PHY6521: ADVANCED SOLID STATE PHYSICS

Effective Term
Semester A 2025/26

Part I Course Overview

Course Title
Advanced Solid State Physics

Subject Code
PHY - Physics
Course Number
6521

Academic Unit
Physics (PHY)

College/School
College of Science (SI)

Course Duration
One Semester

Credit Units
3

Level
P5, P6 - Postgraduate Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
AP3251/PHY3251 Quantum Mechanics or equivalent

Precursors
AP3290/PHY3290 Thermodynamics or equivalent
AP3272/PHY3272 Introduction to Solid State Physics or equivalent

Equivalent Courses
Nil

Exclusive Courses
PHY8521 Advanced Solid State Physics

Part II Course Details

Abstract

This course aims to equip graduate students with advanced knowledge of solid state physics that are necessary to understand contemporary literature and conduct frontier research in condensed matter physics and materials science. The course will start with a review of basic structural and electronic properties of crystals, with an emphasis on the band theory of electrons in periodic potentials. Then, the course will move on to thermodynamic and transport properties of metals, including the temperature dependence of specific heat and conductance, and basic magneto-transport properties. In the last part, the course will cover select advanced topics, which may include magnetism, superconductivity, topological band theory, a brief introduction to topological orders, and Berry phase effects in transport properties of the materials.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Acquire the basic knowledge of crystallography and electronic structure in solids, and the knowledge of fundamental differences between metals and insulators		x	x	
2	Able to derive the Bloch theorem, and apply it to study band structures of toy models; able to analyze basic thermodynamic and transport properties of metals		x	x	x
3	Able to compute the Berry phase and topological properties of insulators in certain toy models		x	x	x
4	Acquire the basic knowledge of quantum Hall effects, edge states, topological insulators, Berry phase effect in metals		x	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.

Learning and Teaching Activities (LTAs)

	LTAs	Brief Description	CILO No.	Hours/week (if applicable)
1	Lecture	Explain key concepts and formulate fundamental theories of selected topics in solid state physics	1, 2, 3, 4	2 hrs/wk

2	Tutorial	Solve some problems with certain techniques and discuss examples of the physical concepts and phenomena discussed in the lectures	1, 2, 3, 4	1 hr/wk

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks ("-" for nil entry)	Allow Use of GenAI?
1	Homework, Quizzes, etc	1, 2, 3, 4	40	-	Yes

Continuous Assessment (%)

40

Examination (%)

60

Examination Duration (Hours)

2

Minimum Examination Passing Requirement (%)

20

Additional Information for ATs

For a student to pass the course, at least 20% of the maximum mark for the examination must be obtained.

Assessment Rubrics (AR)

Assessment Task

Assignment (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

1. Demonstrate correct understanding of key concepts.
2. Being able to use the taught knowledge and theory to solve problems.

Excellent

(A+, A, A-) Will exhibit a high level of competence in understanding, explaining, and integrating the knowledge in written format

Good

(B+, B, B-) Will exhibit a good level of competence in understanding, explaining, and integrating the knowledge in written format

Fair

(C+, C, C-) Will exhibit a basic level of competence in understanding, explaining, and integrating the knowledge in written format

Marginal

(D) Will exhibit some deficiencies in understanding, explaining, and integrating the knowledge in written format

Failure

(F) Will exhibit lack of competence in understanding, explaining, and integrating the knowledge in written format

Assessment Task

Examination (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

1. Demonstrate correct understanding of key concepts.
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Failure

(F) Will exhibit lack of competence in understanding, explaining, and integrating the knowledge in written format

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Assessment Task

Assignment (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

1. Demonstrate correct understanding of key concepts.
2. Being able to use the taught knowledge and theory to solve problems.

Excellent

(A+, A, A-) Will exhibit a high level of competence in understanding, explaining, and integrating the knowledge in written format

Good

(B+, B) Will exhibit a good level of competence in understanding, explaining, and integrating the knowledge in written format

Marginal

(B-, C+, C) Will exhibit some deficiencies in understanding, explaining, and integrating the knowledge in written format

Failure

(F) Will exhibit lack of competence in understanding, explaining, and integrating the knowledge in written format

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Assessment Task

Examination (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

1. Demonstrate correct understanding of key concepts.
2. Being able to use the taught knowledge and theory to solve problems.

Excellent

(A+, A, A-) Will exhibit a high level of competence in understanding, explaining, and integrating the knowledge in written format

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Part III Other Information

Keyword Syllabus

a. Review of crystal structure, band theory, tight-binding models, concept of metals and insulators.
b. Thermodynamic properties, specific heat.
c. Transport properties of metals and the Fermi Liquid Theory.
d. Measuring Fermi surfaces, quantum oscillations.
e. Band insulators, Berry phases, topological band theory.
f. Introduction to Superconductivity.
g. Quantum Magnetism.

Reading List

Compulsory Readings

	Title
1	N. W. Ashcroft and N. D. Mermin, Solid State Physics (Thomson Press 2003)

Additional Readings

	Title
1	M. Tinkham, Introduction to Superconductivity (New York: McGraw-Hill, 2nd ed., 1996)
2	S. H. Simon, Solid State Basics (Oxford University Press, Oxford, 2013)
3	C. Kittel, Introduction to Solid State Physics (Wiley, 8th ed, 2004)
4	P. Phillips, Advanced Solid State Physics (CRC press, 2002)
5	B. Andrei Bernevig, Topological Insulators and Topological Superconductors (Princeton University Press 2013)
6	A. Auerbach, Interacting Electrons and Quantum Magnetism (Springer New York 1994)