EEO 331
SEMICONDUCTOR DEVICES
Fall 2023

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 12:15pm – 2:15pm Wednesdays 12:15pm – 2:15pm

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 Delivery Mode and Structure:

This is an online course delivered in the Brightspace learning management system (LMS) at Stony Brook University. Students must be mindful of all course expectations, deliverables and due dates, especially because the online course requires significant time management. All assignments and course interactions will utilize internet technologies. See "Technical Requirements" section for more information. In Brightspace, you will access online lectures, course materials, and resources.

Homework assignments, homework and exam solutions, and other pertinent information will be posted on the course's Brightspace site. You can access Brightspace using your Net ID username and password. To look up or set your Net ID, you need to login to SOLAR.

How We Will Communicate:

Course-related questions should be posted in the General Questions Forum in the course Discussion board. For personal/private issues, email me directly. If you use Brightspace's **email tool** from the course site, it will automatically include your full name, course name and section when you send me an email. **Please allow between 24-48 hours for an email reply.** Your Stony Brook University email must be used for all University-related communications. You must have an active Stony Brook University email account and access to the Internet. All instructor correspondence will be sent to your SBU email account. **Plan on checking your SBU email account regularly for course-related messages.** To log in to Stony Brook Google Mail, go to http://www.stonybrook.edu/mycloud and sign in with your NetID and password.
Regular announcements will be sent from Brightspace. These will be posted in the course site and may or may not be sent by email.
Regular communication is essential in online classes. Logging in once a day, checking the discussion board and participating with your peers ensures that you are able to remain an active member of the class and earn full points for participation.

Office hours will be held using zoom.

Technical Requirements:

You are responsible for having a reliable computer and Internet connection throughout the term. **Caution!** You will be at a disadvantage if you attempt to complete all coursework on a smartphone or tablet. It may not be possible to submit the files required for your homework assignments.

Students should be able to use email, a word processor, spreadsheet program, and presentation software to complete this course successfully.

The following list details a minimum recommended computer set-up and the software packages you will need to have access to, and be able to use:

- PC with Windows 10 or higher (we recommend a 3-year Warranty)
- Macintosh with OS 10.11 or higher (we recommend a 3-year Warranty)

- Intel Core i5 or higher
- 250 GB Hard Drive
- 8 GB RAM
- Latest version of Chrome or Firefox; Mac users may use Chrome or Firefox.
- High speed internet connection
- Word processing software (Microsoft Word, Google Docs, etc.)
- Headphones/earbuds and a microphone
- Webcam (recommended)
- Printer (optional)
- Ability to download and install free software applications and plug-ins (note: you must have administrator access to install applications and plug-ins).

Part 2: Course Learning Objectives and Assessments

Course 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.

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 3: 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 Brightspace for the course schedule.

Part 4: Grading System and Exam Schedule

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

Attendance, Participation, Homework	10%	weekly
Exam 1	25%	October 11, 2:30pm EST
Exam 2	25%	November 15, 2:30pm EST
Final Exam	40%	December 12, 5:30pm – 8:00pm

A	88 or more
A-	80 or more but less than 88
B+	75 or more but less than 80
B	70 or more but less than 75
B-	65 or more but less than 70
C+	60 or more but less than 65
C	55 or more but less than 60
C-	50 or more but less than 55
D	45 or more but less than 50
F	less than 45