PHY4265: SEMICONDUCTOR PHYSICS AND DEVICES

Effective Term
Semester A 2022/23

Part I Course Overview

Course Title
Semiconductor Physics and Devices

Subject Code
PHY - Physics
Course Number
4265

Academic Unit
Physics (PHY)

College/School
College of Science (SI)

Course Duration
One Semester

Credit Units
3

Level
B1, B2, B3, B4 - Bachelor's Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
(1) AP3202/PHY3202 Modern Physics
(2) AP3272/PHY3272 Introduction to Solid State Physics

Precursors
AP3251/PHY3251 Quantum Physics

Equivalent Courses
AP4265 Semiconductor Physics and Devices

Exclusive Courses
Nil

Part II Course Details

Abstract

Semiconducting materials and semiconductor devices play a very important role in modern technology. Semiconductor devices are not only indispensible parts of systems, such as computers, biomedical equipment, which are important in our daily life, but also from the basis for development of novel technology through their operational principles. Knowledge and understanding of semiconductors and devices are essential for applied physics graduates planning for a technological career.The aim of this course is to provide the students a sound understanding of semiconductor physics and the operational principles of some electronic devices, for learning and using modern technology. In this course, students can also develop the basic analytical skills required for learning or developing novel devices, their fabrication processes and technological applications for their future career.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Describe the physical characteristics, such as electronic structures and optical and transport properties of semiconductors and I-V characteristics of semiconductor devices.	15		x	
2	Relate the electronic structures of semiconductors to their atomic and crystal characteristics.	15		x	
3	Relate the transport and optical properties of semiconductors to fundamental physics processes.	15		x	
4	Apply fundamental principles and processes to operational semiconductor devices and their uses.	15		x	
5	Describe and model some semiconductor properties, processes and device characteristics using equations.	15		x	
6	Evaluate and analyze device characteristics in terms of the material properties and/or structural parameters.	15	x		
7	Correlation with semiconductor theory with emerging semiconductor materials and devices	10	x		

A1: Attitude
Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

A2: Ability
Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to real-life problems.

A3: Accomplishments
Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

Teaching and Learning Activities (TLAs)

	TLAs	Brief Description	CILO No.	Hours/week (if applicable)
1	Lectures	Present basic theories, concepts and examples	1, 2, 3, 4, 5, 6, 7	2 hours / week
2	Tutorials	Provide additional explanations and help the students to practice what they learn in the lectures	1, 2, 3, 4, 5, 6, 7	1 hour / week

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks (e.g. Parameter for GenAI use)
1	Assignments	1, 2, 3, 4, 5, 6, 7	15	
2	Mid-term test	1, 2, 3, 4, 5, 6, 7	15	

Continuous Assessment (%)

30

Examination (%)

70

Examination Duration (Hours)

2

Additional Information for ATs

For a student to pass the course, at least 30% of the maximum mark for the examination must be obtained

Assessment Rubrics (AR)

Assessment Task

1. Assignments

Criterion

The student completes all assessment tasks/activities and the work demonstrates excellent understanding of the scientific principles and the working mechanisms.

Excellent (A+, A, A-)

High

Good (B+, B, B-)

Significant

Fair (C+, C, C-)

Moderate

Marginal (D)

Basic

Failure (F)

Not reaching marginal level

Assessment Task

2. Mid-term test

Criterion

The student can thoroughly identify and explain how the principles are applied to science and technology for solving physics and engineering problems.

Excellent (A+, A, A-)

High

Good (B+, B, B-)

Significant

Fair (C+, C, C-)

Moderate

Marginal (D)

Basic

Failure (F)

Not reaching marginal level

Assessment Task

3. Examination

Criterion

The student can thoroughly identify and explain how the principles are applied to science and technology for solving physics and engineering problems.

Excellent (A+, A, A-)

High

Good (B+, B, B-)

Significant

Fair (C+, C, C-)

Moderate

Marginal (D)

Basic

Failure (F)

Not reaching marginal level

Part III Other Information

Keyword Syllabus

- Review of Quantum Physics
  Wave-particle duality, postulates of quantum mechanics, Schrodinger equation, free particle and particle in a box solutions, periodic boundary condition (3 hours)
- Semiconductor Bandstructure

Bloch theorem, formation of semiconductor energy bands from atomic orbitals, effect of impurity doping, impurity energy energy level, effective mass approximation, electrons and holes, optical processes in semiconductors. (2 hour)

- Semiconductor Transport Properties
  Drift and diffusion motions, continuity equation, generation and recombination of carriers, carrier lifetime, steady state carrier diffusion. (3 hours)
- P-N Junctions
  Equilibrium properties of p-n junctions, space charge layer, I-V characteristics of p-n junctions and its mathematical description. (3 hours)
- Device Applications of p-n Junctions
  Rectifiers, photodiode, light emitting diode and carrier injection in semiconductor lasers. (2 hours)
- Bipolar Junction Transistor
  Device structure and carrier transport, mechanism of current amplification. (2 hours)
- Metal Oxide Semiconductor Field Effect Transistors (MOSFET)
  Device structure, formation of accumulation and inversion layers, current control mechanism, band-bending due to gate voltage, I-V characteristics, application examples. (2 hours)
- Junction Field Effect Transistors (JFET)
  Device structure, current control mechanism, I-V characteristics, application examples. (2 hours)
- Correlation with semiconductor theory with emerging semiconductor materials and devices (4 hrs)

Reading List

Compulsory Readings

	Title
1	S.M. Sze and Kwok K. Ng, Physics of semiconductor devices (latest edition), Wiley

Additional Readings

	Title
1	“Solid State Electronic Devices” B G Streetman, S Banerjee Printice Hall, 6th Edition.
2	“Semiconductor Physics and Devices: Basic Principles” D A Neamen, McGraw-Hill 3rd Edition.