Course Specification

(Postgraduate Programs)

Course Title:	Advanced Solid-State Physics
Course Code:	PHY 6161
Program:	Master of Science in Physics
Department:	Physics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University
Version:	3
Last Revision Date:	*26/09/2024*

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A. General information about the course:

1. Course Identification:

1. Credit hours: 4				
2. Course type				
A.	☐ University	☐ College	☒ Department	☐ Track
B.	☒ Required		☐ Elective	
3. Level/year at which this course is offered: Level 2/Year 1				
4. Course General Description:				
The aim of this course is to give an extended knowledge of the principles and techniques of solid-state physics. It is at the level of first-year graduate students and will deepen the understanding already gained through the introduction to solid-state physics. Topics covered include the Drude and Sommerfeld models of metal, the determination of crystal structures by X-Ray diffraction and electron levels in a periodic potential. Fundamental theories are introduced and then extended to show the irrelevance to important applications in current-day technology, industry, and research.				
5. Pre-requirements for this course (if any): None				
6. Pre-requirements for this course (if any): None				
7. Course Main Objective(s):				
At the end of this course, students will be able to: • **Demonstrate knowledge of fundamental concepts in advanced solid-state physics.** • **Illustrate the concepts of free electron gas model, spin-spin interaction, disorder in solids and their applications and the contact phenomena.** • **Solve problems in several topics in advanced solid-state physics.**				

2. Teaching Mode: (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	75	100%
2	E-learning		
3	Hybrid		

No	Mode of Instruction	Contact Hours	Percentage
	• Traditional classroom • E-learning		
4	Distance learning		

3. Contact Hours: (based on the academic semester)

No	Activity	Contact Hours
1.	**Lectures**	**45**
2.	**Laboratory/Studio**	**0**
3.	**Field**	**0**
4.	**Tutorial**	**30**
5.	**Others (specify)……**	**0**
	Total	**75**

B. Course Learning Outcomes (CLOs), Teaching Strategies and Assessment Methods:

Code	Course Learning Outcomes	Code of PLOs aligned with the program	Teaching Strategies	Assessment Methods
1.0	**Knowledge and understanding**			
1.1	**Recognize different aspects of advanced solid state physics and solve related problems.**	**K1,K2**	• Lectures. • Tutorials. • Class discussions.	▪ Exams. ▪ Participation. ▪ Discussions.
1.2	**Describe and perform simple calculations in different electron model by using Hartree- Fock theory and the spin-spin interaction model concept and its importance in physics.**	**K1,K3**	• Lectures. • Tutorials. • Class discussions.	▪ Exams. ▪ Homework. ▪ Quizzes.
1.3	**Interpret the basic concepts of superconductivity and their applications.**	**K1, K2**	• Lectures. • Class discussions. • Tutorials.	▪ Participation. ▪ Exams. ▪ Discussions. ▪ Homework.

Code	Course Learning Outcomes	Code of PLOs aligned with the program	Teaching Strategies	Assessment Methods
2.0	**Skills**			
2.1	**Explain and summarize the basic knowledge gained from studying solid-state physics course.**	**S1, S2**	• Lectures. • Class discussions. • Tutorials.	▪ Exams. ▪ Discussions. ▪ Participation.
2.2	**Develop the students ability to solve and analyze problems in physics related the topics covered by the course.**	**S2, S3**	• Problem classes and group tutorial. • Homework assignments as well as problems solutions.	▪ Exams. ▪ Discussions. ▪ Homework.
2.3	**Communicate in a clear and concise manner orally, and using IT for acquiring and analyzing information.**	**S4**	• Lectures. • Class discussions. • Tutorials. • Encourage students to use electronic mail and internal network for submitting homework and assignments. • Use digital library.	▪ Exams. ▪ Participation and activities of students in the course community and blackboard. ▪ Homework.
3.0	**Values, autonomy, and responsibility**			
3.1	**Show the collaboration and inter-professionalism in class discussions or team works, as well as solve problems independently.**	**V1, V2, V3**	• Small team tasks • Open discussion at classroom. • Office hours.	▪ Participation ▪ Homework. ▪ Mini-project(s).

