

University Of California, Berkeley
Department of Mechanical Engineering

ME 103 – Experimentation and Measurements (4 units)

Undergraduate Required

Syllabus

CATALOG DESCRIPTION

This course introduces students to modern experimental techniques for mechanical engineering, and improves students' teamwork and communication skills. Students will work in a laboratory setting on systems ranging in complexity from desktop experiments with only a few instruments up to systems such as an internal combustion engine with a wide variety of sensors. State-of-the-art software for data acquisition and analysis will be introduced and used throughout the course. The role of error and uncertainty, and uncertainty propagation, in measurements and analysis will be examined. Design of experiments will be addressed through examples and homework. The role and limitations of spectral analysis of digital data will be discussed. Working as part of an effective team will be emphasized in all aspects of the laboratory exercises, including set-up, data collection, analysis and report writing.

COURSE PREREQUISITES

MEC85, ME40, EE 100/EE 49/EE16A, ME 109

TEXTBOOK(S) AND/OR OTHER REQUIRED MATERIAL

Beckwith T.G. and Marangoni, R.D., 2007, "Mechanical Measurements, 6th edition", Pearson Prentice 5th edition also acceptable

Additional lecture slides and handouts will be provided for free.

COURSE OBJECTIVES

Introduce students to modern experimental techniques for mechanical engineering; provide exposure to and experience with a variety of sensors, including those to measure temperature, displacement, velocity, acceleration and strain; examine the role of error and uncertainty in measurements and analysis; exposure to and experience in using commercial software for data acquisition and analysis; discuss the role and limitations of spectral analysis of digital data; provide experience in working in a team in all aspects of the laboratory exercises, including set-up, data collection, analysis, technical report writing and oral presentation.

DESIRED COURSE OUTCOMES

By the end of this course students will have experienced the many stages in designing, planning and conducting experiments, and eventually reporting the results both orally and in writing in a team environment. They will have also have seen the importance of fundamental science and complex engineering skills that are needed in engineering. Equally important, they will work in a team environment where the success of the team depends on the success of every team member. Specifically, by the end of the course students should: Know how to use, what can be measured with, and what the limitations are of the basic instruments found in the laboratory; know

how to write a laboratory report and communicate their results in the form of an oral presentation; understand the relevance of uncertainty in measurements, and the propagation of uncertainty in calculations involving measurements; know how to program effectively using LabVIEW for data acquisition and analysis. In brief: Prepare students for experimental work, or its management, in academic or industrial labs.

TOPICS COVERED

- Data acquisition and control software: LabVIEW
- Sensors: I/O requirements, calibration, limitations
- Dynamic analysis of signals: spectral analysis, bandwidth, frequency response
- Elementary statistics: normal and t-distributions, confidence intervals
- Uncertainty analysis: techniques for propagation of uncertainty
- Teams: forming, expectations, potential problems
- Technical communication: written, oral
- Design of experiments
- Measurements for complex systems

CLASS/LABORATORY SCHEDULE

Three hours of lecture and three hours of lab per week.

CONTRIBUTION OF THE COURSE TO MEETING THE PROFESSIONAL COMPONENT

Provides a platform where students work on increasingly complex measurement systems as teams, make formal oral presentations and submit complete technical reports. Provides the flexibility and structure to implement experiments designed by the students testing varying configurations and setups.

RELATIONSHIP OF THE COURSE TO ABET PROGRAM OUTCOMES

- (a) an ability to apply knowledge of mathematics, science, and engineering
- (b) an ability to design and conduct experiments, as well as to analyze and interpret data
- (c) an ability to function on multi-disciplinary teams
- (d) an ability to identify, formulate, and solve engineering problems
- (e) an understanding of professional and ethical responsibility
- (f) an ability to communicate effectively
- (g) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
- (h) a recognition of the need for, and an ability to engage in life-long learning
- (j) a knowledge of contemporary issues
- (i) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

ASSESSMENT OF STUDENT PROGRESS TOWARD COURSE OBJECTIVES

Students will perform a set of five or six laboratory experiments and will report their findings both in writing and orally (60% of the grade). Homework will count for 15% of the grade. 5% for lecture and lab participation

5% for in-lab practical exam. The final exam will count for 15% of the final grade.

