phys 687/26:755:687, or equivalents. Intended for doctoral students in applied physics, electrical engineering, and materials science. Silicon and GaAs technologies: crystal growth methods, epitaxy, oxidation, lithography, dry and wet etching

techniques, polysilicon, diffusion, ion implantation, metallization (including silicidation), process integration, analytical characterization techniques, assembly and packaging, and yield and reliability.

Phys 790/26:755:790
Doctoral Dissertation
Credits as designated
Prerequisites: passing grade on departmental qualifying examination. Corequisite: Phys 791. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester until 36 credits are reached; 3 credits per semester are required thereafter. Registration for additional credits, a total of 12 per semester, is permitted with the approval of the department graduate advisor. Experimental or theoretical investigation of a topic in applied physics, including microelectronics, materials science, and laser physics. Research and writing are carried out under the supervision of a designated graduate faculty member. The completed written dissertation should be a substantial contribution to the knowledge of the topic under research, and should be of sufficient merit to warrant totally publication in a leading scientific or technical journal.

Phys 791/26:755:791
Applied Physics Seminar Non-credit
Departments of physics at NJIT and Rutgers-Newark joint seminar on research and current topics in microelectronics, materials science, laser physics and other applied physics areas.

Phys 792/26:755:792
Pre-Doctoral Research 3 credits
Prerequisites: permission of the department. For students enrolled in the Ph.D. program to perform research in one of the designated applied physics areas under the supervision of an applied physics graduate faculty. If the student's research activity culminates in doctoral research in the same area, a maximum of 6 credits may be applied toward the 36 credits required under Phys 790.

Political Science

Offered by the Department of Political Science at Rutgers-Newark

26:790:501
Policy Making in the American Political System 3 credits
Survey of political and governmental institutions and policy-making processes.

26:790:504
Comparative Public Policy 3 credits
Approaches to the study of policy making in different political systems. Includes case studies.

26:790:510
Public Policy Analysis 3 credits
Focuses on approaches to the analysis of the policy-making process and the evaluation of its outputs. Emphasis on the policy agenda-setting processes, the politics of problem definition, policy decision-making strategies, cost-benefit analysis, the problem of legitimation and political feasibility, policy implementation, experimental evaluation research, and the role of values in policy analysis. Special attention given to the integration of empirical and normative research in the analytical process.

26:790:512
Ethical Issues in Public Policy and Administration 3 credits
Consideration of selected ethical problems and dilemmas facing policymakers and public administrators. These include issues of conflict of interest, confidentiality, deception, official disobedience, whistle-blowing, record-keeping, and questions of distributive justice in health care and employment opportunities. Special attention given to conflicts between expedience and principle in policy-making and policy implementation. Readings in political theory and political ethics as well as cases and commentary.

26:790:516
Urban Public Policy 3 credits
Analysis of selected policy problems affecting urban areas.

26:790:537
Recent International Relations: Global Governance 3 credits
The organization of world politics and international cooperation beyond formal international organizations; emphasis on international regimes, institutions and norms; examination of non-governmental organizations (NGOs); epistemic communities and multilateral cooperation.

26:790:538
Recent International Relations: Global Environmental Issues 3 credits
Examines global environmental institutions and issues.

26:790:571
American Politics and Public Policy
3 credits
Impact of American politics upon public policy issues of contemporary relevance.

Public Administration

Offered by the Department of Public Administration at Rutgers-Newark

26:834:521
Technology and Public Administration
3 credits
Implications of computer hardware and software issues for public sector management, with particular emphasis on applications of microprocessors. Includes a survey of database management problems, control, resource allocation, communications, and networking issues. Laboratory exercises required.

26:834:523
Human Resources Administration 3 credits
Human resource administration in public and non-profit settings, including human resource planning, staffing, development, and compensation. Behavioral and environmental determinants are examined, including production technology, market factors, service delivery, and government regulations.

26:834:524
Strategic Planning and Management
3 credits
Strategic planning and management in the public and nonprofit sectors, including methods that facilitate the achievement of organizational goals in a changing environment. Attention is paid to forecasting, goal and objective setting, strategy building, and resource mobilization.

26:834:541
Political Economy and Public Administration
3 credits
Explores basic economic concepts and applies them to issues relevant to public administration, including microeconomic and macroeconomic problems as they impact the public and nonprofit sectors.

26:834:542
Government Budgeting Systems 3 credits
Budget concepts and processes used by the American governments and their administrative units. Provides essential skills and experience in budgetary analysis and management applicable to nonprofit as well as public sector agencies.

26:834:562
Policy and Program Assessment 3 credits
Examines research methodologies and techniques employed in policy and program assessment. Includes social indicators, quantitative and qualitative methods, and experimental and quasi-experimental designs as used in applied policy and program research.

26:834:582
Health Care Management 3 credits
Focuses on the major social and political issues involved in the organization, delivery, and management of health care systems.

26:834:584
Health Care Finance 3 credits
Processes and methods of financial management in the health care industry. Patterns of health-care expenditures, methods of financing health care, financial planning and development, third party reimbursement, and controls in health institutions management.

26:834:585
Health Care Policy 3 credits
Analysis, development, implementation, and evaluation of policies and programs affecting health. Focuses on health care institutions, with some attention to managing health problems with non-medical interventions at the community level. Uses the case method applied to realistic situations in which specific decisions must be made by health managers or officials.

26:834:586
Violence in the United States 3 credits
Life-cycle approach to violence, including violence against children; juvenile, domestic, male-male, and cultural violence. With each type of violence, examination of historical and empirical dimensions of the problem, current theories about dynamics and causality, and the likely efficacy of current and proposed interventions. Emphasis placed on class, racial, and gender inequalities.

26:834:602
Decision Making and Policy Analysis
3 credits
Logic, form, use, and critical assessment of decision making and policy analysis in public administration. Development of a practical yet critical perspective on policy analysis and its role in public administrative decision making and behavior.

Public Health

Offered by the Department of Humanities and Social Sciences

MPH 601
Introduction to Epidemiology 3 credits
Epidemiology and its uses. Occurrence, distribution and dynamic behavior of disease and public health problem in human population. Descriptive epidemiology, observation cross-sectional study, longitudinal study and analytic epidemiologic study. Principles and methods of epidemiologic investigation. Evaluate the efficacy of preventive and therapeutic modalities and of new pattern of health care delivery. Measurement and interpretion of the morbidity and mortality indices. Application of findings to public policy. Evaluating public policy.

MPH 602*
Introduction to Biostatistics 3 credits
Introduction to biostatistical concepts and methods utilizing a lecture format followed by computer laboratory sessions to apply statistical methods to problems commonly encountered by public health professionals.

MPH 603
Principles of Environmental Health 3 credits
Examines the environmental, occupational, residential factors and agents that have an impact on the health of people and the community. Structural and non-structural intervention to prevent, mitigate and minimize the impact as well as intervention benefits and limitations such as the role of biodiversity; ecological influences and impact; community perceptions; behavior impact; the role of culture, tradition and education; legal and regulatory remedies; government agencies; monitoring and technological interventions.

MPH 604
Introduction to Health Care Systems and Policy 3 credits
History, organization, financing and regulation of U.S. medical and public health services, particularly among under-served and urban populations. Social and behavioral factors that shape health and health services.

MPH 605*
Health Education and Public Health Issues
3 credits
Consists of five sessions on health education; one each on public health, history, ethics, nutrition and Newark health problems; and ten half sessions devoted to emerging infections, health promotion, aging, tuberculosis, malaria, sexually transmitted diseases, HIV/AIDS, alcohol and drugs, the genetic revolution, and violence.

