ME 632 Mechanical Engineering Measurements Spring 2025

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- 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, in-lab assistance, and assistance in Project grading

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 ME Measurements (review)
   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 linking measurements to objectives
   -- Measurement methods and equipment selection justifications
   -- Sample of data acquisition and analysis, which lead to experimental results
   -- (Bonus option-1) calibration or comparison against theoretical predictions or simulation, OR
   -- (Bonus option-2) identification of deficiencies of the system design, with a proper system redesign

3. Weekly Arrangement

Week	Date	Content	Assignments
1-3	1/22; 1/29; 2/3	Introduction; Data Analysis; Basic Measurements; Lectures of Group 1	HW#1 - 3
4-5	2/12; 2/19	Lab of Group-1	Lab Reports #1-3
6	2/26	Review of Group-1; Lecture of Group-3 (Stresses)	
7	3/5	Midterm	
8	3/12	MT Solution; Lecture of Group-3 (Stresses)	HW#4
9	3/25	Lab of Group-3 (Dynamic Stresses)	Lab Report #4
10-11	4/2; 4/9	Lecture & Lab on Group 3 (PLC)	HW#5; LR#5

12-13	4/16; 4/23	Presentation of Design Projects	Project Report
14	4/30	Review for Final	

Grading Policy

(1) ***This course expects students to work without artificial intelligence (AI) assistance*** *in order to better develop their skills in this content area. As such, AI usage is not permitted throughout this course under any circumstance.*

(2) 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!

(3) 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).

(4) 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.

(5) 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 +1 points**)

1. The project consists of two parts: (a) oral ppt presentation and defense (12 + 3 min.); and (b) written report (hard copy of presentation + supporting materials). **50% each part**.

2. For a team of two students, there are additional requirements:
   - A roughly equal share on presentation and defense;
   - List of individual's contributions to the project;
   - Develop a lab report of the project, with basic lab-report format and contents.

3. Project must be experiment-based, whose measurement techniques are closely or directly related to our course coverage in Mechanical Engineering Measurement, from a published resource (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.
   - No duplication of previous project design (if unsure, check with Prof. Zhu for approval on project topic before starting the project);
   - Key reference resources must be recent (preferably within 10 years but at least within 20 years).

4. The project should contain the following:

   (a) **What**:
   - What is the purpose of the experiment or what is its background in ME-related applications?
   - What are the specific quantitative objectives 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.
   - Why are these measurements belong to Mechanical Engineering Measurement?

   (c) **How**:

   How is the experiment designed? Key items include:
   - Schematic diagram of a complete design of experiment set-up;
   - Selection of proper measurement devices, with justifications on their suitability (or why to select a particular one against other options, if any). Suitability includes applicable measurement principle, device characteristics (coverage range, accuracy, etc), and cost factors.
   - Arrangement in data acquisition and analysis that lead to the experimental objectives

   (d) **So What**:
   - Conclude the significance of the results from experiment. For example, does the experiments achieve their designed objectives? Any unexpected findings from the measurements?
   - (Bonus option-1) calibration or comparison against theoretical predictions or simulation, OR
   - (Bonus option-2) identification of deficiencies of the system design, with a proper system redesign.

5. The project presentation is scheduled on April 16 and April 23. 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 April. 16 will not be required to attend the class on April 23.

6. The last class is on April 30, for a review preparation for final. **All lab resubmissions are due on April 30.**

7. Project Grading Sheet:

Group No: Student Name(s):

Evaluation category	**Max**	
Project objective that requires experimental design and measurements	1	
Measurands and relation to objective(s)	1	

Design of experimental system	2	
Selection of proper measurement devices	2	
Data acquisition/analysis method/format	1	
Experimental results to support the project objectives	2	
Presentation Time control and verbal clarity	1	
Experiments vs theoretical predictions OR experimental system redesign (to address the deficiencies in the original design) **(bonus)**	1	
Sub-Total	10+1	