APPLIED PHYSICAL SCIENCES

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

APPL 240

Developing Your Sixth Sense: Designing Sensors and Electrical Circuits to Make Measurements

Spring 2020

Introduction	How can you measure temperature, pH, heart rate, movement, distance or anything else in the physical world? First, you need a sensor! These sensors typically measure that physical quantity and convert it into an electrical signal, which then gets processed with an electrical circuit. In most cases, you want to send the electrical signal to a computer or other development tool, such as an Arduino for processing, recording, and displaying the result to the user.
Method	In this class, we will learn how to analyze, design, and build systems for this entire process. We will use a variety of sensors that measure physical parameters such as force and acceleration, and environmental parameters such as temperature and humidity. We will model these sensors and understand how they work and interact with electrical circuits. We will learn the basics of circuit design and analysis so that we can amplify and "clean up" the signals with filters. Finally, we will learn how to acquire these signals to a computer through data acquisition hardware and LabView software. The course will have an active learning format. For most class sessions, we will start by learning new material, and then transition to hands-on laboratory exercises to reinforce these new concepts. There will be a final project in which students design and develop a system that measures a parameter, and acquires and analyzes the resulting signal on the computer.
Results	By the end of the course, students should be able to do the following: • Model and simulate the sensors that we cover in this course. • Determine which sensor is appropriate for different applications. • Design and analyze electrical circuits that are appropriate for amplifying and filtering signals from sensors. • Use MultiSim software to simulate electric circuits. • Interpret the information on data sheets and other materials about sensors and electronic components; use this information insure your designs are appropriate. • Interface electrical circuits with computers through A/D acquisition boards such as the myDAQ. • Write LabView programs to acquire, analyze, and display electrical signals on a computer.
Discussion	The technical material that you will learn will provide you with a valuable skillset. In addition, a goal of this class is to help you develop an entrepreneurial mindset so that you will understand the bigger picture. For example, when choosing a type of sensor and designing a circuit for a real-world application, what are the economic, environmental, and ethical issues that affect your decision? These considerations are important to make a positive impact on our society through engineering and technology.

Engineering Student Outcomes	By the end of this course, students will gain experience in the following engineering student outcomes: • Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics. • Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors. • Recognize ethical and professional responsibilities in engineering situations and make informed judgements, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts. • Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgement to draw conclusions. • Acquire and apply new knowledge as needed, using appropriate learning strategies. • Demonstrate constant curiosity about our changing world. • Integrate information from many sources to gain insight.

Class Essentials

➢ CONTACT INFORMATION

Dr. Richard Goldberg	Teaching assistants
Office Location Room 156 Caudill Labs **Email** r.goldberg@unc.edu **Phone** 919-966-5768	N/A

➢ LOGISTICS

Class meeting times
Mon/Wed 2:30-4:25 pm

Class meeting location
Kenan B030

Office Hours
Fri 11-12am or 2-3pm or by appointment

Required Texts & Software
myDAQ bundle, including
- Circuits textbook
- LabView software
- MultiSim Software
- myDAQ data acquisition hardware

Pre-requisites
- PHYS 115/117/119 Electricity and Magnetism

Course content

➢ Course Topics

- Sensor design, modeling, and implementation
  - Temperature, force, displacement, pH, acceleration, capacitive
- Circuit analysis and design
  - Resistive circuits
  - Capacitive circuits
  - Filters
  - Amplifiers
  - A/D conversion
- Data acquisition and display
  - myDAQ data acquisition
  - LabView programming

➢ Course Schedule

For week-by-week schedule, see link on Sakai

To help you succeed

➢ Course Expectations and policies

- Watch all online lectures and do all reading assignments before coming to class (in-class quizzes will help to encourage you to do this).
- Participate in class discussions and problem-solving activities.
- During class time, do not use your phone or computer for something unrelated to class; research shows that this is distracting to other students in the class. If there is an urgent situation, then you can leave the classroom to use your phone or computer.
- Come to every scheduled class and lab session and let me know ahead of time if you cannot attend.
- Turn in assignments on time; if an assignment is up to 24 hours late, there is a 25% deduction, and if an assignment is beyond 24 hours late, you will get a zero. If you need an extension, you must ask at least 24 hours before the time that the assignment is due (you can avoid a grade deduction this way).

➢ Student Resources

SEE, SAY, DO SOMETHING

We're happy you are here and eager to learn. Despite our best intentions to follow a plan, life may throw us a curve ball. If you or someone you know is experiencing some distress or you are concerned about the well-being of a student, please report it here: https://deanofstudents.unc.edu/carereport. It is important to support one another. If you see something, say, and do something.

ACCESSIBILITY RESOURCES

UNC-CH provides accommodations for any students with documented disabilities. If you have a disability and believe you require accommodations, please contact the Department of Accessibility Resources at http://accessibility.unc.edu. Please contact me early in the semester so we can make any necessary arrangements and discuss the learning checks.

Assignments & Evaluation

➢ Your Course Grade

20%: Homework and quizzes	We will have weekly homework assignments except when we have an exam or project work; we will have in-class multiple choice quizzes on video lectures or reading assignments.
30%: Two midterm exams	These will be open-book, open-note.
15%: Final exam	This will be comprehensive, but with an emphasis on the last 1/3 of the semester.
20%: Labs and lab notebook	Labs will take place during class time. Students will maintain an online lab notebook.
15%: Final project	Final project will take place in the last month of the semester.
100%: total	

➢ Grade Interpretation & Honor Code

Your final course grade will be determined from a standard scale:

A	93+
A-	90.0 - 92.9
B+	87.0 - 89.9
B	83.0 - 86.9
B-	80.0 - 82.9
C+	77 - 79.9
C	73 - 76.9
C-	70 - 72.9
D+	67 - 69.9
D	60 - 66.9
F	<60

ACADEMIC HONESTY

There will be clear communication if assignments are individual or group. For individual assignments, while I encourage collaboration, it is a violation of the honor code if a student duplicates work or obtains solutions from another student and submits it on their own. Please reference the honor code: http://honor.unc.edu.

➢ Major Course Due Dates

Exam 1	Mid Feb (TBD)
Exam 2	Late March (TBD)
Final Project	Due mid April (TBD)

I reserve to right to make changes to the syllabus, including project due dates and test dates (excluding the officially scheduled final examination), when unforeseen circumstances occur. These changes will be announced as early as possible so that students can adjust their schedules.