*pending

MPH 644
Social Foundations of Urban Health
3 credits
Theory used to explain and predict individual and aggregate behavior from the operationalization standpoint. Theories from economics, psychology, sociology, social psychology and geography. Theories of rational and habitual behavior under certain and uncertain outcomes. Statistical models in the estimation of structural models. Simulations using Resampling Stats.

MPH 645
Society, Chronic Illness, and Disability: An Urban Perspective 3 credits
Extend and intensity of chronic illness and disability with emphasis on urban populations. Conduct functional status assessments. Prepare sickness impact profiles. Perform physical performance tests. Depression and costs of several forms of long term care.

MPH 646
Urban Child in a Global Perspective
3 credits
Protective, rehabilitative and preventive strategies addressing the failure to meet the survival, nurturing and participatory rights of children as specified in the U.N. Convention on the Rights of the Child, the UNICEF programs for children in especially difficult circumstances, and the human capability approach of Amartya Sen. Covers the social and economic conditions that affect the care taking arrangements for infants, young children and adolescents at one or more epochs of their physical and psychosocial development.

MPH 647
Perinatal Health and Family Planning
3 credits
Extent of perinatal health problems in the United States particularly inner city populations. Etiology including chemical and behavioral factors. Clinical specialists discuss current issues. Covers clinical solutions and public policy initiatives. Team project includes preparation and presentation of a major project.

MPH 648
Community and Environmental Approaches to Health Behavior Change in Urban Disadvantaged Populations 3 credits
Socio-environmental factors influencing health-related behavior, role of groups, institutions and social structures in encouraging healthy or unhealthy behavior. Intervention designed to improve health behavior through changes in the social environment; economic, social and political structures and practices creating barriers to effective interventions. Examples include environmental characteristics affecting alcohol and tobacco use, diet, and injury control.

MPH 650
Medical Geography 3 credits
Organization of society and the elaboration of disease; spatial vocabulary; geographic concepts related to disease distribution and adaptability; disease as an initiator of social and economic change in geographic constructs, economic development and population; contemporary health policy in the United States and its geographic influences and determinants.

MPH 660
Health Economics 3 credits
Explores questions of policy with regard to quality, cost and distribution of personal health care services and the proper role of government. Involves microeconomic and macroeconomic issues, theories and analysis tools.

MPH 698/699
Special Topics in Public Health I, II
3 credits each
Special area course given when suitable interest develops. Topics are announced in advance.

MPH 725
Independent Study 3 credits
Prerequisite: approval of track coordinator. Covers a topic that is either not offered in the master of public health degree program curriculum or is offered but the student wishes to study the topic in greater depth and or breadth. Work is supervised by a public health faculty member.

Quantitative Methods

Offered by the UMDNJ-New Jersey Medical School

QM 611
Design of Epidemiological Studies and Clinical Trials 3 credits
Prerequisites: biostatistics and epidemiology core courses, or equivalent. Principles of experimental design; recognize a well-designed study in the literature; identify and explain inadequacies in study designs and suggest improvements; prepare and submit a protocol for a well-designed study.

QM 612
Linear Models: Regression and Analysis of Variance 3 credits
Prerequisites: biostatistics core course or equivalent. Practical introduction to the linear statistical methods that are so commonly used in public health research. A statistical computer package such as SAS, STATA or SPSS is used for exercises. Apply regression, correlation and analysis of variance to data. Apply principles of study design and sample size planning. Provide statistically valid interpretation of output from data analysis.

Statistics

Offered by the Department of Management at Rutgers-Newark

26:960:577
Introduction to Statistical Linear Models
3 credits
Prerequisite: undergraduate or master's-level course in statistics. Linear models and their application to empirical data. The general linear model; ordinary-least-squares estimation;

diagnostics, including departures from underlying assumptions, detection of outliners, effects of influential observations, and leverage; analysis of variance, including one-way layouts, two-way, and higher dimensional layouts, partitioning sums of squares, and incomplete layouts (Latin squares, incomplete blocks, and nested or repeated measures). Emphasizes computational aspects and use of standard computer packages such as SAS.

Transportation

Offered by the Interdisciplinary Program in Transportation

Tran 552
Geometric Design of Transportation Facilities 3 credits
Prerequisite: CE 350 or equivalent. Design principles and criteria related to highways and railroads resulting from requirements of safety, vehicle performance, driver behavior, topography, traffic, design, speed, and levels of service. Elements of the horizontal and vertical alignments and facility cross-section, and their coordination in the design. Computer-aided design procedures including COGO, CADAM, Digital Terrain Modeling. *Same as CE 552.*

Tran 553
Design and Construction of Asphalt Pavements 3 credits
Importance of designing asphalt pavements. Topics include the origin of crude, refining crude, types of asphalts, desired properties of asphalt cement, specification and tests for asphalt cement, aggregates for asphalt mixtures, aggregate analysis, gradation and blending, hot-mix asphalt (HMA) mix design, manufacture of HMA and HMA-paving, hot and cold recycling. *Same as CE 553.*

Tran 592
Graduate Co-op Work Experience 3 additive credits
Prerequisites: permission from Transportation Program and Division of Career Development Services. Work assignments and projects are developed by the co-op office in consultation with the transportation program. Work assignments are related to student's major and are evaluated by Transportation Program faculty coordinators. Credits for this course may not be used to fulfill any transportation degree requirements.

Tran 602
Geographic Information Systems 3 credits
Prerequisite: course or working knowledge of CADD or permission of instructor. Geographical/Land Information System (GIS/LIS) is a computerized system capable of storing, manipulating and using spatial data describing location and significant properties of the earth's surface. GIS is an interdisciplinary technology used for studying and managing land uses, land resource assessment, environmental monitoring and hazard/toxic waste control, etc. Introduces emerging technology and its applications. *Same as CE 602.*

Tran 603
Introduction to Urban Transportation Planning 3 credits
Urban travel patterns and trends; community and land activity related to transportation study techniques including survey methods, network analysis, assignment and distribution techniques. Case studies of statewide and urban areas are examined. *Same as CE 603.*

Tran 604
Public and Private Financing of Urban Areas 3 credits
Ties government's budget, tax, policy, allocation of resources between public and private sectors, with the structure, development, and growth needs of urban metropolitan areas. Focuses on problems of poverty, transportation, land-use, economic base, relation between central cities and suburban areas, and alternative engineering and economic solutions. *Same as Fin 618 and MIP 618.*

Tran 608
Behavioral Issues in Transportation Studies 3 credits
Behavioral science concepts and principles such as perception, learning, motivation, and information processing as they relate to: transportation, consumer use of mass transit, automobiles, ridesharing and intelligent transportation systems. *Same as HRM 608.*

Tran 610
Transportation Economics 3 credits
Prerequisite: undergraduate course in economics. Principles of engineering economy. Cost of highway and public transportation facilities. Economic comparisons and evaluations. Financing approaches, tax allocation theory. Programming highway and public transit improvements. *Same as IE 610.*

Tran 615
Traffic Studies and Capacity 3 credits
Prerequisite: elementary probability and statistics. Presentation of the characteristics of the traffic stream, road users, and of vehicles, and a review of traffic flow relationships. Students are exposed to the principal methodologies followed by transportation practices to perform volume, speed, travel time, delay, accident, parking, pedestrian, transit and goods movement studies. Presentation of the principal methodologies used to perform transportation facility capacity analyses for: basic freeway sections, weaving areas, ramps and ramp junctions, multi-lane and two lane roadways, signalized and unsignalized intersections. Students get hands on experience using highway capacity software (HCS) and SIDRA. *Same as CE 660.*

