

ESE 331
SEMICONDUCTOR DEVICES
Fall 2024

Stony Brook University
Department of Electrical and Computer Engineering

Part 1: Course Information

COURSE DESCRIPTION

The course covers physical principles of operation of semiconductor devices. Energy bands, transport properties and generation recombination phenomena in bulk semiconductors are covered first. Junctions between semiconductors and metal-semiconductor will then be studied. Equipped with an understanding of the character of physical phenomena in semiconductors, students learn the principles of operation p-n junction diodes, metal-semiconductor contacts, bipolar junction transistors, field effect transistors. This course will provide general background for subsequent courses in electronics.

Prerequisites: AMS 361 or MAT 303; PHY 127/134 or PHY 132/134 or PHY 142

Credits: 3

Instructor	Ridha Kamoua, 237 Light Engineering ridha.kamoua@stonybrook.edu (631) 632 8406
Office Hours	Mondays 11:30am – 1:30pm Wednesdays 11:30am – 1:30pm
TA	
Class Time	M, W 2:00pm – 3:20pm Frey Hall 201

TEXTBOOK

“*An Introduction to Semiconductor Devices*” Donald Neamen, McGraw Hill, 2006, ISBN 9780072987560

OR

“*Semiconductor Physics and Devices*” Donald Neamen, McGraw Hill, 2011, ISBN

Course Learning Objectives:

To teach properties, models, and concepts associated with semiconductor devices. Provides detailed insight into the internal workings of basic semiconductor devices such as the pn-junction diode, Bipolar Junction Transistor, and MOSFET. Systematically develops the analytical tools needed to solve practical device problems.

Student Outcomes (SO):

Course Learning Outcome	ABET Student Outcome	Assessment Method
knowledge of semiconductor bonding and energy band models	(1)	Exams, final, and homework
knowledge of semiconductor carrier properties and statistics	(1)	Exams, final, and homework
knowledge of semiconductor carrier action	(1)	Exams, final, and homework
ability to apply standard device models to explain/calculate critical internal parameters and standard characteristics of the pn-junction diode	(1)	Exams, final, and homework
ability to apply standard device models to explain/calculate critical internal parameters and standard characteristics of the Bipolar Junction Transistor	(1)	Exams, final, and homework
ability to apply standard device models to explain/calculate critical internal parameters and standard characteristics of the Metal-Oxide-Semiconductor Field Effect Transistor	(1)	Exams, final, and homework

(1) an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.

Part 2: Course Outline and Schedule

COURSE OUTLINE

1. ***Introductory Physical Concepts*** *Chapters 1, 2, 3*
 - Crystal Structure of Semiconductors
 - Energy Band Model
 - Fermi Energy Level
 - Semiconductor Doping
2. ***Carrier Transport and Excess Carriers in Semiconductors*** *Chapters 4,8*
 - Carrier Drift
 - Carrier Diffusion
 - Generation and Recombination
 - Continuity Equation

3. ***Junction Diodes*** ***Chapters 5,9***
- *p-n* Junction
 - Metal-Semiconductor Junction
 - I-V Characteristics
4. ***Bipolar Junction Transistors*** ***Chapters 10***
- Operating Principles
 - Minority Carrier Distribution
 - Ideal I-V Characteristics
 - Non-Ideal Effects
 - Small-Signal Models
5. ***MOS Transistors*** ***Chapters 6,7***
- Operation Principles
 - MOS Capacitor
 - Metal Oxide Field Effect Transistor (MOSFET)
 - a) Enhancement Type
 - b) Depletion type
 - c) Current-Voltage Characteristics
 - MOSFET Fabrication

Course Schedule: Please refer to the schedule in Brightspace under Course Documents

Part 3: Grading System and Exam Schedule

Your grade will be based on attendance and participation, homework assignments, research paper, two exams, and a final exam.

Attendance, Participation, Homework	10%	weekly
Research paper (Extra credit)	5%	
Exam 1	25%	October 9, 2:00pm EST
Exam 2	25%	November 13, 2:00pm EST
Final Exam	40%	December 18, 2:15pm – 5:00pm

Assignments

Homework Assignments

Homework Assignments will be issued weekly. A full schedule will be made available on Brightspace. (This schedule will be updated as needed.) All assignments will be due one week later and should be uploaded to Brightspace as a pdf file.

Collaboration Policy

Homework assignments are to be completed individually. You may *discuss* them with your classmates. (In fact, you are encouraged to do so using the discussion board in Brightspace.) However, you must write up your own solution individually without any help from any other person.

For example, it is fine if you and a friend discuss a problem together, and then separately work out the details and write your own separate solutions. On the other hand, it is not acceptable to share written solutions with another person or to create the written solutions together. In other words, the work you turn in must entirely be your own personal effort.

How to Succeed in this Course:

- Complete all assigned readings in the course
- Start homework assignments early
- Take notes and prepare formula sheets to be used in exams
- Use the office hours for one-on-one help

Part 4: University and Course Policies

University Policies

Student Accessibility Support Center Statement:

If you have a physical, psychological, medical, or learning disability that may impact your course work, please contact the Student Accessibility Support Center, Stony Brook Union Suite 107, (631) 632-6748, or at sasc@stonybrook.edu. They will determine with you what accommodations are necessary and appropriate. All information and documentation is confidential.

Academic Integrity Statement:

Each student must pursue his or her academic goals honestly and be personally accountable for all submitted work. Representing another person's work as your own is always wrong. Faculty is required to report any suspected instances of academic dishonesty to the Academic Judiciary. Faculty in the Health Sciences Center (School of Health Technology & Management, Nursing, Social Welfare, Dental Medicine) and School of Medicine are required to follow their school-specific procedures. For more comprehensive information on academic integrity, including categories of academic dishonesty please refer to the academic judiciary website at http://www.stonybrook.edu/commcms/academic_integrity/index.html

Important Note: Any form of academic dishonesty, including cheating and plagiarism, will be reported to the Academic Judiciary.

