Fall 2019

# MECH 237-005: Strength of Materials

G. Milano

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CIVIL AND ENVIRONMENTAL ENGINEERING
NJIT New Jersey Institute of Technology

**MECH 237 - Strength of Materials** Fall 2019

**Texts:**
1. Beer, Johnson, DeWolf and Mazurek, Mechanics of Materials, Eighth Edition, McGraw-Hill, ISBN 978-1-260-11327-3
2. Hsu, C.T. Thomas, Strength of Materials Laboratory Manual, (PDF to be posted on the Moodle/Canvas site).
3. NCEES, Fundamentals of Engineering Supplied-Reference Handbook, Eighth Edition, 2nd. revision ( or you can reproduce pages from: http://www.ncees.org/exams/study_materials/fe_handbook/ )

**Lecture & Instructors:**
**MECH 237-001 and -003,** Tues., 10:00-12:50, KUPF-210, Prof. E. Castro
**MECH 237-005 and -007, Hybrid,** Thur., 2:30-5:20, KUPF-205, Prof. G. Milano
**MECH 237-009 and -011, Hybrid**, Fri., 1:00-3:50, KUPF-106, Prof. G. Milano
**MECH 237-101 and -103,** Wed., 6:00-9:05 p.m., ECEC-100, Prof. E. Castro
- **Prof. Castro, P.E., 264-Colton Hall, 973-596-6188 ,ecastro@njit.edu**
- **Prof. Milano, P.E., 239-Colton Hall, 973-596-5830, milano@njit.edu**

**Lab: 423-Colton Hall**
MECH 237-**001**, Thur., 2:30-3:30 p.m. and **-003**, Thur., 11:30 a.m.-12:30 p.m., Celina
MECH 237-**005**, Tues., 2:30-3:30 p.m. and -**007**, Tues., 4:00-5:00 p.m., Rima
MECH 237-**009**, Fri., 8:30-9:30 a.m. and -**011**, Fri., 10:00-11:00 a.m., Celina
MECH 237-**101**, Thur., 4:00-5:00 p.m. and -**103**, Thur., 9:00-9:50 p.m., Rima
- **Celina Semaan, PhD Candidate, css39@njit.edu**
- **Rima Abi Saad, PhD Candidate, ra426@njit.eu**

**Prerequisites**: MECH 234 or MECH 235 with a grade of C or better and MATH 112, PHYS111/111A. A working knowledge of statics with emphasis on force equilibrium and free body diagrams. Provides an understanding of the kinds of stress and deformation and how to determine them in a wide range of simple, practical structural problems, and an understanding of the mechanical behavior of materials under various load conditions. Lab should be taken concurrently.

***"Academic Integrity is the cornerstone of higher education and is central to the ideals of this course and the university. Cheating is strictly prohibited and devalues the degree that you are working on. As a member of the NJIT community, it is your responsibility to protect your educational investment by knowing and following the academic code of integrity policy that is found at: http://www5.njit.edu/policies/sites/policies/files/academic-integrity-code.pdf.***

*Please note that it is my professional obligation and responsibility to report any academic misconduct to the Dean of Students Office.* ***Any student found in violation of the code by cheating, plagiarizing or using any online software inappropriately will result in disciplinary action. This may include a failing grade of F, and/or suspension or dismissal from the university.*** *If you have any questions about the code of Academic Integrity, please contact the Dean of Students Office at dos@njit.edu"*

**Tutoring:** The Lab Instructors will have tutoring hours in **423-Colton**
**Colton Hall** and will be available to all students in all of the Strength of Materials sections.
**Rm. 423** Lab Instructors are available for help with course material and lab questions.

**All students must have proper prerequisites for Mech 237, Strength of Materials; Mech 235 Statics and Math 112 Calculus II. Students without these prerequisites will be dropped from the course.**

**Students must earn a grade of C or better in this course to register for CE332, CE341 or CE431.**

**Course Policies:**

- Attendance is mandatory
- There will be NO need for electronic devices during class time. Turn OFF your cell phone and put it away. Put away your laptop, tablet, or any other electronic device.
- Bring your textbook to each class meeting or pages from the relevant chapter.
- Take notes and pay attention. Ask questions.
- Be prepared to participate with board work and/or class problem solving. Bring your calculator for class participation.

**Quizzes, Exams and Grading Policies:**

- Instructors have the discretion to administer exams and/or quizzes to be announced in class. Exams and quizzes will comprise 50% of your grade.
- There will be a Final Exam in week 15 during Finals Week. This will be 25% of your grade.
- Quizzes / exams must have Free-Body-Diagrams. ALL work must be shown for full credit.
- There will be NO make-up quizzes or exams unless there is documentation provided to the Dean of Students Office to validate your absence. Such circumstances may include sickness documented by a doctor or Health Service; a receipt from your mechanic for car failure; etc.
- We do NOT drop the lowest grade. We do NOT curve the grades.
- You must receive a passing grade in both the lab and the lecture to pass the course. Failure of either requires repeating both lecture and lab. In other words, failing the lab or the lecture means failing the course, so, do all of your work, please.

