SGM

Experimental Methods in Engineering Mechanics – ME 412

Fall semester 2020
Lab / lecture: Wednesdays MED 2 2419 or online
according to EPFL campus access policy

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Wiki: https://wiki.epfl.ch/me412-emem-2020
Moodle: https://moodle.epfl.ch/enrol/index.php?id=15732
Grading: Assessment will take place during the semester via reports. Maintenance of an online lab notebook will be used for individual assessment, while a group report on the final experimental measurement of the real-contact area will comprise a component of the final grade. The breakdown of these two components will be weighted 60 % on the online lab notebook for each student, and 40% the group report on the measurement of the real area of contact. Details of expectations for the lab notebook and the final report will be presented in class; however, I include a brief description of these below.

IX. Rationale:

Experimental science is the cornerstone of all scientific progress. Being able to design, construct apparatus, carry out measurements and interpret data is essential to the scientific endeavor. In the field of mechanics, there are some experimental methods that have proved their utility, including the use of electronics in experiment, and imaging*. This class provides a broad introduction to these methods with specific classical examples in three modules. Through these examples, students will develop a foundation for future research and development in applied mechanics.

II. Course Aims and Outcomes:

Aims

At the end of this class, you should be comfortable working with analog electronics, constructing such circuits to perform a specific task, collecting and recording data generated with such apparatus, and collating and describing collected data in both text and plots or graphs.

Specific Learning Outcomes:

Students who have taken this class can expect

- to understand enough analog electronics to build simple circuits using passive and active components with minimal assistance from e.g. Google
- to understand the basics of imaging and geometric optics*
- to understand the construction and essential elements of a microscope*
- to use image processing to extract data from digitally recorded images*

III. Format and Procedures:

The course structure is unconventional, so please ask questions if you do not understand something.

The measurement and method will be introduced in a preliminary lecture, where the scientific motivation for the measurement and experimental approach are introduced. Some guided laboratory exercises will provide a platform for engagement with the necessary experimental apparatus and software (e.g. LTSpice) for off-campus students. Following these preliminary lab exercises, each experimental group will proceed to construct some

components of the experiment, calibrate the constructed components, record data and compile the laboratory procedure and results into a report.

Experimental groups will comprise three students each, for a total of approximately 10 groups. Groups will prepare a report to be assessed after the module. Contributions to the course wiki should be included in the appendix, and will be assessed with the report. Wiki contributions can only enhance the grade of the report, and will not detract from it.

Grading: lab notebooks form the bulk of the grade, with each module weighted equally.
The format for the lab reports should follow the 2-column APS letter format (see https://journals.aps.org/prl/authors), with a focus on concise explanations, and an intense focus on the results of the experiment. All technical details concerning the lab exercises and contributions to the wiki can be submitted as an appendix, or as a second document. Close attention must be paid to figure presentation and captioning, as this is a critical aspect of clearly communicating your results from the experiment.

Each student will share an overleaf project of their ongoing lab notebook. The lab notebook is an essential part of scientific activity, and should record relevant details sufficient to reproduce any reported experiment. Clarity of exposition, figure presentation and captioning, and rigor are all key components to the lab notebook. Briefly,

- Figures should be clear, with legible axis labels and legends.
- Figure captions should be thorough and concise – all aspects of the figure should be explained, but excess erbiage is to be avoided.
- Writing style should be focused in concise and clear exposition.
- Rigor in the scientific approach, including hypothesis formulation, hypothesis testing, development of results with data to support the conclusions drawn from the experiment, and centextualization of the result in a brief discussion convey the rigor of the scientific approach to each experiment, whether conducted in software or with the physical apparatus.
- Expectations of group reports on real area of contact measurement
- The report on the final measurement will follow the format of a PRL paper. Some rough guidelines can be found here: https://www.asc.ohio-state.edu/wilkins.5/onepage/prl.html . I would encourage more a focus on the overall spirit of the guidelines (points 1, 2, 8 and 9) are the most important. Having a precise line count is less important, but any text on page 5 is too much text. A supplementary document including technical details, materials and methods and calibration experiments is allowed, but should only be used to fill in the gaps in the paper.

IV. Background for the class:
This course assumes a strong background in fluid and solid mechanics, as well as some familiarity with electronics.

V. Course Resources: I encourage you to take good notes during introductory lecture for each class period, and maintain a running lab book with figures and graphics, especially including circuit schematics. These will facilitate maintenance of the lab notebook.

Selected readings will be provided each week on the wiki.

The wiki forms a core component of the class. Here, explanations of a particularly helpful procedure, or extra information that you found useful should be posted. Contributions to the wiki should be carefully documented and presented to increase their utility. Wiki contributions should be included with lab reports in the appendix, and can be counted as additional credit for the lab report.

- An incomplete list of course readings:

The art of electronics by Horowitz and Hill
Theory of Elasticity by Landau and Lifshitz
Fluid Mechanics by Landau and Lifshitz
Contact Mechanics by K.L. Johnson
The Friction and Lubrication of Solids by Bowden and Tabor
The Elements of Style by Strunk and White (a gem on clear and concise exposition)
…. Selected papers to be posted to the wiki
…. Data sheets for pertinent op-amps, etc.

VI. Academic Integrity

As laboratory notebooks constitute the bulk of the assessment, a high standard for proper citation practice is essential. Any deliberate plagiarism will detract significantly from your grade. You will not lose credit for proper attribution; on the contrary, proper attribution will enhance the clarity of the report and likely increase your grade.

VII. Accommodations for students with disabilities

In compliance with the EPFL LEX 2.6.5, I am available to discuss appropriate academic accommodations that may be required for student with disabilities.

IX. Tentative Course Schedule: (*Subject to change*)

Date	Anticipated topics
14.9	Introduction to lab hardware / LTspice software; passive circuit components
21.9	Passive filters, Thevenin equivalent circuits; input and output impedence
28.9	Transistors – BJTs and some transistor circuits
5.10	Transistors – Ebers-Moll, differential amplifier and a homemade op-amp
12.10	Op-amps and using positive feedback. The `golden rules'
19.10	Comparators, Schmitt Trigger, Wien Bridge circuit; `Nasty' feedback and how to tame it (sometimes)
26.10	Load cell amplifier circuits, current source circuits that can be used in our measurement
2.11	Build load cell circuit and current source for measurement / model in LTspice; calibrate apparatus
9.11	"
16.11	"
23.11	Carry out in-person testing and write reports
30.11	"
7.12	"
14.12	Present results of measurement to the class (voluntary, extra-credit; via zoom for groups A & C)

Note that * indicates change due to Covid-19 pandemic.