ECE 3030 SEMICONDUCTOR ELECTRONIC DEVICES,
ELECTRICAL AND COMPUTER ENGINEERING CLASS: #10797
SPRING 2021 – ONLINE, SYNCHRONOUS

COURSE OVERVIEW

Instructor

Leonard Brillson (Brillson.1@osu.edu) (he/him/his)
Office hours: Wednesdays, 4 – 5 pm or by appointment (using CarmenZoom)

Course description

Semiconductor materials and devices. Crystals; band structure; charge carrier statistics; excess carriers, transport; PN junction; Schottky barrier; bipolar and field-effect transistors; optoelectronic devices; nanoscale devices. Prereq: 2020 or 2021 or 2100, and Physics 1251, 1261, 133, or both 1240 and 1241; and Chem 1220, 1250, or 121; and enrollment in ECE, MSE, or EngPhysics major. Prereq or concur: Math 2415 (415) or 2174.

Course learning outcomes

Upon successful completion of this course, each student will be able to:

1. Be familiar with the fundamentals of material structure (crystal, amorphous, polycrystalline)
2. Be familiar with the fundamentals of quantum mechanics
3. Be competent in analyzing the relationships between the physical and electronic properties of semiconductors
4. Be competent with drift and diffusion of electrons and holes
5. Be familiar with the fundamental principles of operation of semiconductor devices
6. Be competent with pn junction device physics
7. Master energy band diagram analysis
8. Be familiar with the physical limits of operation (avalanche and Zener breakdown, punch-through, temperature effects) of semiconductor devices
9. Be exposed to a modern engineering simulation tool (2D device simulator)
10. Be familiar with necessary background to understand the principle of new electronic devices as new technologies develop
### ABET related student learning outcomes

<table>
<thead>
<tr>
<th>Course contribution</th>
<th>Some</th>
<th>Substantial</th>
<th>Significant</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.</td>
<td></td>
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<td>X</td>
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<tr>
<td>2. An ability to 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</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>3. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies</td>
<td></td>
<td>X</td>
<td></td>
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</tbody>
</table>

### NACE related Student learning outcomes

<table>
<thead>
<tr>
<th>Course contribution</th>
<th>Some</th>
<th>Substantial</th>
<th>Significant</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Critical thinking/problem solving</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>• Oral/written communications</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>• Teamwork/collaboration</td>
<td></td>
<td></td>
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<tr>
<td>• Digital technology</td>
<td></td>
<td>X</td>
<td></td>
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<tr>
<td>• Leadership</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>• Professionalism/work-ethic</td>
<td></td>
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<tr>
<td>• Career management</td>
<td></td>
<td></td>
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<tr>
<td>• Global/intercultural fluency</td>
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</table>

## HOW THIS COURSE WORKS

**Mode of delivery:** This course is 100% online using CarmenCanvas and CarmenZoom. There are three weekly lecture sessions (synchronous in-person / real time video with recorded lectures available). Each lecture will start with a review of the materials covered in the previous lecture followed by a series of Top Hat quizzes before proceeding to the new lecture. Top Hat course name is “Semiconductor Devices,” Join Code #655271. [OSU course #10797]

**Pace of online activities:** This course is divided into weekly modules that are released at the beginning of the semester excluding recorded lectures. Some elements may be updated during the course. Students are expected to keep pace with weekly deadlines.

**Credit hours and work expectations:** This is a 3-credit-hour course. According to Ohio State policy, students should expect around 3 hours per week of time spent on direct instruction (instructor content and Carmen activities, for example) in addition to 6 hours of
outside work (readings, homework, and project assignments, for example) to receive a passing grade.

**Attendance and participation requirements:** Consistent engagement is expected. All lectures will be delivered synchronously but will be recorded; you will be expected to log into CarmenZoom at the appropriate time to participate synchronously. If any problems arise relative to attendance, please contact the instructor as soon as possible. Communication is important. You are encouraged to participate “in class”, ask questions, work on in-class problems in small groups, and share your experiences relative to the subjects and discussion that day.

