ESE 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
TA	Jhair Alzamora
Class Time	M, W 2:30pm – 3:50pm Frey Hall 305

TEXTBOOK

"An Introduction to Semiconductor Devices" Donald Neamen, McGraw Hill, 2006, ISBN 9780072987560

OR

"Semiconductor Physics and Devices" Donald Neamen, McGraw Hill, 2011, ISBN

9780073529585

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 Bightspace 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 11, 2:30pm EST
Exam 2	25%	November 15, 2:30pm EST
Final Exam	40%	December 12, 5:30pm – 8:00pm

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