SAMPLE OF WEEKLY AGENDA

- 1) Intro to the lab - 2 wk
 - a. Intro to the lab equipment,
 - b. Basics of LabView, etc.
 - c. Vibrating beam to review sensor basics (introducing 6 different sensors, static and dynamic calibration, intro to LVDT, encoders, IR sensors, strain gages, coils, accelerometer, Static and dynamic, calibration of sensors, Data analysis
- 2) Image based measurements^{1,2} – 3 wk
 - a. Intro to color and B&W machine vision
 - b. How to record, stream and analyze (live or post) the data
 - c. Object sizing, motion, etc. (varying from year to year: monitoring of 3D printing, ball position, vibrating beam, PIV, PTV, etc.)
- 3) Wind tunnel lab^{1,2,3} – 3 wk (utilizing two new wind tunnels, with old tunnel as backup)
 - a. Intro to wind tunnels
 - b. Force measurements, flow induced vibrations, flow separation, etc.
- 4) Thermal lab³ (cooling or heating in wind tunnel) – 3 wk
 - a. Intro to IR imaging
 - b. Intro to thermocouples and/or RTDs
 - c. Advective cooling, etc.
- 5) IC engine lab – 3wk
 - a. Intro to IC engines and the various configurations
 - b. Sensors for monitoring IC engine operation

¹most years utilizes 3D printed parts or data from 3D printers

²utilizes new machine vision system, but can be done with old cameras, if scheduling is an issue

³most years utilizes the new wind tunnels

Sample schedule:

Group	1	2	3	4	5	6	7	8
Week 1	Intro lab - vibrating beam							
Week 2								
Week 3	Image based				Temperature lab			
Week 4	Measurements				w/ thermal imaging			
Week 5								
Week 6	Temperature lab				Image based			
Week 7	w/ thermal imaging				Measurements			
Week 8								
Week 9	Wind tunnel				IC		IC	
Week 10	lab				IC		IC	
Week 11								
Week 12	IC		IC		Wind tunnel			
Week 13	IC		IC		lab			
Week 14								

Week	Lectures	Lab #
1	Introduction, team formation Intro lab prep and LabVIEW demo, dynamic calibration	1
2	Probability: student's t-distrib. and ML demo Uncertainty intro, lab 2 & 3 prep	
3	Lab 2 & 3 basic materials for measurements involved Lab 2 & 3 basic materials for measurements involved	2 or 3
4	Discuss LV for labs 2&3 Ideas and intro to image based measurements (for wavelengths from visible to infrared)	
5	Lab reports lecture Uncertainty, probability, 1 of 3	
6	FFT review and ML-demo Measurements based on imaging examples	2 or 3
7	Writing and editing lecture Image processing basics, filters, convolution etc.	
8	Design of experiments 1 Lab 4 & 5 basic materials for measurements involved	
9	Lab 4 & 5 basic materials for measurements involved design of experiments 2	4 or 5
10	Design of experiments 3 System response, system classification	

11	Last (major) homework motivation and details Uncertainty, probability, 2 of 3	
12	Review of statistics and demos Uncertainty, ISO GUM etc., 3 of 3	4 or 5
13	Oral presentations lecture 1 Design of experiments 4	
14	Oral presentations lecture 2 Review lecture	

See lab descriptions above

PERSON(S) WHO PREPARED THIS DESCRIPTION

[Simo Makiharju and George Johnson] [April 4, 2017]

ABBREVIATED TRANSCRIPT TITLE (19 SPACES MAXIMUM): [ss completes]

TIE CODE: LECS

GRADING: Letter

SEMESTER OFFERED: Fall and/or Spring

COURSES THAT WILL RESTRICT CREDIT:

INSTRUCTORS: George Johnson, Simo Makiharju, J-Y Chen

DURATION OF COURSE: 14 Weeks

EST. TOTAL NUMBER OF REQUIRED HRS OF STUDENT WORK PER WEEK: 9

IS COURSE REPEATABLE FOR CREDIT? No

CROSSLIST: None