

## **SYLLABUS: ECE 3030 Electronic Devices**

### **Autumn 2019**

**Description:** Semiconductor materials and devices. Crystals; bandstructure; 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. Not open to students with credit for 331 or 432. Units: 3 credit hours.

**Lecture Hours:** MWF, 10:20-11:15AM, Scott Lab N048

### **Learning Goals:**

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 semiconductor
4. Be familiar with the fundamental principles of operation of semiconductor devices
5. Master energy band diagram analysis
6. Be familiar with the physical limits of operation (avalanche and zener breakdown, punch-through, self-heating) of semiconductor devices
7. Be exposed to a modern engineering simulation tool (2D device simulator)
8. Be familiar with necessary background to understand the principle of new electronic devices as new technologies develop

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**Grader:** TBD

**Text:** Required: Solid State Electronic Devices, Ben G. Streetman and Sanjay Kumar Banerjee, 7<sup>th</sup> Edition, ISBN-13: 978-0133356038; ISBN-10: 0133356035

**References (supplemental reading):**

- Semiconductor Physics and Devices, Donald Neaman, 4<sup>th</sup> Edition, ISBN13: 9780073529585 ISBN10: 0073529583
- Fundamentals of Semiconductor Devices, B.L. Anderson and R.L. Anderson, ISBN-13: 978-0073529561 ISBN-10: 0073529567

**Grading:**

Midterm 1	25%
Midterm 2	25%
Final Exam	30%
Homework	20%

You are allowed to drop one homework with the least score. You will have an opportunity to take a make-up exam and replace your lowest mid term scores

**Policy on Late Homeworks:** Homework is due at the beginning of class on the date shown. No late work will be accepted without prior arrangement. Late work (with arrangements) will be docked 10% per day.

**Working together:** Students are encouraged to work together on homework but each student should hand in his or her individual solution.

**In Class Problems and Groupwork:** I will be doing in class problems and I would like to have you divided into smaller groups of 4-5 students. We will have candy questions and one-minute papers during class to enhance learning.

**Exams:** Exams are closed book. You will be allowed a single cheat sheet, 8.5" by 11", with handwritten notes only, on one side only. Scientific/graphic calculators are allowed. No internet-enabled devices are permitted. No cooperation on the examination is allowed. I am required to report any academic misconduct to the Committee on Academic Misconduct (COAM).

**Missed exams:** Any missed exam will result in a zero grade unless arrangements are made in advance. Suitable circumstances include illness, death in the immediate family, and situations of comparable gravity. In such cases, *if and only if arrangements are made in advance*, a make-up exam can be arranged. Midterms dates are announced will in advance, so plan your job interviews and such around them.

**Office hours:** Wed: 2PM-3PM 377 Caldwell. We will be having an optional recitation/problem session every week to assist with homeworks, review concepts and prepare for mid terms. The time and location of this will be determined based on the students schedule.

**Reaching me:** You may reach me during office hours, or make an appointment by email if you cannot make my office hours.

**Recorded Lectures:** Prof. Krishna will try and record all the lectures to post on Carmen using media site. This will enable students to go over the lecture material at their own pace and enable students who have conflicts or illnesses to keep up with the material. Prof. Krishna will make every attempt to not miss any lectures. However, maintaining an active research requires travel to program reviews, conferences and meetings. In case of travel, Prof. Krishna will post the lecture on Carmen through media site and follow up with a discussion about the lecture content.

**FINAL EXAM:**

Our final exam will be Tuesday, December 10<sup>th</sup> 2019 from 10:00-11:45AM. No make-up or early exams allowed.

Disabilities Statement

Any student who feels they may need an accommodation based on the impact of a disability should contact the instructor privately to discuss specific needs. Please contact the OSU Office for Disability Services for assistance in verifying the need for accommodations and developing accommodation strategies.

Academic Misconduct Statement

Any student found to have engaged in academic misconduct, as set forth in the Code of Student Conduct Section 3335-23-04, Prohibited Conduct, will be subject to disciplinary action by the university. Academic misconduct is any activity that tends to compromise the academic integrity of the university, or subvert the educational process.