The online lectures will be interactive and are essentially for successfully mastering the course learning outcomes. Active in-class participation is found to greatly correlate with students' performance, thus synchronous participation is strongly requested. The lecture slides and video will be posted on CarmenCanvas. If you do miss a lecture, you are expected to view the missed material before the next lecture. The following is a summary of everyone’s expected participation:

- **Participating in live sessions and/or online activities:** **THREE TIMES PER WEEK**
  You are expected to log in to the course in Carmen, CarmenZoom every week. If you have any hardship situation (working in a different time zone, become sick, or had difficulty find a quiet space) let me know so that we work out a solution. This might involve make-up assignments to replace the in-class quizzes. If you have a situation that might cause you to miss an entire week of class, discuss it with me as soon as possible.

- **Office hours:** **AT LEAST ONCE PER SEMESTER.** General office hours are optional but encouraged.

- **Required course materials and technologies:** CarmenCanvas, CarmenZoom.

**REQUIRED**


The textbook courseware for this course is being provided via CarmenBooks. Through CarmenBooks, students obtain publisher materials electronically through CarmenCanvas, saving them up to 80% per title. The fee for this material is included as part of tuition and is listed as CarmenBooks fee on your Statement of Account. In addition to cost-savings, materials provided through CarmenBooks are available immediately on or before the first day of class. There is no need to wait for financial aid or scholarship money to purchase your textbook.
Unless you choose to opt-out of the program, you do NOT need to purchase other textbooks for this course. For more information on the program or information on how to opt out, https://affordablelearning.osu.edu/reducing-textbook-costs-carmenbooks

Access this eBook through the CarmenBooks reader link in the course navigation (left-hand navigation ribbon).

Course technology

For help with your password, university email, Carmen, or any other technology issues, questions, or requests, contact the Ohio State IT Service Desk. Standard support hours are available at o cio.osu.edu/help/ hours, and support for urgent issues is available 24/7.

- **Self-Service and Chat support:** [ocio.osu.edu/help](http://ocio.osu.edu/help)
- **Phone:** 614-688-4357(HELP)
- **Email:** servicedesk@osu.edu
- **TDD:** 614-688-8743

BASELINE TECHNICAL SKILLS FOR ONLINE COURSES

- Basic computer and web-browsing skills
- Navigating Carmen: for questions about specific functionality, see the [Canvas Student Guide](https://canvas.osu.edu/).
- Familiarity with Matlab

REQUIRED TECHNOLOGY SKILLS SPECIFIC TO THIS COURSE

- **CarmenZoom virtual meetings**

REQUIRED EQUIPMENT

- Computer: current Mac (OS X) or PC (Windows 7+) with high-speed internet connection
- Webcam: built-in or external webcam, fully installed and tested
- Microphone: built-in laptop or tablet mic or external microphone
- Other: a mobile device (smartphone or tablet) or landline to use for BuckeyePass authentication

REQUIRED SOFTWARE
- **Microsoft Office 365**: All Ohio State students are now eligible for free Microsoft Office 365 ProPlus through Microsoft’s Student Advantage program. Full instructions for downloading and installation can be found at [go.osu.edu/office365help](http://go.osu.edu/office365help).
- Matlab and PISCES will be available on the ECE linux workstations.
- Top Hat: available at: [https://www.ohio.edu/oit/services/teaching/top-hat](https://www.ohio.edu/oit/services/teaching/top-hat)

**CARMEN ACCESS**

You will need to use BuckeyePass multi-factor authentication to access your courses in Carmen. To ensure that you are able to connect to Carmen at all times, it is recommended that you take the following steps:

- Register multiple devices in case something happens to your primary device. Visit the BuckeyePass - Adding a Device help article for step-by-step instructions.
- Request passcodes to keep as a backup authentication option. When you see the Duo login screen on your computer, click Enter a Passcode and then click the Text me new codes button that appears. This will text you ten passcodes good for 365 days that can each be used once.
- Download the Duo Mobile application to all of your registered devices for the ability to generate one-time codes in the event that you lose cell, data, or Wi-Fi service.

If none of these options will meet the needs of your situation, you can contact the IT Service Desk at 614-688-4357 (HELP) and IT support staff will work out a solution with you.