**Homework Policies:**

- Follow the syllabus and do the homework problems suggested. Quiz problems may be taken from the homework problems or be very similar to the homework or those Sample Problems in the textbook. Same for exam problems.

- Do your homework. Have it ready each week. Your instructor has the discretion to modify assignments and collection policy. NO credit for homework copied from another source.
- NO late homework will be accepted. NO credit for homework copied from another source.
- All homework MUST include a Free-Body-Diagram. All work must be shown for full credit.
- For more information on the format for homework and the type of paper, read the information following the course outlines.

**NJIT classes begin on Tuesday, Sept. 3 and end on Wednesday, Dec. 11, 2019.**

| **WEEK** | **TOPICS** | **ARTICLES** | **Homework Problems** (your instructor may modify) |
|---|---|---|---|
| 1<br>Ch. 1 | Concept of Stress and Strain<br>with a Review of Statics | p. 1-26 | 1.4, 1.8, 1.10, 1.12, 1.24, 1.26 |
| 2<br>Ch. 1<br>Ch. 2 | <br>Concept of Stresses, continued<br>Stress and Strain - Axial Loading | <br>p. 27-47<br>p. 57-79 | <br>1.30, 1.52, 1.67<br>2.2, 2.6, 2.8, 2.22 |
| 3<br>Ch. 2 | Composites, Temperature Change, and<br>Poisson's Ratio | p. 80-95<br>p. 96-116 | 2.37, 2.47, 2.59<br>2.61, 2.63, 2.68 |
| 4<br>Ch. 3 | Torsion<br>Torsional Stresses in Shafts | p. 148-167 | 3.2, 3.6, 3.9, 3.20 |
| 5<br>Ch. 3 | Torsion, Transmission Shafts and Gear<br>Trains, Horsepower | p. 168-193 | 3.41, 3.48, 3.57, 3.64, 3.76 |
| 6<br>Ch. 4 | Pure Bending | p. 237-258 | 4.9, 4.11, 4.18, 4.20,<br>4.22*, 4.24 |
| 7<br>Ch. 5 | Analysis and Design of Beams for<br>Bending: Shear and Moment Diagrams | p. 347-361 | **Draw the V & M diagrams:**<br>5.7, 5.9, 5.10, 5.12, 5.16, 5.20 |
| 8<br>Ch. 5 | Section 5.2 Develop Equations<br><br>Section 5.3 Design / Select the Beam<br>Review and Summary | p. 362-370<br><br>p. 373-381<br>p. 408-410 | **Write the equations for these:**<br>5.42, 5.43, 5.47, 5.49<br>**Design** / **select** the beam for:<br>5.67, 5.75 |
| 9<br>Ch. 6<br>Ch. 7 | Shearing Stresses: Beams and Thin-<br>Walled Members<br>Transformations of Plane Stress | p. 417-426<br><br>p. 477-491 | <br><br>**Solve by equations:**<br>7.1, 7.2, 7.6 & 10, 7.7 & 11 |
| 10<br>Ch. 7 | Mohr's Circle for Plane Stress<br><br>Plane Strain, Strain Rosettes | p. 492-502<br><br>p. 538-550 | **Draw Mohr's Circle**:<br>7.31, 7.33, 7.38, 7.50<br>7.128 &132, 7.147, 7.148 |
| 11<br>Ch. 9 | Deflection of Beams,<br>Integration Method | p. 599-622 | 9.10, 9.11, 9.13, 9.16 |
| 12<br>Ch. 9 | Deflection of Beams,<br>Superposition Method | p. 635-648 | 9.73, 9.78<br>refer to table in FE Handbook |
| 13<br>Ch. 10 | Column Buckling under Axial Load | p. 691-708 | 10.10, 10.13, 10.19, 10.26 |

| | | | |
|---|---|---|---|
| 14 | Column Buckling continued | p. 722-728 | |
| 15 | FINAL EXAM | . | . |

