Fall 2023

ME 632-101: Mechanical Engin Measurements

Chao Zhu

ME 632 Mechanical Engineering Measurements Fall 2023

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TA: Mohammad (Mo) Moghanjooghi; Office: MEC104; e-mail: mm422@njit.edu

- Prof. Zhu for all lectures (except for PLC), HW/Project/Exam grading and lab supervision;
- Prof. Ji for PLC lecture and PLC lab;
- Mo for all lab report grading and in-lab assistance

Office hours: Wednesdays: 4:00 pm -5:00 pm

Lecture Notes: to be sent after each class

Textbook: J. P. Holman, Experimental Methods for Engineers, 8th Ed., McGraw Hill, 2012

1. Prerequisites of Basic ME Measurements Methods and Relevant Theories

Measurement/Theory Topics	Textbook Sections	Key concepts
Electric circuits; Signal Conditioning	2.7, 4.12, 14.3	Wheatstone bridge; RC filtration; Power spectrum; Digital filtration
Data analysis	3.2-3.9, 3.11-3.14	Random and precision errors; Least square method; Uncertainty analysis
Speed Measurements: Linear or Rotation	-	Cross-correlation theory; Oscilloscope applications
Temperature Measurements	8.5,8.6, 8.8, 8.9	Thermocouple; thermo-resistance; pyrometers
Force and Torque Measurements	10.3-10.8	Strain-stress relationship; strain gage method
Flow measurements: Flowrate, Velocity and Flow frictional losses	7.3, 7.4, 7.6, 7.13	Venturi, orifice & rotameter; Pitot tube, LDV and PIV; Flow visualization, Flow frictional losses
Programmable Logic Control	-	Ladder logic diagram
Thermodynamic properties and processes of pure substances and binary mixture	-	Thermodynamic processes (such as isobaric, isothermal, adiabatic, and isentropic) on p-h diagram, Psychrometric processes on psychrometric chart
Thermodynamics: power cycles	-	Carnot cycles, Otto cycles, Diesel cycles, Rankine cycles
Thermodynamics: refrigeration cycles	-	Reverse Carnot cycles, Reverse Rankine cycles
Turbine Machinery: fluid power	-	Fans/blowers, Pumps, Compressors
*Acoustics and sound measurement	11.5	Sound pressure level (dB); Attenuation
*Vibration measurements	-	Vibration frequency
*PID Control	-	PID Control

* preferred but not required

2. Lab and Project Arrangement

	Lab Title	Lab requirements
Group 1 (thermodynamics & thermofluids)	Pipe Flows: Flow and Heat Transfer Characteristics	Measurement & analysis
	Power Generation of Gasoline Engine	Design & exp. methods
	Air Conditioning by Vapor-compression Cycle	Design & exp. methods
Group 2	Dynamic Stresses and Deformation in Collision	Measurement & analysis

(stress & control)	PLC Pneumatic Actuator Control	Design & exp. methods
Project Design (one project per one/two students)	Using a published research paper or thesis, present & defend an experiment-based project	Design, exp. methods, data analysis, & presentation

3. Lecture Arrangement

1) Introduction to ME Measurement
   -- Course structure & requirement
   -- Understand predesigned labs vs design new labs
   -- Calibration vs theoretical (or CFD) comparison
   -- Lab report & lab group constitute
2) Basic Data Analysis
   Curve fitting; data uncertainty; system uncertainty
3) Basic Measurements
   Flow, temperature, force, motion, signal conditioning
4) Predesigned Group-1 Labs
   -- Flow Measurements in Pipe Flows
   -- Heat Transfer Measurements in Tubular Heat Exchangers
   -- Power Generation and Cooling by Thermodynamic Cycles
5) Predesigned Group-2 Labs
   -- Static and Dynamic Load Measurements
   -- PLC Logic Control
6) Project Design (based on published paper or thesis)
   - Project objectives & background
   -- System design with theoretical basis
   -- Measurement methods and equipment characteristics
   -- Sample experimental results
   -- (Bonus) calibration or uncertainty analysis
   -- (Bonus) theoretical comparison

3. Weekly Arrangement

Week	Date	Content	Assignments
1-3	9/6; 9/13; 9/20	Introduction; Data Analysis; Basic Measurements; Lectures of Group 1	HW#1 - 3
4-5	9/27; 10/4	Lab of Group-1	Lab Reports #1-3
6	10/11	Review of Group-1; Lecture of Group-3 (Stresses)	
7	10/18	Midterm	
8	10/25	MT Solution; Lecture of Group-3 (Stresses)	HW#4
9	11/1	Lab of Group-3 (Dynamic Stresses)	Lab Report #4
10-11	11/8; 11/15	Lecture & Lab on Group 3 (PLC)	HW#5; LR#5