**GRADING AND FACULTY RESPONSE**

How your grade is calculated

<table>
<thead>
<tr>
<th>ASSIGNMENT CATEGORY</th>
<th>POINTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>In class Top-Hat quizzes</td>
<td>20</td>
</tr>
<tr>
<td>Homework (11 + 1 CAD)</td>
<td>15</td>
</tr>
<tr>
<td>Midterm exam #1</td>
<td>20</td>
</tr>
<tr>
<td>Midterm exam #2</td>
<td>20</td>
</tr>
<tr>
<td>Final exam</td>
<td>25</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

*See course schedule on CarmenConnect for all detailed assignments and due dates.*
Late assignments

Only two late submissions will be accepted (minus 10% for each late day). Please refer to Carmen for due dates. All assignments are to be posted in Carmen.

Grading scale

93–100: A  
90–92.9: A-  
87–89.9: B+  
83–86.9: B  
80–82.9: B-  
77–79.9: C+  
73–76.9: C  
70 –72.9: C-  
67 –69.9: D+  
60 –66.9: D  
Below 60: E

Instructor feedback and response time

My availability throughout the course is as follow:

- **Grading and feedback:** For large weekly assignments, you can generally expect feedback within 7 days.

- **Email:** I will try to reply to emails within 24 hours on days when class is in session at the university. If somehow, I did not, please resend your email.

Course Evaluation

- A series of evaluation tools will be used throughout the course. Final evaluation will include University SEI and forms developed by the instructor. During final exam week, you will schedule an online interview with the course instructor to evaluate your mastery of semiconductor device physics, receive direct feedback on your CAD project, debrief on the course, and provide suggestions for improvement.

OTHER COURSE POLICIES

Discussion and communication guidelines
At the Ohio State we are committed to insure a friendly, inclusive and supportive environment for all.

- **Writing style:** While there is no need to participate in class discussions as if you were writing a research paper, you should remember to write using good grammar, spelling, and punctuation. A more conversational tone is fine for non-academic topics.

- **Tone and civility:** Let’s maintain a supportive learning community where everyone feels safe and where people can disagree amicably. Remember that sarcasm doesn’t always come across online.

- **Citing your sources:** When we have academic discussions, please cite your sources to back up what you say. For the textbook, journal articles, or other course materials, list at least the author, title, and page numbers. For online sources, include a link.

- **Backing up your work:** Consider composing your academic posts in a word processor, where you can save your work, and then copying into the Carmen discussion. Academic integrity policy

**OHIO STATE’S ACADEMIC INTEGRITY POLICY**

Academic integrity is essential to maintaining an environment that fosters excellence in teaching, research, and other educational and scholarly activities. Thus, The Ohio State University and the Committee on Academic Misconduct (COAM) expect that all students have read and understand the university’s *Code of Student Conduct*, and that all students will complete all academic and scholarly assignments with fairness and honesty. Students must recognize that failure to follow the rules and guidelines established in the university’s *Code of Student Conduct* and this syllabus may constitute “Academic Misconduct.”

The Ohio State University’s *Code of Student Conduct* (Section 3335-23-04) defines academic misconduct as: “Any activity that tends to compromise the academic integrity of the university or subvert the educational process.” Examples of academic misconduct include (but are not limited to) plagiarism, collusion (unauthorized collaboration), copying the work of another student, and possession of unauthorized materials during an examination. Ignorance of the university’s *Code of Student Conduct* is never considered an excuse for academic misconduct, so I recommend that you review the *Code of Student Conduct* and, specifically, the sections dealing with academic misconduct.

If I suspect that a student has committed academic misconduct in this course, I am obliged by university rules to report my suspicions to the Committee on Academic Misconduct. If COAM determines that you have violated the university’s *Code of Student Conduct* (i.e., committed academic misconduct), the sanctions for the misconduct could include a failing grade in this course and suspension or dismissal from the university.
If you have any questions about the above policy or what constitutes academic misconduct in this course, please contact me.

Other sources of information on academic misconduct (integrity) to which you can refer include:

- The Committee on Academic Misconduct web pages (COAM Home)
- Ten Suggestions for Preserving Academic Integrity (Ten Suggestions)
- Eight Cardinal Rules of Academic Integrity (www.northwestern.edu/uacc/8cards.htm)

POLICIES FOR THIS ONLINE COURSE

Class Only Exam Policy: In-class exams (midterms and final exam) will be conducted live with the camera on. Exams will be open book/notes. Students will not communicate with anybody else during the exam and follow the ECE honor pledge to not receive nor give help to someone else for an exam.