## Laboratory Schedule (remember that our weeks begin on Tuesday)

| Week beginning: | Lab Topic | Due |
|---|---|---|
| 1<br>Sept. 3 | Room **423-Colton Hall**: Introduction, Safety, Procedures for Lab, Instructions on how to prepare your Lab Reports, Grading Policies | READ about Reports in Lab Manual |
| 2<br>Sept. 10 | Experiment 1: **Pre-Lab Presentation, 423-Colton**<br>Tension Test of Metals, Automated Testing of Steel and other metal (refer to Ch. 1 and 2 in text) | . |
| 3<br>Sept. 17 | Experiment 1: **Experiment**, 413-Colton Hall<br>Tension Test of Metals, Automated Testing of Steel and other metal | Formal report dueweek 6 |
| 4<br>Sept. 24 | Meet with Lab Instructor for assistance with Analysis of Data and using Spreadsheets for the Labs and how to prepare your Lab Report | . |
| 5<br>Oct. 1 | Experiment 2: **Pre-Lab Presentation,** 423-Colton<br>Torsion Test of Metallic Materials (refer to Ch. 3 in text) | . |
| 6<br>Oct. 8 | Experiment 2: **Experiment**, 413-Colton Hall<br>Torsion Test of Metallic Materials | Formal report dueweek 8 |
| 7<br>Oct. 15 | Meet with Lab Instructor for help to complete lab reports and begin to study for the next experiment | . |
| 8<br>Oct. 22 | Experiment 3: **Pre-Lab Presentation**, 423-Colton<br>Stresses, Strains and Deflection of Steel Beams in Pure Bending (refer to Ch. 4 and 5 in text) | . |
| 9<br>Oct. 29 | Experiment 3: **Experiment** in 413-Colton Hall<br>Stresses, Strains and Deflection of Steel Beams in Pure Bending | Formal report dueweek11 |
| 10<br>Nov. 5 | Experiment 4: **Pre-Lab Presentation**, 423-Colton<br>Strain Measurements Using Strain Rosettes in Aluminum Beams (refer to Ch. 7 in text) | . |
| 11<br>Nov. 12 | Experiment 4: **Experiment,** 413 Colton Hall<br>Strain Measurements Using Strain Rosettes in Aluminum Beams | Informal report dueweek 13 |
| 12<br>Nov. 19 | Experiment 5 : **Pre-Lab Presentation,** 423-Colton Hall<br>Compression Test of Steel Columns, Column Buckling (refer to Ch. 10 in text) | . |
| 13<br>Dec. 2 | Experiment 5 : **Experiment,** 413-Colton Hall<br>Compression Test of Steel Columns, Column Buckling | Informal report dueweek 14 |
| 14<br>Dec. 9 | Experiment 5 reports are due this week. | . |

The **Honor Code** will be upheld and any violations will be brought to the immediate attention of the Dean of Students.
Remember to cite your references when writing your lab reports. Each person will contribute to and be responsible for each lab report submitted.

**Laboratory Safety**

Your safety and the safety of those around you are of prime importance. Efforts have been made to reduce the hazard in the lab as much as possible. If you should see anything that you consider to be a safety hazard report this condition to your lab instructor. Take your experiments seriously. Forces into the thousands of pounds will be used throughout the course and if these forces are released in an uncontrolled manner injuries are possible. Horseplay will not be tolerated and will constitute grounds for dismissal from the course.

**Grading Policies for LAB**

Your lab grade will represent 15% of your course grade. The lab grade will be averaged into your lecture grade to determine your final grade. You must receive a passing grade in both the lab and the lecture to pass the course. Failure of either requires repeating both lecture and lab. In other words, failing the lab or the lecture means failing the course, so, do all of your work, please. **Three unexcused absences will result in automatic failure of the lab and course.**

All reports should be word processed. Graphs are to be computer generated.

The results of the experiment are the results you must work with. Do not "cook" the results to produce the "expected" results. Draw your conclusions based on these results. If they are not as expected (you should have an idea of the expected results), account for the discrepancies.

Reports are also graded on your presentation. Is the material presented in a logical way? Can all of the required results be found with ease? Are the results discussed intelligently, in a good technical language? Can all the questions that enter the readers mind be satisfied? Be advised that your discussion and conclusions will probably carry more weight than production of the right answers.

All labs are due at the meeting after they were conducted. Due dates are listed on the syllabus. After the due date reports will be accepted for 75% credit. After the reports have been returned to the class late papers will be accepted for only 50% credit. Papers more than two weeks late will not be accepted.

You should keep a copy of the work you turn-in. If a report is "lost" it is a favor to the instructor, and insurance for you, to be able to submit a copy of the report.

QUIZZES, EXAMSand FINAL (Attendance at exams is mandatory. Excused absences will require appropriate documentation.)

1. Quiz/exam problems will include theory as well as numerical problems. Questions on the laboratory may also be asked.
2. All quizzes, exams and final exam are closed book. Only the FE Handbook may be used as a resource BUT no additional notes may be written in the handbook.
3. All problem solutions must be done on paper provided. The format of the solution must include assumptions and the solution or answer clearly shown.
4. The solution must illustrate the understanding of the material. Correct numerical solutions alone are insufficient for any credit.
5. If a problem starts with incorrect assumptions and formulations, it will receive no credit.
6. All answers must be accompanied by the appropriate and correct units.
7. Quizzes, exams and the final are to be taken with a fully charged calculator. Calculators may not be borrowed during the quizzes.
8. The dates of the quizzes/exams will be announced in advanced.
9. The grade of "I" (incomplete) will not be given for unsatisfactory academic performance.
10. No mid-term warning notice will be given. Maintain your own records of grades.
11. Students cannot leave the classroom during quizzes or exam.
12. Cell phones (and other electronic devices) must be OFF and put away during exams.

