PHY3272: INTRODUCTION TO SOLID STATE PHYSICS

Effective Term

Semester B 2023/24

Part I Course Overview

Course Title

Introduction to Solid State Physics

Subject Code

PHY - Physics

Course Number

3272

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) PHY1101 Introductory Classical Mechanics or PHY1201 General Physics I or equivalent*
(2) PHY1202 General Physics II

Precursors

PHY2191 Electricity and Magnetism
PHY3202 Modern Physics
PHY3251 Quantum Physics

Equivalent Courses

Nil

Exclusive Courses

MSE3172 Electronic Properties of Solids

Additional Information

* This pre-requisite requirement is waived for Advanced Standing I students (admitted in 2015/16 and thereafter) and Advanced Standing II students.

Part II Course Details

Abstract

This course is designed to provide students with an opportunity to develop knowledge and understanding of the key principles and applications of Solid State Physics and their relevance to many disciplines in engineering (e.g. materials and electronic engineering). This is a self-contained course which includes theoretical descriptions of crystal and electronic structure, lattice dynamics, electrical and optical properties of different materials (metals, semiconductors, dielectrics, magnetic materials and superconductors) based on classical and quantum physics principles.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Demonstrate knowledge for crystal structures of solids, different physical mechanisms involved in crystal binding and lattice dynamics			x	
2	Formulate the problem of electrons in a periodic potential, examine its consequence on the band-structure of solids and explain the physical properties of solids in terms of their band-structure			x	
3	Describe the behaviour of solid matters and explain the underlying physical concepts based on solid state theory and principles.			x	
4	Apply physics principles and mathematical methods in solid state physics to explain various physical, electrical and optical properties of materials			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/Student Centred Activities/	Explain key concepts; formulate mathematical models and nurture analytical skills.Provide numerical examples and solutions of advanced problems in solid state physics	1, 2, 3, 4	2 hours/week
2	Tutorial	Provide numerical examples and solutions of advanced problems in solid state physics and materials science	1, 2, 3, 4	1 hr/wk

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks (e.g. Parameter for GenAI use)
1	Assignments	1, 2, 3, 4	15	
2	Test	1, 2, 3, 4	25	

Continuous Assessment (%)

40

Examination (%)

60

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

showing a good understanding of the course materials by being able to solve numerical problems or deriving relevant equations

Excellent (A+, A, A-)

Strong performance

Good (B+, B, B-)

Solid understanding

Fair (C+, C, C-)

Moderate

Marginal (D)

Basic knowledge

Failure (F)
Not given any effort

Assessment Task
2. test

Criterion
able to solve common problems and demonstrate an understanding of the key concepts in solid state physics

Excellent (A+, A, A-)
Strong performance

Good (B+, B, B-)
Solid understanding

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic knowledge

Failure (F)
Unable to grasp the basic concepts

Assessment Task
3. final exam

Criterion
ability to grasp the concept of the taught materials and to solve common problems in solid state physics.

Excellent (A+, A, A-)
Strong performance

Good (B+, B, B-)
Solid understanding

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic knowledge

Failure (F)
Unable to grasp the basic concepts

Part III Other Information

Keyword Syllabus

- Crystal structure and diffraction
  Primitive and conventional unit cells, Bravais lattice, basis, Miller Indices

Diffraction, Bragg’ s law, structure factor, Reciprocal lattice and Brillouin zone.

- Lattice dynamics
  Elastic wave, lattice vibration, vibrational modes and phonons, 1D monatomic and diatomic chains, phonon dispersion curves, acoustic and optical branches, phase and group velocities
  Specific heat, Dulong-Petit model, Einstein model, Debye model, thermal conductivity.
- Free electron gas
  Drude model, Density of states, Fermi-Dirac distribution and Fermi level, electrical conductivity from free electron gas. Electronic specific heat, thermal conductivity due to free electron in metal.
- Energy band in solids
  Bloch wave and Bloch's theorem, periodic potential, energy and band gap, first Brillouin zone and extended zone scheme, metal, insulator and semiconductors, Fermi surfaces, effective mass, holes
- Semiconductors
  Electrons and holes. intrinsic and extrinsic, doping n and p-types semiconductors, donors and acceptors, the Hall effect, optical processes
  p-n junction, drift and diffusion currents, depletion region, built-in potential
- Dielectric properties of solid
  Dielectric constant and polarization, dielectric constant, polarizability, Piezoelectricity, Ferroelectricity and their applications
- Magnetic properties of solids
  Magnetization, Diamagnetism, paramagnetism, ferromagnetism, hysteresis loop
  Application of magnetic resonance: imaging. Giant magnetoresistance and its application.
- Superconductivity
  The phenomenon of superconductivity, zero resistance, perfect diamagnetism and Meissner effect, type I and II superconductors, critical temperature and critical magnetic field, Cooper pair and BCS theory.

Reading List

Compulsory Readings

	Title
1	Nil

Additional Readings

	Title
1	“Elementary Solid State Physics” Omar, Addison Wesley Publishing Company.
2	“Introduction to Solid State Physics” C Kittel, John Wiley and Sons Inc.
3	“Introductory Solid State Physics” H. P. Myers, CRC Press.
4	“Electronic Properties of Materials,” Rolf E. Hummel, 4th Edition, Springer, New York, c2011 (QC176.H86 2001) (E-book)
5	“Principles of Electronic Materials and Devices,” S. O. Kasap, McGraw-Hill (TK453.K26 2006)