

**ECEN 2060 Electronic and Semiconductor Device Laboratory  
Fall 2020**

**Class times:** Lecture: T 9:35 - 10:25 am | <https://cuboulder.zoom.us/j/95547340042>  
Lab: T, Th 6:30 - 8:20 pm | Remote for Week 1; ECEE 282 thereafter

**Instructor:** Prof. Sean Shaheen  
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Office hours: M, 4:00 - 5:00 pm (virtual) or by appointment

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office hours: by appointment

**Textbook (required):** No textbook is required. Readings will be assigned each week.

**Textbook (recommended):** *Semiconductor Device Fundamentals*, 2<sup>nd</sup> Edition, R. F. Pierret

*Principles of Semiconductor Devices*, B. Van Zeghbroeck  
web edition - <http://ece-www.colorado.edu/~bart/book/>

### **Course Description**

Investigates the operation of electronic and semiconductor devices, including: resistors, transparent conductors, capacitors, inductors, diodes and light emitting diodes, photovoltaics, bipolar junction and field effect transistors, and organic electrochemical transistors. Laboratory work will provide learning of the basic operation of the devices and how underlying material properties influence their operation. Some of the labs will involve a fabrication component.

*Recommended pre/corequisites: PHYS 1140 (prerequisite), ECEN 2250 (corequisite)*

### **Course Learning Goals**

- Learn the basic operation of electronic and semiconductor devices relevant to the ECEE undergraduate curriculum
- Understand the connection between conducting/semiconducting materials properties and the behavior of devices resulting from them
- Gain familiarity with electronic test equipment and techniques required to probe electronic and semiconductor devices
- Learn techniques of materials processing and device fabrication (for a select number of labs in the course)
- Improve skills in experimental data taking, numerical analysis, curve fitting, and error analysis
- Develop research and design skills for emerging electronic device concepts and implementations
- Advance proficiencies in written and oral communication of scientific and engineering concepts
- Improve teamwork and communication skills

## **Laboratories**

The sequence of laboratories to be conducted throughout the semester is listed below. This schedule is subject to change as the situation dictates.

### **Part I: Basic Electronic Components**

8/25-27 | Lab 1: Resistors

9/1-3 | Lab 2: Capacitors (+ Transparent Conductors)

9/8-10, | Lab 3: Inductors

### **Part 2: 2-Terminal Devices**

9/15-17 | Lab 4: Diodes

9/22-24 | Lab 5: Light Emitting Diodes (LEDs)

9/29-10/1 | Lab 6: Photovoltaic Devices I - Monocrystalline and Polycrystalline Silicon

10/6-8 | Lab 7: Photovoltaic Devices II - Monocrystalline and Polycrystalline Silicon

10/13-15 | Lab 8: Photovoltaic Devices III - Organic Photovoltaics (OPVs)

10/20-22 | Lab 9: Photodetectors

### **Part 3: 3-Terminal Devices**

10/27-29 | Lab 10: Bipolar Junction Transistors (BJTs)

11/3-5 | Lab 11: Field Effect Transistors (FETs) I

11/10-12 | Lab 12: Field Effect Transistors (FETs) II

11/17-19 | Lab 13: Organic Electrochemical Transistors (OECTs) (tentative)

### **12/1-3 | Final Project Presentations**

## **Grading**

A written report worth 50 points is due for each laboratory. *The lowest laboratory grade will be dropped from the gradebook.*

### **Final Research & Design Project**

There will be Final Research & Design Project worth 100 points, consisting of an oral presentation and a written report. It is a team project, and the oral presentation is done in a team format, with all members of the team receiving the same point grade. The written report is done and graded individually.

### **Course point distribution**

Weekly lab reports.....600 points total (submissions due 5:00 pm on Tuesdays)

Final R&D project.....100 points total

## **Late Submission Policy**

Late submission of laboratory reports will be penalized 10% per weekday beyond the deadline. If you have a valid, documented reason for late submission such as a medical issue, an unplanned family emergency, a religious observance, or attendance at a professional conference or other academic obligation, please contact the instructor before the due date of the assignment to make other arrangements.

## **Course Grading Criteria**

Grading for individual problems will be based on the following general criteria:

- 100% – Answer is fully correct and was arrived at through sound reasoning.
- 90% – Answer is wrong due to a minor math or algebraic error; reasoning was sound.
- 75% – Substantial effort was put into the problem, but a conceptual error was made near the end of the solution.
- 50% – Substantial effort was put into the problem, but a fundamental conceptual error was made near the beginning of the problem.
- 25% – Only a cursory attempt was made at the problem.
- 0% – No attempt made.

The final grading scale for the class will be determined by the instructor according to the following rationale:

- A – Mastery or near mastery of course material, concepts, and problems.
- B – Demonstrated understanding of most of the concepts covered in the course; good proficiency at problem solving.
- C – Reasonable effort was put into the class, but substantial gaps in conceptual understanding and low performance on problem solving tasks were demonstrated.
- D – Little effort was put into the class, and little was learned.
- F – No attendance or attempt at material.