Tran 625
Public Transportation Operations and Technology 3 credits
Prerequisite: graduate standing in civil or industrial engineering or instructor approval. Presentation of the technological and engineering aspects of public transportation systems. Historical development of public transportation technologies. Vehicle and right-of-way characteristics, capacity and operating strategies. Public transportation system performance. Advanced public transportation systems. *Same as CE 625.*

Tran 640
Distribution Logistics 3 credits
Prerequisite: EM 602 or Tran 650 or equivalent. Distribution logistics emphasizing systems engineering techniques used to optimize corporate profit and customer service: transportation modes; inventory policies; warehousing and order processing; and the best logistics gross margin. *Same as EM 640.*

Tran 643
Transportation Finance 3 credits
Prerequisite: undergraduate course in economics. Balance sheets and income statements. Asset and liability management, sources and costs of debt and equity financing. Financial performance measures in the private sector (airlines, railroads, trucking and bus companies). Financing issues associated with the public sector (highways and mass transit). Equity and efficiency in pricing. Subsidy allocation formulae. Innovative financing schemes in the public sector. *Same as IE 643.*

Tran 650
Urban Systems Engineering 3 credits
Prerequisite: computer programming background. Identifies the various urban problems subject to engineering analysis, and modern techniques for their solution, including inductive and deductive mathematical methods, mathematical modeling and simulation, and decision making under uncertainty. *Same as CE 650.*

Tran 653
Traffic Safety 3 credits
Prerequisite: Tran 615 or equivalent. System behavioral principles are applied to safety aspects of highway operation and design, and improvements of existing facilities. Solutions are evaluated on the basis of cost effectiveness. *Same as CE 653.*

Tran 655
Land Use Planning 3 credits
Spatial relations of human behavior patterns to land use; methods of employment and population studies are evaluated; location and spatial requirements as related to land use plans; and concepts of urban renewal and recreational planning are investigated by case studies. *Same as CE 655 and MIP 655.*

Tran 659
Flexible and Rigid Pavements 3 credits
Prerequisite: CE 341 or equivalent. Types of rigid (Portland cement) and flexible (bituminous pavements). Properties of materials, including mineral aggregates. Design methods as functions of traffic load and expected life. Importance and consequences of construction methods. Maintenance and rehabilitation of deteriorated pavements. *Same as CE 659.*

Tran 700
Master's Project 3 credits
Prerequisite: written approval of project advisor. An independent project demonstrating the student's professional competence in an area of specialization. Oral examination and written report required.

Tran 701
Master's Thesis 6 credits
Prerequisite: written approval of thesis advisor. A comprehensive project, usually in the form of substantial study and analysis, a functional design project or control-operations systems study.

Tran 702
Selected Topics in Transportation 3 credits
Prerequisite: advisor's approval. Topics of special or current interest.

Tran 705
Mass Transportation Systems 3 credits
Prerequisite: Tran 610 or IE 610. Investigation of bus, rapid transit, commuter railroad, and airplane transportation systems. Existing equipment, economics, capacity, and terminal characteristics are discussed, as well as new systems and concepts. Long- and short-range transportation systems are compared. *Same as CE 705.*

Tran 720
Discrete Choice Modeling for Travel Demand Forecasting 3 credits
Prerequisite: Tran 610 or equivalent. Discrete choice modeling describes a class of theoretical and analytical models essential for most advanced planning and forecasting efforts in transportation analysis. Includes logit, multinominal, and probit models. Develops theoretical and analytical skills needed to design, estimate and apply both revealed and stated preference models to appropriate travel demand forecasting problems.

Tran 740
Management of Transportation Carriers 3 credits
Prerequisites: Tran 610 or equivalent and Tran 650 or EM 602 or equivalent. Presents theory and practice of managing transportation carriers, including the concepts of costing, pricing, designing and marketing transportation service; the concepts of financial efficiency and resource productivity with application to the selected freight carriers in each mode of transportation. Selected case studies of carriers' operations management practices in various modes. Comparative studies of service characteristics, market share, cost structures both within a particular transportation mode and between modes. *Same as EM 740.*

Tran 751
Transportation Design 3 credits
Prerequisite: Tran 603. Design problems for airports, terminals, and highway intersections and interchanges are undertaken. *Same as CE 751.*

Tran 752
Traffic Control 3 credits
Traffic laws and ordinances; regulatory measures; traffic control devices; markings, signs and signals; timing of isolated signals; timing and coordination of arterial signal systems; operational controls; flow, speed, parking; principles of transportation system management/administration; highway lighting; and state-of-the-art surveillance and detection devices and techniques. Hands-on experience with TRAF/NETSIM and FREESIM. *Same as CE 752.*

Tran 753
Airport Design and Planning 3 credits
Prerequisites or corequisites: Tran 610 or EM 693 and Tran 615. Planning of individual airports and statewide airport systems. Functional design of air and landside facilities. Orientation, number and length of runways. Concepts of airport capacity. Passenger and freight terminal facility requirements. Airport access systems. FAA operating requirements. Financial, safety and security issues. *Same as CE 753 and IE 753.*

Tran 754
Port Design and Planning 3 credits
Prerequisites: Tran 610 or EM 693 and Tran 615. Functional design of the water and landsides for general cargo, liquid and dry bulk, and container operations. Yard and storage systems. Port capacity in an intermodal network. Economic, regulatory, and environmental issues. *Same as CE 754 and IE 754.*

Tran 755
Intelligent Transportation Systems 3 credits
Prerequisite: Tran 752. Techniques used to improve the safety, efficiency and control of surface transportation systems. Emphasis on technological and operational issues of these systems and using them for incident detection and for traffic management through route and mode diversion.

Tran 760
Urban Transportation Networks 3 credits
Prerequisites: elementary probability and statistics and Tran 650 or equivalent. Provides analytical techniques for the analysis of transportation problems in an urban environment. Principal components include applications of models for the analysis of transportation problems, advanced static, dynamic, and stochastic traffic assignment procedures and transportation network design exact and heuristic solution algorithms. Offers hands-on experience with existing software in traffic assignment and transportation network design.

Tran 765
Multi-modal Freight Transportation Systems Analysis 3 credits
Prerequisites: Tran 610 or equivalent and Tran 650 or EM 602 or equivalent. Quantitative methods for the analysis and planning of freight transportation services. The supply-performance-demand paradigm for freight transportation systems. Cost and performance as determined by system design and operations. Relationship of traffic and revenue to service levels and pricing. Optimal service design and redesign for transportation enterprises and operations planning. Fleet and facility investment planning. Applications to various modes. *Same as EM 765 and CE 765.*

Tran 790
Doctoral Dissertation and Research
Credits as designated
Corequisite: Tran 791. Required of all candidates for the Doctor of Philosophy in Transportation. A minimum of 36 credits is required. Students may register for 6 to 15 credits of dissertation per semester. If 36 credits are achieved prior to completion of the doctoral dissertation and research, students must register for 3 credits per semester thereafter.

Tran 791
Doctoral Seminar Non-credit
Corequisite: Tran 790. A seminar in which faculty, students, and invited speakers will present summaries of advanced topics in transportation. Students and faculty will discuss research procedures, dissertation organization, and content. Students engaged in research will present their own problems and research progress for discussion and criticism.