Class Homework Policy: Homework will be graded based on effort so as not to penalize students who are working alone.

Copyright disclaimer

The materials used in connection with this course may be subject to copyright protection and are only for the use of students officially enrolled in the course for the educational purposes associated with the course. Copyright law must be considered before copying, retaining, or disseminating materials outside of the course.

Statement on Title IX

All students and employees at Ohio State have the right to work and learn in an environment free from harassment and discrimination based on sex or gender, and the university can arrange interim measures, provide support resources, and explain investigation options, including referral to confidential resources.

If you or someone you know has been harassed or discriminated against based on your sex or gender, including sexual harassment, sexual assault, relationship violence, stalking, or sexual exploitation, you may find information about your rights and options at titleix.osu.edu or by contacting the Ohio State Title IX Coordinator at titleix@osu.edu. Title IX is part of the Office of Institutional Equity (OIE) at Ohio State, which responds to all bias-motivated incidents of harassment and discrimination, such as race, religion, national origin and disability. For more information on OIE, visit equity.osu.edu or email equity@osu.edu. Note that OSU instructors are mandated reporters.
Your mental health

As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance or reduce a student's ability to participate in daily activities. The Ohio State University offers services to assist you with addressing these and other concerns you may be experiencing. If you find yourself feeling isolated, anxious or overwhelmed, please know that there are resources to help: ccs.osu.edu. You can reach an on-call counselor when CCS is closed at (614) 292-5766 and 24 hour emergency help is also available through the 24/7 National Prevention Hotline at 1-(800)-273-TALK or at suicidepreventionlifeline.org. The Ohio State Wellness app is also a great resource available at go.osu.edu/wellnessapp.

Student Emergency Financial Support

The Student Advocacy Center staff members are continuing to serve students during normal business hours and are accepting online appointments.

The Student Emergency Fund is available to students who may otherwise be at risk of dropping out of college due to an unexpected financial emergency. If you, or a student you know, are experiencing an unplanned expense, the Student Emergency Fund may be an option. Their office is accepting applications and may be able to award up to $1,000 to eligible students. Learn more and apply

The Together As Buckeyes emergency grants program, funded primarily by the federal Coronavirus Aid, Relief and Economic Security (CARES) Act, is available to all students — undergraduate, graduate and professional — through the Student Financial Aid office. To apply for a grant, students need to complete a one-page Emergency Request form and provide any supporting documentation. The Office of Student Financial Aid will process applications after determining eligibility based on each student’s circumstances and guidance from the U.S. Department of Education.

Franklin County Department of Job and Family Services has amended its Prevention, Retention and Contingency Program to provide targeted relief for families impacted by the COVID-19 pandemic. The Franklin County COVID-19 Response PRC Program provides eligible families with $500 in one-time cash assistance to help address emergent needs and expenses brought about by the public health emergency. Families can apply online today. The Student Wellness Center offers financial coaching through the Scarlet and Gray Financial nationally recognized peer financial coaching program. Through the program, students will learn about financial goal setting, banking basics, budgeting, credit education, debt repayment education and saving and retirement education. Learn more.
Food Assistance

It’s a common idea that pervades American culture: when you’re in college, it’s simply a rite of passage to sustain yourself on cheap, unhealthy food. We disagree. We highly recommend OSU’s Buckeye Food Alliance Lincoln Tower 150 food pantry (https://www.buckeyefoodalliance.org) and the MidOhio Foodbank (https://www.midohiofoodbank.org). The Buckeye Food Alliance will remain open to support students in need. Starting Monday, March 23 the pantry will be open Monday/Thursday 10 a.m. – 2 p.m.; Tuesday/Wednesday 4 – 8 p.m. and Friday 11 a.m. – 3 p.m. If these times do not work for your schedule, you can schedule a special appointment by contacting Nick Fowler at fowler.318@osu.edu.

