Physics 5760/6760 - Principles of Physical Measurement and Instrumentation
Lecture and Laboratory
Fall 2019 Syllabus

Professor: Clayton Williams
Office: 302 N. Physics
Phone: 801-585-3226
Office Hrs: TBD in 217 JFB (or by appointment)

Lecture: Monday, Wednesday 5:00-6:00 pm, South Physics Bldg, Room 404)
5760/6760 Lab: Thursday: 4:35-8:35 pm, South Phys. Room 404 (4 hour lab / week)
Lab Instructor: Gernot Laicher

Class begins: Monday, August 19
Last class: Wednesday, Dec 4th
Mid. Exam: To be arranged, South Phys Room 404

Holidays: Labor Day September 2
Fall Break October 7-11
Thanksgiving Break November 28-29

References: J. Bentley, Principles of Measurement Systems

Overview
Quantitative measurements are performed in every area of science, engineering and technology, providing a critical comparison of reality with theoretical predictions. Measurements are employed to control, calibrate and diagnose physical processes. In order to accurately perform measurements, one must understand the basic principles of metrology, the science of measurement. This course is focused on teaching basic measurement concepts and sensing methods. The concepts include random include static
and dynamic system response, system calibration, systematic & statistical error analysis, noise, signal filtering/averaging, impedance effects and frequency/time domain analysis. The methods include optical, thermal, magnetic, acoustic and electrical sensing approaches.

During the first 7 weeks, a weekly laboratory will help students gain hands-on experience with the concepts and methods. During the next six weeks, students will engage in solving an extended “less-structured” measurement challenge. Students will work in teams and choose from a set of experimental problems (or propose their own), design and build a system to achieve their goal, demonstrate that it works, characterize the system performance and present their results to the class. The “less-structured” problem solving experience will develop useful research skills that standard courses often do not require. The problem solving component will be managed somewhat like a “technology incubator,” in which a solution is searched for from scratch. Examples of measurement challenges that students have taken on include building a 3D position acoustic sensing system, a rudimentary optical spectrometer, a rudimentary atomic force microscope, and a cell tracking system. You could also consider building a car sensing system for determining the available capacity of a parking garage. You get to propose a project that you would like to develop and build!

*The 6760 version of this course satisfies the core course requirements for the Science Instrumentation track of the Professional Masters of Science and Technology (PMST) program.

**Course Objectives**
1. Understand the basic concepts of quantitative measurements & instrumentation
2. Experience with many useful sensing methods
3. Solve a “less-structured” real-world measurement challenge

The lectures and homework will cover the general measurement principles and basic physics behind the instrumentation/sensors. The laboratory will provide “hands on” experience with the measurement concepts and physical sensors.

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**Course Mechanics**

**Required prerequisite:** Engineering physics sequence (Phys 2210,2220) or equivalent

**Lectures:** Lectures will cover the concepts and sensing approaches needed to do the laboratory work and homework.

**Laboratory:** a total of seven lab experiments will be done. One laboratory session will be scheduled each week, typically taking 4 hours. A laboratory write-up will be due at the beginning of class on the Monday following the laboratory session. Laboratory reports that are turned in late will receive reduced credit. Gernot Laicher will direct the labs and grade the lab write-ups.

**Homework:** There will be short but regular homework problem sets given each week which will help prepare students for the laboratories.

**Exams:** A midterm exam will be given at the end of the first half of the course.
**Lab Presentation:** Each team of students will make a presentation of the results of his 6 week "measurement challenge" project. The talk will be approximately 15 minutes, summarizing all of the key results and analysis. The measurement challenge and presentation will take the place of a final exam.

Details of this course can be found at the canvas website.

**Grading**

Student performance will be judged on the exams, problem sets and lab presentations approximately weighted as shown below:

- Problem sets: 10%
- Laboratory: 30%
- Measurement Challenge Project: 30%
- Midterm Exam: 30%

**Grading (Laboratory write-ups)**

The laboratory component of the course will determined by performance in the laboratories (25%) and on the weekly laboratory reports (75%).

**Weekly Laboratories**

1. Electronic amplifiers (voltage, current, addition, subtraction, filter, integrators)
2. Static measurement system characterization (capacitance, position sensing)
3. Dynamic 1st order system (thermore resistor, dynamic response)
4. Dynamic 2nd order system (Optical beam displacement, resonance)
5. Feedback loop (closed loop response, gain, oscillation)
6. Ultrasonic sensing (piezoelectric transducer, distance measurement)

**ADA Policy**

The University of Utah seeks to provide equal access to its programs, services, and activities for people with disabilities. If you will need accommodations in this class, reasonable prior notice needs to be given to the Center for Disability Service, 162 Olpin Union Bldg, (801-581-5020). CDS will work with you and the instructor to make arrangements for accommodations. All written information in this course can be made available in an alternative format with prior notification to the Center for Disability Services.

**Addressing Sexual Misconduct.**
Title IX makes it clear that violence and harassment based on sex and gender (which includes sexual orientation and gender identity/expression) is a civil rights offense subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories such as race, national origin, color, religion, age, status as a person with a disability, veteran’s status or genetic information. If you or someone you know has been harassed or assaulted, you are encouraged to report it to the Title IX Coordinator in the Office of Equal Opportunity and Affirmative Action, 135 Park Bldg, 801-581-8365, or the Office of the Dean of Students, 270 Union Building, 801 581-7066. For support and confidential consultation, contact the Center for Student Wellness, SSB 328, 801 581-7776. To report to the police, contact the Department of Public Safety, 801 585-2677 (COPS).

Campus Safety

The University of Utah values the safety of all campus community members. To report suspicious activity, call campus police at 801-585-COPS (801-585-2677). You will receive important emergency alerts and safety messages regarding campus safety via text message. For more information regarding safety and to view available training resources, including helpful videos, visit: safeu.utah.edu