Tran 792
Seminar Non-credit
Students periodically present the results of their research activities to faculty, research staff and other students. Outside speakers may be invited. Required each semester for those students who receive departmental or research-based awards.

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GRANIK, GERALD, P.E., Professor of Applied Mathematics (1952). Newark College of Engineering, B.S., 1950; M.S., 1954; Stevens Institute of Technology, M.S., 1958; Sc.D., 1965.

HAUSSER, PAUL C., Professor of Physical Education (1952). Panzer College, B.S., 1950; Columbia University, Cert. in Physical Therapy, 1951; M.A., 1954; Professional Diploma, 1955. New Jersey Licensed Physical Therapist.

HELFGOTT, ROY B., Distinguished Professor of Economics (1968). City College of New York, B.S., 1948; Columbia University, M.A., 1949; New School for Social Research, Ph.D., 1957.

HERMAN, HARRY, P.E., Professor of Mechanical Engineering (1964), Associate Chairperson for Graduate Studies and Graduate Advisor (1979). Cooper Union, B.M.E., 1948; Columbia University, M.S., 1956; Polytechnic Institute of Brooklyn, Ph.D., 1964.

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MILLER, EDWARD, Professor of Mechanical Engineering (1948), and Dean of Newark College of Engineering (1981). Newark College of Engineering, B.S., 1948; University of Delaware, M.M.E., 1949; Columbia University, M.A., 1951; Stevens Institute of Technology, M.S., 1952; New York University, M.Aero.E., 1959.

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MOSHOS, GEORGE J., Professor of Computer and Information Science (1968). University of Michigan, B.S., 1949; M.S., 1949; Case Institute of Technology, Ph.D., 1965.

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REIZISS, DANIEL, Associate Professor of Physics (1955). City College of New York, B.M.E., 1944; Newark College of Engineering, M.S.E.E., 1960.

RICH, JOSEPH A., Jr., Professor of Management Engineering (1941). Rutgers University, B.S., 1941; M.S., 1948; D.Jur., 1952. Licensed Attorney, New Jersey Bar and Federal Bar.

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SHUKAR, ARTHUR, Associate Professor of Physics (1958). Newark College of Engineering, B.S., 1958; M.S., 1959.

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SMITH, H. HUNTER, Professor of Physics (1956). Davidson College, B.S., 1926; North Carolina State College, M.S., 1930.

SMITHBERG, EUGENE H., Professor of Mechanical Engineering and Dean of the Graduate Division (1950). College of the City of New York, B.M.E., 1943; Polytechnic Institute of Brooklyn, M.M.E., 1949; New York University, D.Eng.Sc., 1961.

STAMPER, EUGENE, P.E., Professor of Mechanical Engineering (1952). City College of New York, B.M.E., 1948; New York University, M.M.E., 1952.

STEINBERG, ABRAHAM H., Professor of English (1955). Brooklyn College, B.A., 1937; Columbia University, Ph.D., 1955.

STEPHANS, CLARENCE H., P.E., Professor in Industrial Relations, Director of Relations with Industry, Director of Continuing Education Engineering Studies (1932). Newark College of Engineering, B.S., 1932.

SUCHOW, LAWRENCE, Professor of Chemistry (1964). City College of New York, B.S., 1943; Polytechnic Institute of Brooklyn, Ph.D., 1951.

SWANSON, ROBERT F., Professor of Physical Education and Director of Physical Education and Athletics (1948). Panzer College, B.S., 1947; Rutgers University, M.Ed., 1962.

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THOMAS, STAN S., P.E., Associate Professor of Industrial Engineering (1971). University of Akron, B.S.M.E., 1950; Cornell University, M.S., 1955; Purdue University, Ph.D., 1967.

WACKER, ROBERT L., Associate Professor of English (1954). Northwestern University, B.A., 1947; Columbia University, M.A., 1948.

WELLER, MONROE R., Associate Professor of Physics (1946). Upsala College, B.A., 1935; Montclair State College, M.A., 1937.

WENISCH, WERNER J., Associate Professor of Chemistry (1963). Massachusetts Institute of Technology, B.S., 1943; New York University, M.S., 1949; Ph.D., 1955.

WINTERS, STANLEY B., Distinguished Professor of History (1957). New York University, A.B., 1948; Columbia University, A.M., 1950; Rutgers University, Ph.D., 1966.

WISE, JAMES N., Associate Professor of English (1955). College of Wooster, B.A., 1941; Columbia University, M.A., 1948.

WITTES, LEO, Assistant Professor of Applied Mechanics (1953). Rutgers University, B.S., 1928; University of Maryland, M S., 1931.

YU, YI-YUAN, Research Professor of Mechanical Engineering (1981). Tientsin University, B.S., 1944; Northwestern University, M.S., 1950; Ph.D., 1951.

ZAMBUTO, MAURO H., Distinguished Professor of Electrical Engineering (1962). University of Rome and Padua (Italy), Ph.D., 1944.

ZAMES, FRIEDA, Associate Professor of Mathematics (1972). Brooklyn College, B.S., 1954; New York University, M.S., 1966; Ph.D., 1972.

ZATZKIS, HENRY, Distinguished Professor of Mathematics (1953). Ohio State University, B.S., 1942; Indiana University, M.S., 1944; Syracuse University, Ph.D., 1950.

Adjunct Faculty, Visiting Professors, Special Lecturers, University Lecturers (Partial Listing)

ALJALLAD, FIRAS, Computer and Information Science (1999). New Jersey Institute of Technology, B.S., 1994; M.S., 1996; Ph.D. candidate.

ASCIONE, ALFRED, Electrical Engineering (1986). New Jersey Institute of Technology, B.S.E.E, 1983; M.S.E.E., 1986.

AYAD, IRENE, Architecture (1997). Empire State College, B.A., 1982; State University of New York at Buffalo, M.U.P., 1987; Cornell University, Ph.D., 1995.

BARASH, LOUIS, Chemistry (1993). City College of New York, B.S., 1956; Florida State University, M.S., 1960; Rutgers University, Ph.D., 1968.

BARNETT, ROBERT SPENCER, R.A., Architecture (1997). University of Pennsylvania, B.A., 1967; Columbia University, M.Arch., 1975.

BARR, DAVID, Electrical Engineering Technology (1997). Southern Illinois University, B.S., 1979; Stevens Institute of Technology, M.S., 1994; Ph.D., 1996.

BARTLE, ANDREW B., Architecture (1991). Bennington College, B.A.; Princeton University, M.Arch., 1980.

BASAVIAH, MATT, Electrical Engineering (1988). Annamalai University (India), B.S.E.E., 1969; Polytechnic Institute of Brooklyn, M.S.E.E., 1970; Fairleigh Dickinson University, M.B.A., 1979.

BASU, SANAT, Computer and Information Science (1999). Banaras Hindu University, M.S., 1959; Tata Institute of Fundamental Research, Ph.D., 1972.

BELL, WALTER, Humanities and Social Sciences (1998). Roosevelt University, B.A., 1977; Tufts University, M.A., 1978; University of Geneva, Doctorat, 1992.

BERKOWITZ, JERRY, Mathematical Sciences (1996). City College of New York, B.S., 1963; Stevens Institute of Technology, M.S., 1966.

BILASH, BORISLAW, Chemistry (1998). University of Manitoba, B.S., 1986; Rutgers, The State University of New Jersey, Ed.M., 1993.

