**University Of California, Berkeley**
**Department of Mechanical Engineering**

# ME 102A – Introduction to Measurement Systems for Mechatronics

**Syllabus**

## CATALOG DESCRIPTION

The objectives of this course are to introduce students to modern experimental techniques for mechanical engineering, and to improve students' written and oral communication skills. Students will be provided exposure to, and experience with, a variety of sensors used in mechatronic systems including sensors to measure temperature, displacement, velocity, acceleration and strain. The role of error and uncertainty in measurements and analysis will be examined. Students will also be provided exposure to, and experience with, using commercial software for data acquisition and analysis. The role and limitations of spectral analysis of digital data will be discussed.

## PREREQUISITES

Engineering 26 (waived for Junior Transfers), Mechanical Engineering C85, ME 104, ME 132 (can be taken as a co-requisite if the course schedule allows) Electrical Engineering 16A or 40. Reading and Composition courses completed

## TEXTBOOK(S) AND/OR OTHER REQUIRED MATERIAL

*Introduction to Mechatronics and Measurement Systems,4th Edition*, David G. Alciatore and Michael B. Histand, McGraw Hill, 2012.

*i>Clicker*. Every student must bring an i>Clicker with them to each lecture.

## COURSE OBJECTIVES

Introduce students to modern experimental techniques for mechanical engineering; provide exposure to and experience with a variety of sensors used in mechatronic systems, including sensors 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 and report writing.

## STUDENT LEARNING OUTCOMES

By the end of this 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: oscilloscope, multimeter, counter/timer, analog-to-digital converter; know how to write a summary laboratory report; understand the relevance of uncertainty in measurements, and the propagation of uncertainty in calculations involving measurements; understand the physics behind the instruments and systems used in the laboratory; know how to program effectively using LabVIEW for data acquisition and analysis; understand the use of spectral analysis for characterizing the response of an instrument or system.

**TOPICS COVERED**

Measurement statistics and error propagation
Analog & digital signals
Data acquisition and control software (LabVIEW)
Digital data acquisition (A/D, speed, resolution, quantization errors, aliasing, reconstruction, etc.)
Dynamic response of measurement systems (amplitude, frequency and phase response, dynamic models and their response to standard excitations)
Signal processing (filtering, spectral analysis, integration & differentiation, etc.)
Review of simple circuits (voltage dividers, filters, amplifiers, etc.)
Laboratory instrumentation (desk-top: oscilloscope, digital multimeter, counter function generator and DC power supply)
Sensors
- Position
- Velocity
- Acceleration
- Strain
- Pressure
- Force
- Temperature
- Optical

Technical Communication
- Editing (for clarity, conciseness and directness) and review of grammatical conventions, proper punctuation and subordination.
- Letter, memo and basic written communication formats.
- Outlining/Abstracting.
- Oral presentations and use of video/visuals/illustrations.

**RELATIONSHIP OF THE COURSE TO ABET STUDENT OUTCOMES**[1]

An ability to apply knowledge of mathematics, science, and engineering.
An ability to design and conduct experiments, as well as to analyze and interpret data.
An ability to function on multi-disciplinary teams.
An ability to identify, formulate, and solve engineering problems.
An ability to communicate effectively.
A recognition of the need for, and an ability to engage in life-long learning.
An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

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[1] http://www.me.berkeley.edu/undergraduate/degree-program/program-objectives-and-outcomes-abet

**GRADING**

Lecture Participation (5%)
Homework (15%)
Technical Communications – lab reports and one oral report (60%)
1 In-Lab Practical Exam (5%)
1 In-Class Written Exam (15%)

**LECTURE PARTICIPATION**

We will be using the i>clicker student response system in class this term. Questions will be posed during most lectures based on expected prior knowledge, on readings that should have been done prior to class, or topics that we not sure what students know in advance. i>clickers help me to understand what you know and gives everyone a chance to participate in class. Past experience with this and other audience response systems indicates that their use improves student engagement and learning. We will use i>clicker to keep track of lecture participation. For full participation, you must respond to at least 75% of the questions posed throughout the semester.

If you do not have a clicker yet, you should purchase the latest model (i>clicker 2), but earlier models should also work as questions will be either to multiple choice or true/false. At this point, the mobile application REEF Polling will not be used.

You should register your clicker only within bCourses. **Do not** register your clicker online. If you do, we will not be able to match your responses with your name.

**HOMEWORK**

While this is largely a lab-based course, homework will be assigned on topics that complement the hands-on work that you will do.

Lab Schedule
(Version 1 – August 24, 2016)

| Week | Dates | Lab | Equipment/ Sensors |
|---|---|---|---|
| 1 | 8/24 – 8/26 | No Lab | -- |
| 2 | 8/29 – 9/2 | Introduction | Simple circuits; PXI instruments: Power Supply, Waveform Generator, Oscilloscope & Multimeter to produce/measure DC & AC Voltage & Current |
| 3 | 9/6 – 9/9 | No Lab (Labor Day) | -- |
| 4 | 9/12 – 9/16 | Introduction (continued) | LabVIEW; Digital data acquisition (DAQ); Spectral Analysis |
| 5 | 9/19 – 9/23 | Beam Bending | Load cell; linear optical encoder |
| 6 | 9/26 – 9/30 | Vibration | Kinematic Sensors: Encoder, strain gages, linear variable differential transformer (LVDT), IR proximity sensor, voice coil, accelerometer. |
| 7 | 10/3 – 10/7 | Vibration | -- |
| 8 | 10/10 – 10/14 | Ball Control | IR sensor, feedback control |
| 9 | 10/17 – 10/21 | Ball Control | Camera vision system |
| 10 | 10/24 – 10/28 | Peltier Heating/Cooling | Thermocouple, thermistor |
| 11 | 10/31 – 11/4 | Motor Characterization | Rotary encoder |
| 12 | 11/7 – 11/11 | Motor Characterization | -- |
| 13 | 11/14 – 11/18 | Inertial Measurement Unit Characterization | Accelerometer, gyroscope, magnetometer |
| 14 | 11/21 – 11/25 | No Lab (Thanksgiving) | -- |
| 15 | 11/28 – 12/2 | Lab Practical Exam | LabVIEW, Sensors, Spectral Analysis |
| RRR | 12/5 – 12/9 | Oral Report Presentations | -- |