Critical Incident Management:

Stony Brook University expects students to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of Student Conduct and Community Standards any disruptive behavior that interrupts their ability to teach, compromises the safety of the learning environment, or inhibits students' ability to learn. Until/unless the [latest COVID guidance](#) is explicitly amended by SBU, during Spring 2022 "disruptive behavior" will include refusal to wear a mask during classes.

Course Policies

Understand When You May Drop This Course:

It is the student's responsibility to understand when they need to consider withdrawing from a course. Refer to the Stony Brook Academic Schedule for dates and deadlines for registration:

http://www.stonybrook.edu/commcms/registrar/calendars/academic_calendars.

- [Undergraduate Course Load and Course Withdrawal Policy](#)
- [Graduate Course Changes Policy](#)

Course Materials and Copyright Statement:

Course material accessed from Blackboard, SB Connect, SB Capture or a Stony Brook Course website is for the exclusive use of students who are currently enrolled in the course. Content from these systems cannot be reused or distributed without written permission of the instructor and/or the copyright holder. Duplication of materials protected by copyright, without permission of the copyright holder is a violation of the Federal copyright law, as well as a violation of Stony Brook's Academic Integrity.

Online Communication Guidelines and Learning Resources:

Maintain professional conduct both in the classroom and online. The classroom is a professional environment where academic debate and learning take place. I will make every effort to make this environment safe for you to share your opinions, ideas, and beliefs. In return, you are expected to respect the opinions, ideas, and beliefs of other students—both in the face-to-face classroom and online communication. Students have the right and privilege to learn in the class, free from harassment and disruption. The course follows the standards set in the Student Code of Conduct, and students are subject to disciplinary action for violation of that code. If your behavior does not follow the course etiquette standards stated below, the grade you receive for a posting may suffer. I reserve the right to remove any discussion messages that display inappropriate language or content.

Online Etiquette:

- Offensive language or rudeness will not be tolerated. Discuss ideas, not the person.
- Avoid cluttering your messages with excessive emphasis (stars, arrows, exclamations).
- If you are responding to a message, include the relevant part of the original message in your reply, or refer to the original post to avoid confusion,
- Be specific and clear, especially when asking questions.
- Use standard punctuation and capitalization. Using all UPPERCASE characters gives the appearance of shouting and makes the message less legible;.
- Remember that not all readers have English as their native language, so make allowances for possible misunderstandings and unintended discourtesies.

Online Classes Require Better Communication:

It is important to remember that we will not have the non-verbal cues that occur in a face-to-face classroom. I cannot see the confused, frustrated, or unhappy expressions on your face if you encounter

problems. You MUST communicate with me so that I can help. To make the experience go smoothly, remember that you're responsible for initiating more contact, and being direct, persistent, and vocal when you don't understand something.

My Role as the Instructor:

As the instructor, I will serve as a "guide" in our online classroom. While I will not respond to every post, I will read what is posted, and reply when necessary. Expect instructor posts in the following situations:

- To assist each of you when it comes to making connections between discussion, lectures, and textbook material.
- To fill in important things that may have been missed.
- To re-direct discussion when it gets "out of hand."
- To point out key points or to identify valuable posts.

Part 5: Student Resources

Academic and Major Advising (*undergraduate only*): Have questions about choosing the right course? Contact an advisor today. Phone and emails vary-please see website for additional contact information; website: <https://www.stonybrook.edu/for-students/academic-advising/>

Academic Success and Tutoring Center (*undergraduate only*): <https://www.stonybrook.edu/tutoring/>
Amazon @ Stony Brook: Order your books before classes begin. Phone: 631-632-9828; email: Bookstore_Liaison@stonybrook.edu; website: <http://www.stonybrook.edu/bookstore/>
Bursar: For help with billing and payment. Phone: 631-632-9316; email: bursar@stonybrook.edu; website: <http://www.stonybrook.edu/bursar/>

Career Center: The Career Center's mission is to support the academic mission of Stony Brook University by educating students about the career decision-making process, helping them plan and attain their career goals, and assisting with their smooth transition to the workplace or further education. Phone: 631-632-6810; email: sbucareercenter@stonybrook.edu; website: <http://www.stonybrook.edu/career-center/>

Counseling and Psychological Services: CAPS staff are available by phone, day or night. <http://studentaffairs.stonybrook.edu/caps/>

Ombuds Office: The Stony Brook University Ombuds Office provides an alternative channel for confidential, impartial, independent and informal dispute resolution services for the entire University community. We provide a safe place to voice your concerns and explore options for productive conflict management and resolution. The Ombuds Office is a source of confidential advice and information about University policies and procedures and helps individuals and groups address university-related conflicts and concerns. <http://www.stonybrook.edu/ombuds/>

Registrar: Having a registration issue? Let them know. Phone: 631-632-6175; email: registrar_office@stonybrook.edu; <http://www.stonybrook.edu/registrar/>

SBU Libraries: access to and help in using databases, ebooks, and other sources for your research.

- Research Guides and Tutorials: <http://guides.library.stonybrook.edu/>
- Getting Help: <https://library.stonybrook.edu/research/ask-a-librarian/>

Student Accessibility Support Center: Students in need of special accommodations should contact SASC. Phone: 631-632-6748; email: sasc@stonybrook.edu; <https://www.stonybrook.edu/sasc/>

Support for Online Learning: <https://www.stonybrook.edu/online/>

Writing Center: Students are able to schedule face-to-face and online appointments.
<https://www.stonybrook.edu/writingcenter/>