BOJSZA, WALTER J., Humanities and Social Sciences (1995). Newark College of Engineering, B.S., 1969; Rensselaer Polytechnic Institute, M.S., 1970.

BRAUN, JACK, Electrical Engineering (1985). Rose Polytechnic Institute, B.S.E.E., 1966; Rose-Hulman Institute of Technology, N.S.B.E., 1970.

BUECHEL, FREDERICK, Biomedical Engineering (1985). Seton Hall University, B.A., 1967; New Jersey Medical School, M.D., 1971.

CAMCRO, LORRAINE, Environmental Science (1997). Rutgers, The State University of New Jersey, B.S., 1992; New Jersey Institute of Technology, M.S., 1997.

CASTRONOVA, LOUISE, Humanities and Social Sciences (1983). Upsala College, B.A., 1973; Seton Hall University, M.A., 1975.

CHANG, GEORGE, Computer and Information Science (1999). State University of New York at Stony Brook, B.S., 1994; New Jersey Institute of Technology, M.S., 1995.

CHAUDHRY, HANS RAJ, Mathematics (1991). Punjab University (India), B.A., 1952; Agra University, M.A., 1954; Indian Institute of Technology, Kharagpur, Ph.D., 1967.

CHEN, WAN-LING, Electrical Engineering (1993). National Tsing-Hua University, B.S.E.E., 1984; Michigan Technological University, M.S.E.E., 1986; Case Western Reserve University, M.S., 1988; New Jersey Institute of Technology, Ph.D., 1993.

CHRISTOU, PROKOPIS, Environmental Science (1994). New Jersey Institute of Technology, B.S., 1988; Rutgers, The State University of New Jersey, M.S., 1994.

CHU, JOSEPH C., P.E., Engineering Technology (1990). Kansas State University, M.S.C.E., 1970; Diploma C.E., Taipei Institute of Technology, 1965.

COHEN, HARVEY, Electrical Engineering (1959). Newark College of Engineering, B.S.E.E, 1956; Yale University, M.S., 1958.

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DAKEN, RICHARD, P.E., Electrical Engineering Technology (1993). New Jersey Institute of Technology, B.S.E.E., 1975; M.S.E.E., 1982; William Paterson College, M.B.A., 1992.

DAME, ENID, Humanities and Social Sciences (1998). Towson State College, B.S., 1963; City College of New York, M.A., 1973; Rutgers, The State University of New Jersey, Ph.D., 1983.

DART, JAMES, A.I.A., R.A., Architecture (1985). Rhodes College, B.A., 1976; University of Pennsylvania, M.Arch., 1981.

DAVIE, GEORGE W., Industrial and Manufacturing Engineering (1994). Polytechnic Institute of Brooklyn, B.S., 1967; Fairleigh Dickinson University, M.B.A., 1976.

DEAUX, THOMAS, Computer and Information Science (1998). Christopher Newport College, B.S., 1974; New Jersey Institute of Technology, M.S., 1998.

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DELVECCHIO, GUY R., Industrial and Manufacturing Engineering (1985). New Jersey Institute of Technology, B.S.I.E., 1981; Rutgers University, M.S.I.E., 1984.

DINE, PAUL J., Management (1997). Campion House (U.K.), B.A., 1951; St. John's Seminary (U.K.), M.A., 1957; Pontificia Universita Gregoriana (Italy), S.T.L. (M.A.), 1959; Pontificium Institutum Bliblicum (Italy), L.S.S. Ph.D., 1961.

DOBI, JOHN, Environmental Science (1995). Rutgers University, B.S., 1970; M.S., 1972; University of Massachusetts, Ph.D., 1979.

DUPRÉ, ARTHUR, Computer and Information Science (1998). Wofford College, A.B., 1959; George Washington University, M.S., 1962; University of Maryland-College Park, Ph.D., 1965.

DURAN, WALTER, Biomedical Engineering (1985). Catholic University of Chile, Ph.D., 1965; Duke University, Ph.D., 1974.

DURAN, SERGIO, R.A., Architecture (1996). Southern California Institute of Architecture, B.Arch., 1985; University of Tokyo, M.Arch., 1989.

ELLERBUSCH, FRED, Humanities and Social Sciences (1999). New Jersey Institute of Technology, B.S., 1973; M.S., 1980.

ENGLISH, JERRY FITZGERALD, Esq., Environmental Science (1987). Stanford University, B.A., 1956; Boston College Law School, J.D., 1963.

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FISHER, ELLIOT A., Mathematics (1991). Cooper Union, B.S., 1973; California Institute of Technology, Ph.D., 1977.

FLEISCHER, DORIS, Humanities and Social Sciences (1988). Brooklyn College, B.A., 1958; New York University, M.A., 1961; Ph.D., 1979.

FRANKENFELD, JOHN, Chemistry (1993). University of Chicago, B.A., 1952; M.S., 1957; Massachusetts Institute of Technology, Ph.D., 1961.

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FUNKHOUSER, CHRISTOPHER, Humanities and Social Sciences (1997). University of Virginia B.A., 1986; M.A., 1988; University of Albany, Ph.D., 1997.

GONZALEZ, LUIS, Humanities and Social Sciences (1983). Pace University, B.A., 1967; New York University, M.A., 1976; Fairleigh Dickinson University, M.B.A., 1977.

GRASSO, GIORGIO, Computer and Information Science (1998). University of Catania (Italy), B.S., 1993; New Jersey Institute of Technology, M.S., 1999.

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HERNANDEZ, ROGER, Humanities and Social Sciences (1997). Rutgers, The State University of New Jersey, B.A., 1977.

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HORNSBY, MICHAEL L., Civil and Environmental Engineering (1986). New Jersey Institute of Technology, B.S., 1985; M.S., 1987.

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HUTTER, ROBERT, Biomedical Engineering (1985). Syracuse University, B.A., 1950; State University of New York at Syracuse, M.D., 1954.

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KOLLAR, KEITH, Environmental Science (1992). Fairfield University, B.S., 1986; New Jersey Institute of Technology, M.S., 1988.

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KUSHWAHA, RAKESH, Computer and Information Science (1989). University of Delhi, B.E., 1986; New Jersey Institute of Technology, M.S., 1989; Ph.D., 1993.

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MOGHADDASI, VAHID, Computer and Information Science (1995). New Jersey Institute of Technology, B.S., 1992; M.S., 1995.

MOHAMMED, FRANKIE, Mathematics (1993). Long Island University, C.W. Post Campus, B.S., 1987; M.S., 1989; Stevens Institute of Technology, Ph.D., 1994.

MOHEBBI, SOROOSH, Mathematical Sciences (1993). Arak University (Iran), B.S., 1979; Jersey City State University, M.S., 1994.

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MORALES, EDUARDO, Computer and Information Science (1998). Indiana University, B.S., 1991; New Jersey Institute of Technology, M.S., 1994.

MORTIMER, JAMES J., P.E., Civil and Environmental Engineering. Manhattan College, B.E.C.E., 1968; New Jersey Institute of Technology, M.S.C.E., 1980.

MOSHENBERG, DAVID, Electrical Engineering (1984). Singalovsk: Technical College, B.S.E.E., 1984; M.S.E.E., 1985.

NASTASI, JOHN, R.A., Architecture (1992). Pratt Institute, B.Arch., 1986.

NATELSON, BENJAMIN, Biomedical Engineering (1985). University of Pennsylvania, B.A., 1963; M.D., 1967.