12-13	11/29; 12/6	Presentation of Design Projects	Project Report
14	12/13	Review for Final	

Grading Policy

(1) Grade Calculations

25% Lab abstracts (5; 5% each)
10% Project Report (1; 10%)
25% Homework (5; 5% each; each problem has the equal weight factor)
20% Mid-term Examination
20% Final Examination

Final Grade is based on the total grade. Some bonus points may be assigned in HW (20%) and tests (15%). Specifically above 85% guarantees an "A" grade and below 60% will result in an "F" grade (**No curving**!). "C and C+" grade is for 60-69%; and "B and B+" grade is for 70-84%.

No make-up exams!

(2) Lab Report Requirement

All reports should be individually completed and submitted in time. Group discussion is encouraged but not for "Group Report". For identical reports or very similar reports, the grade is divided by the number of students involved. Resubmitted Lab report is accepted (final grade will be averaged with the original grade).

(3) Homework Requirement

(a) Five Assignments will be given, with 5 (+1) problems per assignment.
- Assignments are due on noon of Friday of the due week, with no late or resubmission.
- HW in hard copy should be submitted directly to my office (MEC204) or in class. Do not leave it to my mailbox in ME department office!
- No online submission unless pre-approved by instructor.

(b) Homework grade is based on "completeness" and "reasonableness", not necessarily on "correctness".
- Completeness: answer all questions asked in the problem, with brief and clear explanation (preferably in terms of equations or graphic diagrams).
- Reasonableness: apply relevant academic approaches (using theories or engineering knowledge) to seek the solution.

(c) Solution discussions will be given in class in the next class after the week of due.

(4) Mid-term/Final Exam Requirement

(a) A 2-hour mid-term exam will be given, mainly covering topics on Data Analysis and Methods in Group 1 Labs & lab designs.
(b) A 2.5-hour final exam will be given, mainly covering topics of Methods in Group 2 & lab designs.
(c) **All exams are open book and notes (hard copies only!)**. No computer/iPad/iPhone/any internet-connectable device!

Project Requirement and Grading Policy

(one project per one/two students; total **10 points**)

1. The project consists of two parts: (a) oral ppt presentation (10 min.) and oral defense (5 min); and (b) written report (hard copy of presentation + supporting materials). **5 points each part**.

2. For a team of two students, one is for presentation and the other is for defense, without any assistance between the two during the presentation and defense. Individual grading for this part (Part (a)). The grade of report (Part (b)) will be the same for each student.

3. Project must be experiment-based and related to Mechanical Engineering, from a published resources (such as research paper or thesis that can be publicly cited). No on-going research projects can be used without the written permission of project principal investigator (PI).

4. The project should contain the following:

   (a) **What**: what is the purpose of the experiment or what needs to be determined from the measurements?
   (b) **Why**: Why can the measurements be linked to your experiment objectives. Quantitative relationship between the two must be provided.
   (c) **How**: How is the experiment designed? (Schematic diagram of experiment set-up must be provided); and how are the measurements obtained (with what types of measurement devices used and why to select a particular one against other options, if any)?
   (d) **So What**: Conclude the significance of the results from experiment. For example, how to validate your measurements (such as against available theory or definition)? Or by conducting an error/analysis of the measurements.

5. The project presentation is scheduled on Nov. 29 and Dec. 6. Any volunteers to present first will be allow to do so. Otherwise, the order to present will be based on the alphabetic order of the last names of students (whichever comes first of the two students in a team). Those completing the presentation on Nov. 29 will not be required to attend the class on Dec. 6.

6. The last class is on Dec. 13, for a review preparation for final. **All lab resubmissions are due on Dec. 13.**

7. Project Grading Sheet:

Group No: Presenter/Defender:

Evaluation category	**Presenter**		**Defender**	
	Max			
Project objective that requires experimental design and measurements	1		Total points to be judged by answers to questions relevant to any items in evaluation category	
Measurands and relation to objective(s)	1			
Design of experimental system	1			
Experimental results to support the project objectives	1			
Presentation Time control and verbal clarity	1			
Experimental system redesign (to address the deficiencies in the original design) or Uncertainty analysis **(bonus)**	1			
Sub-Total	5+1			