## **ABET Learning Outcomes**

This course strives to provide the student with a variety of specific learning outcomes. These include the student outcomes identified by ABET, and adhered to by the ECEE department, related to the skills, knowledge, and behaviors that students acquire as they progress through the program. The specific Student Outcomes can be found here: <http://ecee.colorado.edu/academics/courses/criterion3.html>.

## **Course Ethics**

Discussion and group brainstorming about concepts and problems in the course is strongly encouraged. However, copying of assignments, project reports, or examinations, or any other form of academic dishonesty is strictly forbidden. For homeworks and other out-of-class work, as a general rule one should not visually look at another person's solutions; however, it is acceptable to verbally discuss the general problem-solving strategy and its conceptual basis. In case of doubt on a particular assignment, please consult the instructor.

## **FERPA**

The privacy of student's education records is protected by regulations set by the Family Educational Rights & Privacy Act (FERPA). Details can be found at <http://www.colorado.edu/registrar/annual-ferpa-notification>.

## **Classroom Behavior**

Both students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote or online. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are

especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy. For more information, see the policies on [classroom behavior](#) and the [Student Code of Conduct](#).

### **Requirements for COVID-19**

As a matter of public health and safety due to the pandemic, all members of the CU Boulder community and all visitors to campus must follow university, department and building requirements, and public health orders in place to reduce the risk of spreading infectious disease. Required safety measures at CU Boulder relevant to the classroom setting include:

- Maintain 6-foot distancing when possible,
- Wear a face covering in public indoor spaces and outdoors while on campus consistent with state and county health orders,
- Clean local work area,
- Practice hand hygiene,
- Follow public health orders, and
- If sick and you live off campus, do not come onto campus (unless instructed by a CU Healthcare professional), or if you live on-campus, please alert [CU Boulder Medical Services](#).

Students who fail to adhere to these requirements will be asked to leave class, and students who do not leave class when asked or who refuse to comply with these requirements will be referred to [Student Conduct and Conflict Resolution](#). For more information, see the policies on [COVID-19 Health and Safety](#) and [classroom behavior](#) and the [Student Code of Conduct](#). If you require accommodation because a disability prevents you from fulfilling these safety measures, please see the “Accommodation for Disabilities” statement on this syllabus.

Before returning to campus, all students must complete the [COVID-19 Student Health and Expectations Course](#). Before coming on to campus each day, all students are required to complete a [Daily Health Form](#).

### **Accommodation for Disabilities**

If you qualify for accommodations because of a disability, please submit your accommodation letter from Disability Services to your faculty member in a timely manner so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities in the academic environment. Information on requesting accommodations is located on the [Disability Services website](#). Contact Disability Services at 303-492-8671 or [dsinfo@colorado.edu](mailto:dsinfo@colorado.edu) for further assistance. If you have a temporary medical condition, see [Temporary Medical Conditions](#) on the Disability Services website.

### **Preferred Student Names and Pronouns**

CU Boulder recognizes that students' legal information doesn't always align with how they identify. Students may update their preferred names and pronouns via the student portal; those

preferred names and pronouns are listed on instructors' class rosters. In the absence of such updates, the name that appears on the class roster is the student's legal name.

### **Honor Code**

All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the Honor Code. Violations of the policy may include: plagiarism, cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, submitting the same or similar work in more than one course without permission from all course instructors involved, and aiding academic dishonesty. All incidents of academic misconduct will be reported to the Honor Code ([honor@colorado.edu](mailto:honor@colorado.edu); 303-492-5550). Students found responsible for violating the academic integrity policy will be subject to nonacademic sanctions from the Honor Code as well as academic sanctions from the faculty member. Additional information regarding the Honor Code academic integrity policy can be found at the [Honor Code Office website](#).

### **Sexual Misconduct, Discrimination, Harassment and/or Related Retaliation**

The University of Colorado Boulder (CU Boulder) is committed to fostering an inclusive and welcoming learning, working, and living environment. CU Boulder will not tolerate acts of sexual misconduct (harassment, exploitation, and assault), intimate partner violence (dating or domestic violence), stalking, or protected-class discrimination or harassment by members of our community. Individuals who believe they have been subject to misconduct or retaliatory actions for reporting a concern should contact the Office of Institutional Equity and Compliance (OIEC) at 303-492-2127 or [cureport@colorado.edu](mailto:cureport@colorado.edu). Information about the OIEC, university policies, [anonymous reporting](#), and the campus resources can be found on the [OIEC website](#).

Please know that faculty and instructors have a responsibility to inform OIEC when made aware of incidents of sexual misconduct, dating and domestic violence, stalking, discrimination, harassment and/or related retaliation, to ensure that individuals impacted receive information about options for reporting and support resources.

### **Religious Holidays**

Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. Please discuss with your instructor prior to any religious obligations that impact your academic work in order for arrangements to be made.

See the [campus policy regarding religious observances](#) for full details.

### **Required Syllabus Statements**

Further information and description of campus policies regarding *Accommodation for Disabilities, Classroom Behavior, the Honor Code, Sexual Misconduct, Discrimination, Harassment and/or Related Retaliation*, and *Religious Holidays* can be found online in the [Required Syllabus Statements](#) posted by Academic Affairs.