NAVIN, THOMAS, A.I.A., R.A., Architecture (1987). Rhode Island School of Design, B.F.A., 1975; University of Virginia, M.Arch., 1979.

NEUMAN, IRINA, Management (1997). Academy of Economic Sciences, Diploma, 1975; Hebrew University, M.A., 1978; University of Rochester, M.S., 1982; Ph.D., 1987.

NICHOLSON, THEODORE, Computer and Information Science (1998). New York University, B.A., 1987; Syracuse University College of Law, J.D., 1990.

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OGUINE, PRISCILLA, Humanities and Social Sciences (1998). University of Nigeria Nsukka, B.A., 1974; University of London, Post.Dip., 1977; University of Jos, Nigeria, M.Ed., 1979; University of Reading (England), M.A., 1991.

OLSEN, GEORGE W., Industrial and Manufacturing Engineering (1994). State University of New York, B.S., 1965; University of Florida, M.S., 1996; University of West Florida, M.B.A., 1975.

OPYRCHAL, HALINA, Applied Physics (1996). Polytechnic University (Poland) M.S., 1969; Institute of Low Temperature and Structure Research, Polish Academy of Sciences, Ph.D., 1976.

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OSOLINIEC, EDWARD, P.E., Electrical Engineering Technology (1984). New Jersey Institute of Technology, B.S.E.E., 1978; University of California, M.S.E.E., 1979.

O'SULLIVAN, WILLIAM, Humanities and Social Sciences (1997). Brooklyn College, City University of New York, B.A., 1967; City College of New York, M.A., 1995.

OWEIS, ISSA S., P.E., Civil and Environmental Engineering (1986). University of Baghdad, B.S., 1962; Oklahoma State University, M.S., 1965; University of Texas, Ph.D., 1968.

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PATNAIK, PRADYOT, Environmental Science (1995). Utbal University (India), B.S., 1970; M.S., 1972; Indian Institute of Technology (Bombay), Ph.D., 1976.

PEPE, RUSSELL C., Electrical Engineering Technology (1991). New Jersey Institute of Technology, B.S.E.E., 1977; M.S.E.E., 1992.

PETROVA, ROUMANIA S., Physics (1994). Bulgarian Academy of Sciences, Ph.D., 1993; Chemical Technical Institute (Bulgaria), M.S., 1976.

PHILOBOS, ALEXANDER M., Industrial and Manufacturing Engineering (1990). Ain Shams University, B.S.M.E., 1967; Stevens Institute of Technology, M.S.M.E., 1975.

PIATEK, SLAWOMIR S., Applied Physics (1995). New Jersey Institute of Technology, B.S., 1988; Rutgers University, Ph.D., 1994.

PICARELLI, MICHELE, Mathematical Sciences (1999). St. Peter's College, B.S., 1996; New Jersey Institute of Technology, M.S., 1998.

PIETRUCHA, BERNARD, Electrical Engineering (1986). New Jersey Institute of Technology, B.S.E.E., 1967; M.S.E.E., 1973; Rutgers University, Ph.D., 1985.

PISTACCHIO, JOHN, Electrical Engineering (1983). New Jersey Institute of Technology, B.S., 1981; M.S., 1985.

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POUSTCHI, RON, Civil and Environmental Engineering (1997). University of Madras, B.S., 1979; University of Winsor, M.S., 1981; Ph.D. 1985.

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RUSH, BENJAMIN, Biomedical Engineering (1985). University of California, Berkeley, B.A., 1944; Yale University, Medical School, M.D., 1948.

RUTH, SAMUEL A., P.E., Construction and Contracting Engineering Technology (1992). Newark College of Engineering, B.S.C.E., 1964.

SARKAR, SAMIR K., Mechanical Engineering (1980). Punjab University, B.S.M.E., 1960; Indian Institute of Science, M.Eng., 1963; New York University, M.Eng., M.E., 1966; M.Eng. Nuc.E., 1975.

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SCHAUBACH, JOHN W., Chemical Engineering (1995). Kansas State University, B.S., 1960; New Jersey Institute of Technology, B.S., 1985.

SCHREIHOFER, ELLEN, Computer and Information Scence (1996). Upsala College, B.A., 1985; M.S., 1988; Montclair State University, M.A., 1995.

SELIM, AHMED A., Electrical Engineering Technology (1995). New York Institute of Technology, B.S.E.E., 1980; Stevens Institute of Technology, M.S.C.S., 1993.

SERICO, BENJAMIN J., Mechanical Engineering (1994). Newark College of Engineering, B.S., 1973; New Jersey Institute of Technology, M.S., 1975; Central Michigan University, M.A., 1978.

SIEGEL, JOY W., A.I.A., R.A., Architecture (1992). Syracuse University, B.Arch., 1982; Harvard University, M.Arch., 1985.

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SOLLOHUB, DARIUS, R.A., Architecture (1995). Columbia University, B.A., 1983; M.Arch., 1988.

SOLU, JOHN C.R., Industrial and Manufacturing Engineering (1995). New Jersey Institute of Technology, B.S., 1975.

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SPENCER, THOMAS, III, Mathematics and Industrial and Manufacturing Engineering (1989). New Jersey Institute of Technology, B.S., 1964; M.S., 1967; Stevens Institute of Technology, M.S., 1969; Ph.D., 1976.

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STORZ, RALPH H., Electrical Engineering Technology (1978). New Jersey Institute of Technology, B.S.E.T., 1977.

SUN, BEN, Electrical Engineering (1985). National Chiao-Tung University, B.S., 1977; Ohio State University, M.S., 1981; Ph.D., 1983.

SURJANHATA, HERLI, Mechanical Engineering (1988). Trisakti University, Eng. Degree, 1976; New Jersey Institute of Technology, M.S., 1984; Ph.D., 1993.

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CAINE, JR., RUFUS, Associate Professor, Oral Pathology, Biology and Diagnostic Sciences, (1977). University of Arkansas, B.S., 1965; Meharry Medical College, D.D.S., 1972; University of Michigan School of Public Health, M.P.H., 1974.
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NJIT on the Internet:	www.njit.edu

Many academic and administrative departments have home pages on NJIT's World Wide Web site and are accessible at the address above.

Main Offices	Extension
Admissions: Graduate and Undergraduate	3300
Alumni Affairs, Office of	3441
Applied Science Program	3291
Biological Sciences, Federated Department of NJIT and Rutgers-Newark	6597
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Academic Calendar 1999-2002

FALL SEMESTER 1999

First day of classes	Monday, August 30
Saturday classes meet	Saturday, September 4
Sunday classes meet	Sunday, September 5
Labor Day (university closed)	Monday, September 6
Last day to add a course	Tuesday, September 7
Last day for a partial refund	Monday, September 13
Fall Awards Ceremony	Wednesday, September 22
Deadline for applying for January commencement ceremony	Friday, October 15
Last day for a refund based upon a complete withdrawal	Monday, October 18
Last day to withdraw from course(s)	Tuesday, November 2
Classes follow a Friday schedule	Wednesday, November 24
Thanksgiving Recess (no classes scheduled)	Thursday-Sunday, November 25-28
Reading day	Tuesday, December 7
Last day of Wednesday classes	Wednesday, December 8
Last day of Thursday classes	Thursday, December 9
Last day of classes	Thursday, December 9
Final exam period	Friday-Thursday, December 10-16
Deadline for applying for May commencement ceremony	Wednesday, December 15
Fall grades due in Registrar's Office	Monday, December 20