Student Conduct

Students are expected to abide by the provisions in the Code of Student Conduct. The University's [Code of Student Conduct](#) and [Sexual Harassment Policy](#) are available on the OSU Web page

	DATE	Lec #	Topics To be Covered	Reading Assignments
	<b>Module 1: Properties of Semiconductors</b>			<b>Streeman/ Banerjee</b>
Week 1	Aug 21st 2019 (Wed)	1	Introduction/ Semiconductor Crystal Structure	1.1-1.2
	Aug 23rd 2019 (Fri)	2	Crystal planes and directions	1.2
Week 2	Aug 26th, 2019 (Mon)	3	Bulk and Epitaxial Growth	1.3-1.4
	Aug 28th, 2019 (Wed)	4	Modern Physics and Wave-Particle Duality	1.5,2.1-2.3
	Aug 30th 2019 (Fri)	5	Quantum Mechanics	2.4
Week 3	Sept 2nd 2019 (Mon)		<b>Labor Day</b>	
	Sept 4th 2019 (Wed)	6	Atomic Structure	2.5
	Sept 6th 2019 (Fri)	7	Module 1 Review and Problem Session	Ch. 1 - 2
	<b>Module 2: Semiconductor Bandstructure and Carriers</b>			
Week 4	Sept 9th 2019 (Mon)	8	Energy Bands and Intro to Charge Carriers	3.1-3.2.2
	Sept 11th 2019 (Wed)	9	Charge Carriers	3.2
	Sept 13th 2019 (Fri)	10	Carrier Concentrations	3.3
Week 5	Sept 16th 2019 (Mon)	11	Drift of Carriers and Hall Effect	3.4 - 3.5
	Sept 18th 2019 (Wed)	12	Ch. 3 Review and Problem Session	Ch. 3
	Sept 20th 2019 (Fri)	13	Optical Absorption and Luminescence	4.1-4.2
Week 6	Sept 23rd 2019 (Mon)	14	Review for Mid Term 1	Ch. 1 - 3
	<b>Sept 25th 2019 (Wed)</b>	<b>15</b>	<b>Mid Term 1</b>	<b>Ch. 1 - 3</b>
Week 7	Sept 27th 2019 (Fri)	16	Carrier Lifetime	4.3
	Sept 30th 2019 (Mon)	17	Diffusion of Carriers	4.4
Week 8	Oct 2nd 2019 (Wed)	18	Diffusion of Carriers, Problems	4.4
	<b>Module 3: Semiconductor Junctions</b>			
Week 8	Oct 4th 2019 (Fri)	19	PN Junctions at Equilibrium	5.1-5.2
	Oct 7th 2019 (Mon)	20	PN Junctions Under Applied Bias	5.3
	Oct 9th 2019 (Wed)	21	Breakdown	5.4
	Oct 11th 2019 (Fri)		<b>Fall Break</b>	
Week 9	Oct 14th 2019 (Mon)	22	Transient Conditions and Non-Ideal Effects	5.5-5.6
	Oct 16th 2019 (Wed)	23	Metal-Semiconductor Junctions	5.7
	Oct 18th 2019 (Fri)	24	Heterojunctions	5.8
Week 10	Oct 21st 2019 (Mon)	25	Review for Mid Term 2	Ch. 4 - 5
	<b>Oct 23rd 2019 (Wed)</b>	<b>26</b>	<b>Mid Term 2</b>	<b>Ch. 4 - 5</b>
	<b>Module 4: Semiconductor Devices</b>			
Week 11	Oct 25th 2019 (Fri)	27	Field Effect Transistor (JFET)	6.1-6.2
	Oct 28th 2018 (Mon)	28	MESFET and HEMT	6.3
	Oct 30th 2019 (Wed)	29	MOSFET	6.4
	Nov 1st 2019 (Fri)	30	MOSFET Contd	6.4
Week 12	Nov 4th 2019 (Mon)	31	MOSFET Device Characteristics	6.5
	Nov 6th 2019 (Wed)	32	Advanced MOSFET Structures	6.6
	Nov 8th 2019 (Fri)	33	Photodetectors	8.1
Week 13	Nov 11th 2019 (Mon)		<b>Veteran's day</b>	
	Nov 13th 2019 (Wed)	34	Solar Cells	8.1
	Nov 15th 2019 (Fri)	35	Light Emitting Diodes	8.2
Week 14	Nov 18th 2019 (Mon)	36	Semiconductor Lasers	8.3-8.4
	Nov 20th 2019 (Wed)	37	Bipolar Junction Transistors	Ch. 7
	Nov 22nd 2019 (Fri)	38	Bipolar Junction Transistors	Ch.7
Week 15	Nov 25th 2019 (Mon)	39	Make up Exam (Optional)	Ch 6-8
	Nov 27th 2019 (Wed)		<b>Thanksgiving</b>	
	Nov 29th 2019 (Fri)		<b>Indigenous People's Day (observed)</b>	
Week 16	Dec 2nd 2019 (Mon)	40	Module 1-2 Review and Problems	Ch. 1 - 4
	Dec 4th 2019 (Wed)	41	Module 3-4 Review and Problems	Ch. 5 - 8
	Dec 6th 2019 (Fri)		Optional: Extra Review Session	Students' Choice
	Dec 10th 2019 (Tue)		Final Examination (10:00 AM-11:45AM)	Ch. 1 - 8