ACCESSIBILITY ACCOMMODATIONS FOR STUDENTS WITH DISABILITIES

Requesting accommodations

The university strives to make all learning experiences as accessible as possible. If you anticipate or experience academic barriers based on your disability including mental health, chronic or temporary medical conditions, please let me know immediately so that we can privately discuss options. To establish reasonable accommodations, I may request that you register with Student Life Disability Services. After registration, make arrangements with me as soon as possible to discuss your accommodations so that they may be implemented in a timely fashion. SLDS contact information: slds@osu.edu; 614-292-3307; 098 Baker Hall, 113 W. 12th Avenue.

Accessibility of course technology

This online course requires use of Carmen (Ohio State's learning management system) and other online communication and multimedia tools. If you need additional services to use these technologies, please request accommodations with your instructor.

- CarmenCanvas accessibility
- Streaming audio and video
- CarmenZoom accessibility
- Collaborative course tools

ECE Diversity and Antiracism Statement
Success in engineering requires multiple perspectives, a wide range of expertise, and diverse backgrounds to solve societal problems and advance science. To be a student, faculty, or staff member in the Department of Electrical and Computer Engineering means being innately tied to a rich tapestry of diverse cultures, ethnicities, and backgrounds through people from all over the world. ECE faculty and staff aspire to hear the voices of those disenfranchised by racism. As educators and mentors within ECE, we will promote a culture of care. We are working to become better allies to create a safer society for everyone, and to invite all of our students, staff, and faculty to be courageous, take a stand against racism, and condemn any form of racial injustice. Not only do we help cultivate diversity in ECE, we celebrate it.

The Office of Institutional Equity (OIE) at Ohio State responds to all bias-motivated incidents of harassment and discrimination, such as race, religion, national origin and disability. For more information on OIE, visit equity.osu.edu or email equity@osu.edu.

COUNSELING AND CONSULTATION SERVICES

As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance or reduce a student’s ability to participate in daily activities. The Ohio State University offers services to assist you with addressing these and other concerns you may be experiencing. If you or someone you know are suffering from any of the aforementioned conditions, you can learn more about the broad range of confidential mental health services available on campus via the Office of Student Life’s Counseling and Consultation Service (CCS) by visiting ccs.osu.edu or calling 614-292-5766. CCS is located on the 4th Floor of the Younkin Success Center and 10th Floor of Lincoln Tower. You can reach an on-call counselor when CCS is closed at 614-292-5766 and 24-hour emergency help is also available through the 24/7 National Suicide Prevention Hotline at 1-800-273-TALK or at suicidepreventionlifeline.org. The ECE website also offers a listing of student wellness and support services available at Ohio State.

The instructor reserves the right to make any changes he considers academically advisable. Such changes, if any, will be announced in class and at CarmenCanvas.
COURSE TOPICS

These topics will be discussed throughout the course:

- Semiconductor materials, crystals and band structure
- Charge carrier statistics, excess carriers, transport
- PN junction and Schottky barrier and nanoscale devices
- Bipolar and field-effect transistors
- Optoelectronic devices

COURSE SCHEDULE

<table>
<thead>
<tr>
<th>Week</th>
<th>Topics</th>
<th>Readings</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction to Semiconductor Devices</td>
<td></td>
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<tr>
<td>1</td>
<td>Crystal Properties, Growth</td>
<td>Chapter 1</td>
</tr>
<tr>
<td>2</td>
<td>Atoms &amp; Electrons</td>
<td>Chapter 2</td>
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<tr>
<td>3, 4</td>
<td>Energy Bands</td>
<td>Chapter 3</td>
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<tr>
<td>5</td>
<td>Charge Carriers</td>
<td>Chapter 3</td>
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<tr>
<td>6, 7</td>
<td>Excess Carriers</td>
<td>Chapter 4</td>
</tr>
<tr>
<td>8, 9</td>
<td>Transport</td>
<td>Chapter 4</td>
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<tr>
<td>10, 11</td>
<td>Junctions</td>
<td>Chapter 5</td>
</tr>
<tr>
<td>12, 13</td>
<td>Bipolar Junction Transistor</td>
<td>Chapter 7</td>
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<tr>
<td>14</td>
<td>Field Effect Transistor</td>
<td>Chapter 6</td>
</tr>
<tr>
<td>15</td>
<td>Optoelectronic Devices</td>
<td>Chapters 8</td>
</tr>
</tbody>
</table>