SPRING SEMESTER 2000

First day of Sunday classes	Sunday, January 16
Martin Luther King, Jr.'s Birthday (university closed)	Monday, January 17
First day of classes	Tuesday, January 18
Last day to add a course	Monday, January 24
Last day for a partial refund	Tuesday, February 1
Last day for a refund based upon a complete withdrawal	Monday, March 6
Spring Recess (university open, no classes scheduled)	Monday-Sunday, March 13-19
Last day to withdraw from course(s)	Monday, March 20
Good Friday (no classes scheduled)	Friday, April 21
Saturday classes meet	Saturday, April 22
Easter (university closed)	Sunday, April 23
Classes follow a Friday schedule	Tuesday, May 2
Last day of classes	Tuesday, May 2
Reading day	Wednesday, May 3
Final exam period	Thursday-Wednesday, May 4-10
Spring grades due in Registrar's Office	Thursday, May 11
Commencement	Friday, May 19
First day of summer session	Monday, May 22
Deadline for applying for August graduation	Thursday, June 15

FALL SEMESTER 2000

First day of Saturday classes	Saturday, September 2
First day of Sunday classes	Sunday, September 3
Labor Day (university closed)	Monday, September 4
First day of classes	Tuesday, September 5
Last day to add a course	Monday, September 11
Deadline for applying for January commencement ceremony	Monday, October 16
Last day for a refund based upon a complete withdrawal	Tuesday, October 24

Last day to withdraw from course(s)	Monday, November 6
Classes follow a Thursday schedule	Tuesday, November 21
Classes follow a Friday schedule	Wednesday, November 22
Thanksgiving Recess (no classes scheduled)	Thursday-Sunday, November 23-26
Last day of classes	Wednesday, December 13
Reading day	Thursday, December 14
Final exam period	Friday-Thursday, December 15-21
Deadline for applying for May commencement ceremony	Friday, December 15
Fall grades due in Registrar's Office	Friday, December 22

SPRING SEMESTER 2001

First day of Sunday classes	Sunday, January 14
Martin Luther King, Jr.'s Birthday (university closed)	Monday, January 15
First day of classes	Tuesday, January 16
Last day to add a course	Monday, January 22
Last day for a refund based upon a complete withdrawal	Tuesday, March 6
Spring Recess (university open, no classes scheduled)	Monday-Sunday, March 12-18
Last day to withdraw from course(s)	Monday, March 26
Good Friday (no classes scheduled)	Friday, April 13
Saturday classes meet	Saturday, April 14
Easter (university closed)	Sunday, April 15
Classes follow a Friday schedule	Tuesday, May 1
Last day of classes	Tuesday, May 1
Reading day	Wednesday, May 2
Final exam period	Thursday-Wednesday, May 3-9
Spring grades due in Registrar's Office	Thursday, May 10
Commencement	Friday, May 18
First day of summer session	Monday, May 21
Deadline for applying for August graduation	Friday, June 15

FALL SEMESTER 2001

Saturday classes meet	Saturday, September 1
Sunday classes meet	Sunday, September 2
Labor Day (university closed)	Monday, September 3
First day of classes	Tuesday, September 4
Last day to add a course	Monday, September 10
Deadline for applying for January commencement ceremony	Friday, October 15
Last day for a refund based upon a complete withdrawal	Monday, October 18
Last day to withdraw from course(s)	Monday, November 2
Classes follow a Thursday schedule	Tuesday, November 21
Classes follow a Friday schedule	Wednesday, November 22
Thanksgiving Recess (no classes scheduled)	Thursday-Sunday, November 23-26
Last day of Classes	Wednesday, December 12
Reading day	Thursday, December 13
Final exam period	Thursday-Wednesday, December 14-20
Deadline for applying for May commencement ceremony	Friday, December 15
Fall grades due in Registrar's Office	Friday, December 21

SPRING SEMESTER 2002

First day of Sunday classes	Sunday, January 20
Martin Luther King, Jr.'s Birthday (university closed)	Monday, January 21
First day of classes	Tuesday, January 22
Last day to add a course	Monday, January 28
Last day for a refund based upon a complete withdrawal	Tuesday, March 7
Spring Recess (university open, no classes scheduled)	Monday-Sunday, March 18-24
Good Friday (no classes scheduled)	Friday, March 29
Saturday classes meet	Saturday, March 30
Easter (university closed)	Sunday, March 31
Last day to withdraw from course(s)	Monday, April 1
Classes follow a Friday schedule	Tuesday, May 7
Last day of classes	Tuesday, May 7
Reading day	Wednesday, May 8
Final exam period	Thursday-Wednesday, May 9-15
Spring grades due in Registrar's Office	Thursday, May 16
Commencement	Friday, May 24
First day of summer session	Tuesday, May 27
Deadline for applying for August graduation	Friday, June 15

Accreditation Appendix

Accreditation Board for Engineering and Technology, Inc. (ABET)
111 Market Place, Suite 1050
Baltimore, MD 21202
Tel. (410) 347-7700

American Assembly of Collegiate Schools of Business (AACSB)-The International Association for Management Education
600 Emerson Road, Suite 300
St. Louis, MO 63141-6762
Tel. (314) 872-8481

Computing Sciences Accreditation Board, Inc.
Suite 209, Two Landmark Square
Stamford, CN 06901
Tel. (203) 975-1117

Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (EAC of ABET)
111 Market Place, Suite 1050
Baltimore, MD 21202
Tel. (410) 347-7700

