ME 170B: Experimental Techniques

Department of Mechanical Engineering
University of California, Riverside
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Lectures: F 2:00–3:50pm
Winston Chung Hall 143

Labs: Section 1: M/W 9:00–11:50am
Section 2: T/TH 10:00–12:50pm
Bourns Hall B140 & B164

Course Webpage: https://intra.engr.ucr.edu/~jrealmuto/courses/me170b-w24/

Book: *An Introduction to Error Analysis*
John R. Taylor (not required)

Course Description

This course consists of analysis and verification of engineering theory using laboratory measurements in advanced, project-oriented experiments involving fluid flow, heat transfer, structural dynamics, thermodynamic systems, and electromechanical systems.

Coursework

There will be three components:

I. Lab Reports. There are nine labs over the course of the 10-week quarter. Attendance is required. Make up labs will only be offered in extenuating circumstances (e.g., out sick). For each lab section, the students will be assigned into lab groups for the whole quarter. The first lab session of each week will be dedicated to planning: studying the experiment, understanding the objectives, and designing a strategy for performing the experiment. This includes developing a procedure for data collection, and laying out how to analyze the data once collected. Each lab group must receive written approval from the TA before the group moves on. Each group should maintain a Lab Notebook (either paper or electronic) to take notes and develop your experimental plan. The second lab session will be dedicated to executing the experiment and collecting the requisite data.

Suggestions for the planning session:

(a) Understand the objectives of the experiment.

(b) Study the experimental apparatus. Record the manufacturer and the specifications of each piece of equipment used. For example: You may need to know the wattage of a power source, the range of a temperature sensor, etc. Use the internet to find the information required.

(c) Bring the relevant recommended reading to the lab session (listed below).

(d) Design and write down (step-by-step) your experimental procedures.

(e) Answer any questions that are listed in the lab handout.

(f) Draw a schematic of the experimental setup.

(g) Derive the appropriate equations for the experiment and prepare a data collection sheet. The data sheet should include all the relevant info necessary for the completion of the experiment.

(h) Prepare a MATLAB program or Excel worksheet where the data can be transferred for analysis.

(i) You must receive TA approval before moving on.

Suggestions for the experiment session:

(a) Safety is number one priority: be mindful of long hair, no open toe shoes, wear safety goggles.

(b) After you record data, the TA must again review and sign it. Only then should you transfer you measurement to your MATLAB/Excel file.

(c) Bring a flash drive for storing data.

Lab report format:

Lab reports must be submitted as a group. All reports should be 10 point font Times New Roman, single spaced. Use headers to distinguish different sections and subsections. The following sections are required for each lab report:

(a) **Abstract.** A single paragraph summarizing the Lab Report, including a concise introduction, outline of the results, and summary of the conclusions.

(b) **Introduction.** This section should provide context for the Lab Assignment. What are the goals of the assignment? Why is it interesting? *What are the hypotheses?*

(c) **Methods.** Here you should provide a detailed description of all the techniques used to generate your results. Include a detailed description of the experimental apparatus including images.

(d) **Results.** Present the results of the Lab Assignment, including addressing any specific questions posed in the Assignment. Include figures and graphs to support your results.

(e) **Discussion.** What is the significance of your results? Is your hypotheses refuted or supported? Describes how the results address the topic under investigation and/or the issues that the experiment was designed to address. Expand upon the implications of those findings. Discuss the errors and uncertainties, limitations, and directions for further inquiry.

(f) **Conclusion.** Restate the methods used, and your major findings. Contextualize your results in terms of what you've learned.

(g) **Statement of Contributions.** Explicitly state how each member of the Lab group contributed to the final written report. Ex: *JR designed the experiment; NT wrote the introduction; All collected and analyzed the data.*

In addition to the Statement of Contributions, each student will submit a confidential statement about each group members contributions. Ex: *[Name of group member 1]: 100% effort, [Name of group member 2]: 50% effort, etc.* Your lab report must be in pdf format! Please do not turn in a word file. No late lab reports will be accepted.

II. Individual Presentations.

Each student is required to give one presentation during the quarter based on a scholarly article (use Google scholar or UCR libraries). The article can be in any field but must include an experiment. Your presentation will provide a five minute summary focusing on the experimental methods. It can be any experiment on any topic, but must include an experiment that *measures a physical quantity.* Your presentation should include the following *six* slides:

(a) Title Page: Title, author, journal

(b) Big Picture: Summarize the purpose of the paper and the main hypotheses.

(c) Setup: Summary of the experimental setup including what is being measured.

(d) Analysis and Results: Details of the models and/or statistics used to analyze the data. What is the main result? Was the hypothesis supported?

(e) Uncertainty: How did the authors account for and report uncertainty in their measurements? Is the uncertainty analysis appropriate?

(f) Comments: Why was the study interesting to you and how could it be improved? What can we learn from the experimental techniques?

III. Midterm and Final. There will be a midterm (approximately week 5) and a cumulative final designed to test your knowledge of the course material.

Suggestions for preparing for exams:

(a) Homework problems will be assigned, but not graded. It is highly recommended that you use the problem set as practice for the exams.

(b) Materials for the exams will be derived directly from materials covered during lecture. I will post notes for each course. Attending lecture is an integral part of your learning; we will cover practice problems during this time, it's highly recommended you attend all the lectures.

Grading

Components

Labs:	55 %
Presentation:	10 %
Midterm:	15 %
Final:	20 %

Grading Scheme

A+	100 - 97%	C+	< 80 - 77%
A	< 97 - 94%	C	< 77 - 74%
A-	< 94 - 90%	C-	< 74 - 70%
B+	< 90 - 87%	D+	< 70 - 67%
B	< 87 - 84%	D	< 67 - 64%
B-	< 84 - 80%	D-	< 64 - 60%
		F	< 60 - 0%

Final grade is determined by rounding to nearest integer value (no exceptions!).

Tentative schedule

Week	Topic	Chapter
1	Intro to error analysis	1
2	Uncertainties / Uncertainty propagation	2 & 3
3	Statistical analysis	4
4	Normal distributions, Review	5
5	Exam 1	
6	Rejection of data, Weighted averages	6 & 7
7	Least squares	8
8	Covariance and Correlation	9
9	Binomial / Poisson Distributions	10 & 11
10	Review	
11	Exam 2	

Suggested reference material for Labs

1. Incropera, F.P., and DeWitt, D.P., *Fundamentals of Heat and Mass Transfer, 5^{th} edition*, John Wiley & Sons, New York, 2002.

2. Flinn, R. A., and Trojan, P. K., *Engineering Materials and their Applications, 4th edition*, Houghton Mifflin Company, 1990.

3. Callister, W. D., *Materials Science and Engineering – An Introduction, 6th edition*, John Wiley & Sons, New York, 2002.

4. Steve Attaway, *Rope System Analysis*, 1996.

5. William T. Thomson, *Theory of Vibrations with applications*, Prentice Hall, 1979.

6. Robert K. Vierck, *Vibration Analysis, 2nd edition,* Harper and Row, 1979.

7. Kenneth Wark, Jr., *Thermodynamics, 5th edition*, McGraw Hill, Inc., 1988.

8. S. Carlson, *Measuring the Wind with Hot Metal*, Scientific American, Nov, 1995.

9. R. W. Fox and A. T. McDonald, *Introduction to Fluid Mechanics, 5th edition*, John Wiley and Sons, 2000.

10. Jeter, S, J. Donnel,. *Writing Style and Standards in Undergraduate Reports*, College Publishing, Glen Allen, Virginia, 2004.

11. Texts for all previous ME courses.