HOMEWORK

1. Homework sets are due as announced by your instructor.
2. Homework must be submitted in sets, arranged in order as in course outline.
3. The homework must be written on quadrille 8½ x 11 engineering pad. Use 5-square per inch National Computation pad paper ONLY (sold at the NJIT Bookstore). The proper form consists of doing the problems on one side of 8-1/2 x11 pad paper. Also acceptable; engineering paper from office supply stores.)
4. On the top of each page, in the space provided, PRINT your name, course and **section**, and problem number. Write on ONLY the front side of the paper.
5. All problems must have a F.B.D. or some figure to describe the problem.
6. Sets must be stapled together in the upper left hand corner. DO NOT HAND IN CLASS NOTES. Put the problem number in the UPPER RIGHT corner.
7. NO LATE Homework will be accepted. NO credit for work copied from a solution source.

Students are expected to properly maintain their registration status. If your name does not appear on the final grade sheet, it is not possible to assign you a grade and it will be necessary for you to repeat the course.

| GRADING | GRADE RANGE | GRADE |
|---|---|---|
| Weekly Quizzes / Exams ….. 50% | 100 - 88 | A |
| Final Exam ……. 25% | 87 - 82 | B+ |
| Laboratory ……. 15% | 81 - 76 | B |
| Homework ……. 10% | 75 - 70 | C+ |
| | 69- 65 | C |
| *NOTE: There is no grade of D for | 64 - 60 | D* |

CE students. 59 and below F

Students will be consulted for any substantial changes to the course outline. Changes will be discussed and announced in advance.

Prepared by Milano, 8/25/14, 1/8/15, 1/16, 1/17, 8/17, 1/18, 8/18, 1/19, 8/19

**Outcomes Course Matrix MECH 237 Strength of Materials**

| Strategies, Actions and Assignments | ABET Student Outcomes (1-7) | Program Educational Objectives | Assessment Measures |
|---|---|---|---|
| **Student Learning Outcome 1: Identify and calculate the state of stresses and strains in engineering components as a result of different loading conditions.** | | | |
| Introduce the concept of determining stresses and strains from the member forces. | 1 | 1 | Weekly homework and quizzes. |
| Provide the principles of normal and shearing stresses and how to determine the principal stresses. | 1 | 1, 2 | Weekly homework and quizzes. |
| **Student Learning Outcome 2: Analyze structural members under axial loads, bending, shear, and torsion.** | | | |
| Provide the basic concepts and effects of axial loads, bending, shear, and torsion on structural components. | 1 | 1 | Weekly homework, quizzes and lab experiments. |
| Introduce the methods used to solve determinate and indeterminate problems. Compare analytical work with results from MD Solids software program. | 1 | 1, 6 | Weekly homework, quizzes and review of assigned problems. |
| **Student Learning Outcome 3: Identify the behavior of various engineering materials, their performance under loads, and design needs.** | | | |
| Introduce a state of the art analysis with Instron testing apparatus. | 1, 7 | 1, 2, 6 | Homework and lab experiments. |

**CEE Mission, Program Educational Objectives and Student Outcomes**

The mission of the Department of Civil and Environmental Engineering is:

- to educate a diverse student body to be employed in the engineering profession
- to encourage research and scholarship among our faculty and students
- to promote service to the engineering profession and society

Our program educational objectives are reflected in the achievements of our recent alumni:

1 – Engineering Practice: Alumni will successfully engage in the practice of civil engineering within industry, government, and private practice, working toward sustainable solutions in a wide array of technical specialties including construction, environmental, geotechnical, structural, transportation, and water resources.

2 – Professional Growth: Alumni will advance their skills through professional growth and development activities such as graduate study in engineering, research and development, professional registration and continuing education; some graduates will transition into other professional fields such as business and law through further education.

3 – Service: Alumni will perform service to society and the engineering profession through membership and participation in professional societies, government, educational institutions, civic organizations, charitable giving and other humanitarian endeavors.

Our Student Outcomes are what students are expected to know and be able to do by the time of their graduation:

1. an ability to identify, formulate and solve complex engineering problems by applying principles of engineering, science and mathematics
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety and welfare, as well as global, cultural, social, environmental and economic factors
3. an ability to communicate effectively with a range of audiences
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental and societal contexts
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks and meet objectives
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data and use engineering judgment to draw conclusions
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies

Revised: 2/13/18, 5/18/18