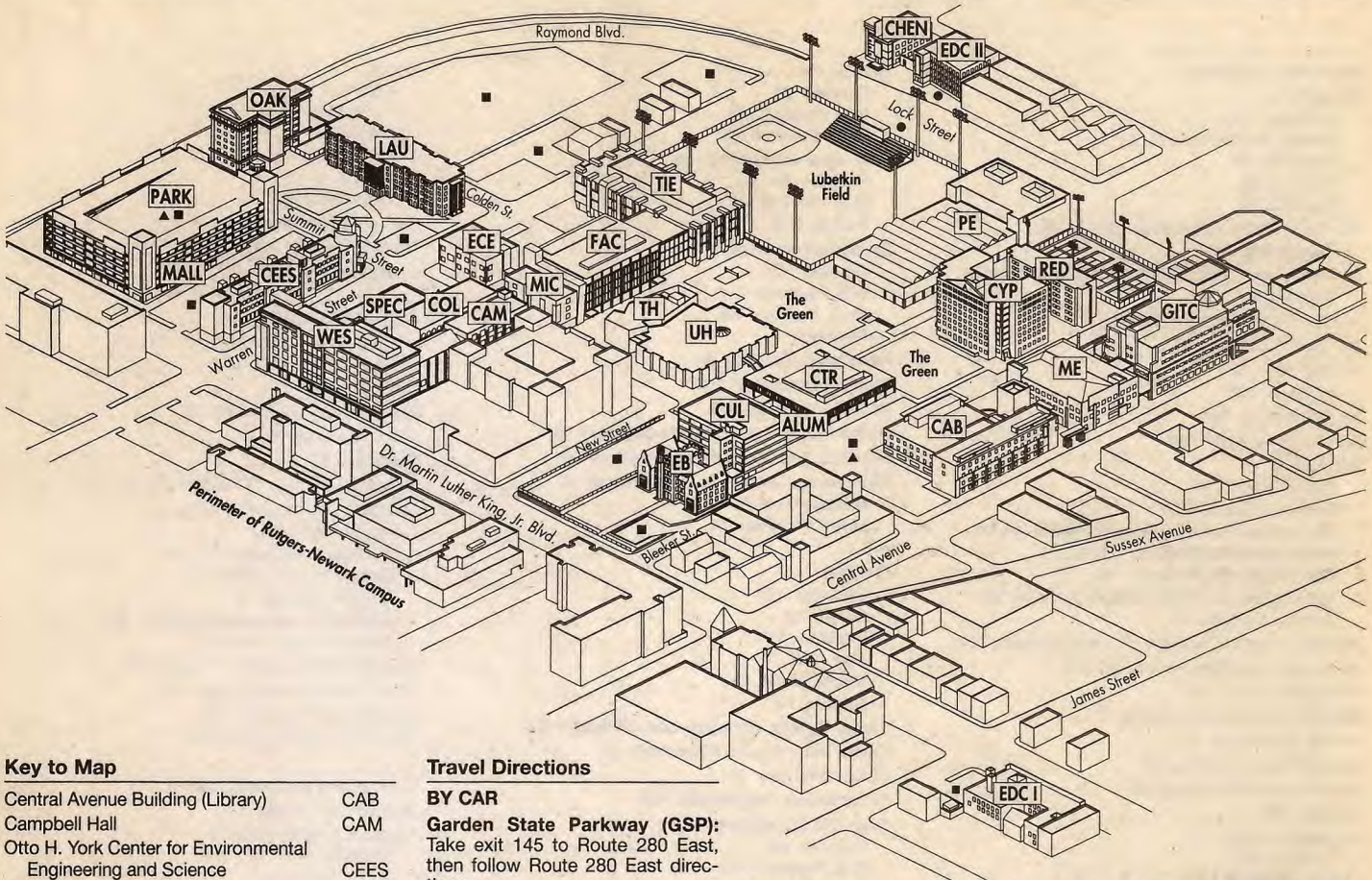
Middle States Association of Colleges and Schools
3624 Market Street
Philadelphia, PA 19104
Tel. (215) 662-5606

National Architectural Accrediting Board, Inc.
1735 New York Avenue, NW
Washington, DC 20006
Tel. (202) 783-2007

National League for Nursing Accrediting Commission
61 Broadway, 33rd Floor
New York, NY 10006
Tel. 1 (800) 669-1656

Technology Accreditation Commission of the Accreditation Board for Engineering and Technology (TAC of ABET)
111 Market Place, Suite 1050
Baltimore, MD 21202
Tel. (410) 347-7700

Map of the NJIT Campus



Key to Map

Central Avenue Building (Library)	CAB
Campbell Hall	CAM
Otto H. York Center for Environmental Engineering and Science	CEES
Council for Higher Education in Newark Building	CHEN
Colton Hall	COL
Hazell Center	CTR
Cullimore Hall	CUL
Cypress Hall	CYP
Eberhardt Hall	EB
Electrical and Computer Engineering	ECE
Enterprise Development Center I	EDC I
Enterprise Development Center II	EDC II
Faculty Memorial Hall	FAC
William S. Guttenberg Information Technologies Building	GITC
Laurel Hall	LAU
Mechanical Engineering Center	ME
Microelectronics Research Center	MIC
Oak Hall	OAK
Parking Deck	PARK
Physical Education Building	PE
Redwood Hall	RED
Specht Building	SPEC
Tiernan Hall	TIE
Theater	TH
University Hall	UH
Weston Hall	WES
Wilson Alumni Center	ALUM
Parking	■
Guest Parking	▲
Newark Subway (Warren St. Station)	●

Travel Directions

BY CAR

Garden State Parkway (GSP): Take exit 145 to Route 280 East, then follow Route 280 East directions.

New Jersey Turnpike: Take exit 15W to Route 280 West, then follow Route 280 West directions.

Route 280 West: After drawbridge, take Exit 14B (Broad Street/King Blvd.). At bottom of exit ramp, make a left. Go one block to stop sign. Make a left on King Blvd. Go three lights to Warren Street. Make a right on Warren Street. Go two blocks to Colden Street. Make a left on Colden Street. Follow signs to NJIT parking deck.

Route 280 East: Take Exit 13 (First Street/Newark). At light, make a right on First Street. Go three lights to W. Market Street. Make the soft left on W. Market Street. Go four lights to King Blvd. Make a left on King Blvd. Go one light to Warren Street. Make a left on Warren Street. Go two blocks to Colden Street. Make a left on Colden Street. Follow signs to NJIT parking deck.

Route 1 & 9 North & South: Take exit marked Newark, Route 21 (McCarter Highway). Cross bridge. At light at end of bridge, make quick left then quick right for Broad Street. (There are clear signs for Broad Street) Go about 1 mile. Make a left on Court Street. Make a right at third light on King Blvd. Make a left at fifth light on Warren Street. Go two blocks to Colden Street. Make a left on Colden Street. Follow signs to NJIT parking deck.

Route 78: Take Route 78 to the Garden State Parkway. Follow GSP directions.

Route 22: Take Route 22 to Route 21 North. Follow directions for Route 21 North.

Route 21 North: Cross bridge. At light at end of bridge, make quick left then quick right for Broad Street. (There are clear signs for Broad Street.) Go about 1 mile. Make a left on Court Street. Make a right at third light on King Blvd. Make a left at fifth light on Warren Street. Go two blocks to Colden Street. Make a left on Colden Street. Follow signs to the NJIT parking deck.

Route 21 South: From 21 South, turn right on Bridge Street. Turn left on Broad Street. Go one block and turn right on Washington Place. Go one block and turn left on Halsey Street. Go one block and turn right on Central Avenue. Make the third left on King Blvd. At first light, turn right on Warren Street. Go two blocks to Colden Street. Make a left on Colden Street. Follow signs to NJIT parking deck.

New York Thruway: Thruway to Exit 14A, Garden State Parkway. Follow GSP directions.

George Washington Bridge: NJ Turnpike South to Exit 15W. Follow Route 280 West directions above.

Lincoln Tunnel: West on Route 3 to NJ Turnpike South to Exit 15W. Follow Route 280 West directions.

From Brooklyn, Queens and Long Island: Take Verrazano-Narrows Bridge (Interstate 278) and follow 278 across Staten Island. Cross Goethals Bridge. Follow signs to New Jersey Turnpike North then follow New Jersey Turnpike directions.

Visitor Parking at NJIT is available in the NJIT parking deck, located near the corner of Warren and Summit streets with access from Colden Street. Visitor parking may be reserved in advance through your host. Other parking is available on campus during weekend activities and special events.

OTHER TRANSPORTATION SYSTEMS

Newark International Airport: Five miles from NJIT campus. A minibus (Newark Airlink) or taxi service connects the airport with Penn Station in Newark. Bus, city subway and taxi connections may be obtained at the station.

Newark Penn Station: Connections to the NJIT campus may be made by bus, city subway, or taxi.

Morris & Essex Broad Street Station: A five-block walk to the NJIT campus via King Blvd. to Central Avenue. Taxi service is also available.

Newark City Subway: From Penn Station in Newark, take the Warren Street stop for the NJIT Campus.

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Photography: Peter Byron 18; G. Steve Jordan 18;
Mike Peters cover, 18, 22, 30, 40; Bill Wittkop 2, 26

NJIT
New Jersey Institute of Technology

A Public Research University

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University Heights
Newark, New Jersey 07102-1982

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