University Of California, Berkeley
Department of Mechanical Engineering

ME 102A – Introduction to Measurement Systems for Mechatronics

Course Outline
Fall, 2016

PROFESSORS: George Johnson
6149 Etcheverry Hall
gcjohnson@berkeley.edu
Office Hours: Wednesday and Thursday 12:30 – 2:30

Marcel Kristel
6173 Etcheverry Hall
marcelk@berkeley.edu
Office Hours: Wednesday, 1:30 – 3:30 & by appt.

GSIs: Jianlan Luo
122 Hesse Hall
jianlanluo@berkeley.edu
Office Hours: Monday and Wednesday 5:00 – 6:00

Mohamed Hariri
122 Hesse Hall
mhariri@berkeley.edu

LECTURES: Monday and Wednesday 11:10 – 12:00, 390 Hearst Mining Building

LABS: Monday, Tuesday, Wednesday & Thursday 2:10 – 5:00, 122 Hesse Hall
A schedule of labs with topics is provided later in this document.

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


i>Clicker. Every student must bring an i>Clicker with them to each lecture.
QUESTIONS, DISCUSSION AND CLASS COMMUNICATION

This term we will be using Piazza for class discussion. The system is highly catered to getting you help fast and efficiently from classmates, the GSIs, and the faculty. Rather than emailing questions us, please post your questions on Piazza. Your posts can be made anonymous (to your classmates) if you wish. If you have any problems or feedback for the developers, email team@piazza.com.

You should have been invited to enroll already, but if not you may find our class page through bCourses, or at: https://piazza.com/berkeley/fall2016/meceng102alec001/home

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 us to understand what students 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 limited 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. Some problems will be assigned directly from the text, others will go beyond what the text covers. All homework answers are to be uploaded to bCourses in the form of a single PDF for each assignment. Please allow yourself time to complete the assignments and the upload before the submission deadline.

You are welcome to discuss the homework with others in the course, but every student is responsible for completing every problem on her or his own. To maximize learning, it is usually best for everyone involved to work on all problems before discussing them, then
get together to resolve difficulties or to discuss aspects of the results that may be unexpected, surprising, or seem wrong. It does very little good to have one person solve one problem, another solve another problem, then “share” their answers. The learning happens in the process of doing the work, not in copying what someone else has done!

TECHNICAL COMMUNICATION

Since this is largely a lab-based course, the majority of your effort will be spent in lab and in preparing descriptions of what you have done and learned from your lab work. This will involve writing short lab reports and making a group oral presentation at the end of the class. Most, if not all, of the reports will be submitted as a group, but every group member is expected to contribute equally to the final product. Specific information will be provided with each assignment regarding the format of the reports and the presentation.

LabVIEW

We will use the graphical programming language LabVIEW to interface between the computer and the “outside” world in the lab, and some of the homework will involve LabVIEW as well. LabVIEW is an extremely powerful and widely used program for data acquisition and system control. Thanks to the College of Engineering, the student version is available to you at no cost. Please download, install and activate (for PC installations) a copy on your computer as soon as you can. Having your own copy will allow you to complete the homework and prepare programs for lab without having to physically be in the lab.
## Lab Schedule
*(Version 1 – August 24, 2016)*

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

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.

RELATIONSHIP OF THE COURSE TO ABET STUDENT OUTCOMES

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.

---

1 [http://www.me.berkeley.edu/undergraduate/degree-program/program-objectives-and-outcomes-abet](http://www.me.berkeley.edu/undergraduate/degree-program/program-objectives-and-outcomes-abet)
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
  o Position
  o Velocity
  o Acceleration
  o Strain
  o Pressure
  o Force
  o Temperature
  o Optical
Technical Communication
  o Editing (for clarity, conciseness and directness) and review of grammatical conventions, proper punctuation and subordination.
  o Letter, memo and basic written communication formats.
  o Outlining/Abstracting.
  o Oral presentations and use of video/visuals/illustrations.