C. Course Content:

No	List of Topics	Contact Hours
1.	**The Drude's Theory of Metals:** Basic assumptions of the model, Collision or relaxation times, DC electrical conductivity, Hall effect and magnetoresistance, AC electrical conductivity, Dielectric function and plasma resonance, Thermal conductivity, Thermoelectric effects.	**10**

2.	**The Sommerfeld Theory of Metals:** Fermi-Dirac distribution, Free electrons, Density of allowed wave vectors, Fermi momentum, energy, and temperature, Ground-state energy and bulk modulus, Thermal properties of a free electron gas, Sommerfeld theory of conduction, Wiedemann-Franz law.	**10**
3.	**Crystal Lattice:** Bravais Lattice and primitive vectors, Simple, body-centered, and face-centered cubic lattices, Primitive unit cell, Wigner-Seitz cell, and conventional cell, Crystal structures and lattices with bases, Hexagonal close-packed and diamond structures, Sodium chloride, Cesium chloride, and Zincblende structures.	**10**
4.	**The Reciprocal Lattice:** Definitions and examples, First Brillouin zone, Lattice planes and Miller indices.	**8**
5.	**Determination of Crystal Structures by X-Ray Diffraction:** Formulation of Bragg and von Laue, The Laue condition and Ewald's construction, Experimental methods, Geometrical structure factor, Atomic form factor.	**8**
6.	**Classification of Bravais Lattice and Crystal Structures:** Symmetry operations and the classification of Bravais lattices, The seven crystal systems and fourteen Bravais lattices, Crystallographic point groups and space groups,Schoenflies and international notations, Examples from elements.	**8**
7.	**Electron Levels in a Periodic Potential:** The periodic potential and Bloch's theorem, Born-von Karman boundary condition, A second proof of Bloch's theorem, Crystal momentum, band index, and velocity, The Fermi surface.	**5**
8.	**Electrons in a Weak Periodic Potential:** Perturbation theory and weak periodic potentials, Energylevels near a single Bragg plane, Illustration of extended-, reduced-, and repeated-zone schemes in one dimension, Fermi surface and Brillouin zones, Geometrical structure factor, spin-orbit coupling.	**4**
9.	**Beyond the Independent Electron Approximation:** The Hartree equations, The Hartree-Foch equations, Correlation, The dielectric function, Fermi liquid theory.	**4**
10.	**Classification of Solids:** The spatial distribution of valence electrons, Covalent, molecular, and ionic crystals, The alkali halides, Ionic radii, metals.	**4**
11.	**Cohesive Energy:** The noble gases, Ionic crystals, Cohesion in covalent crystals, Cohesion in metals.	**4**
Total		**75**

D. Students Assessment Activities:

No	Assessment Activities *	Assessment timing (in week no)	Percentage of Total Assessment Score
1.	**Class Activities (class quizzes, homework, solving problems, etc.....)**	**weekly**	**20 %**

No	Assessment Activities *	Assessment timing (in week no)	Percentage of Total Assessment Score
2.	Midterm Exam 1	6th week	20 %
3.	Midterm Exam 2	12th week	20 %
4.	Final Exam	16th week	40 %

*Assessment Activities (i.e., Written test, oral test, oral presentation, group project, essay, etc.)

E. Learning Resources and Facilities:

1. References and Learning Resources:

Essential References	*N.W. Ashcroft, N.D. Mermin, Solid State Physics, Harcourt College Publishers, 1976.*
Supportive References	*P. Phillips, Advanced Solid State Physics, 2nd Edition, Cambridge University Press, 2012.* *-C. Kittel, Introduction to Solid State Physics, 8th Edition, John Wiley and Sons, 2005.* *-L. M. Sander, Advanced Condensed Matter Physics, Cambridge University Press, 2009.*
Electronic Materials	https://units.imamu.edu.sa/colleges/en/science/Pages/default.aspx
Other Learning Materials	Multimedia associated with the textbook and the relevant websites.

2. Educational and Research Facilities and Equipment Required:

Items	Resources
facilities (Classrooms, laboratories, exhibition rooms, simulation rooms, etc.)	- Classrooms - XRD research Lab
Technology equipment (Projector, smart board, software)	- Classroom equipped with a whiteboard and a projector.
Other equipment (Depending on the nature of the specialty)	

F. Assessment of Course Quality:

Assessment Areas/Issues	Assessor	Assessment Methods
Effectiveness of teaching	- Students. - Second examiner	Indirect (The student will complete evaluation forms at the end of semester. Final exam is evaluated by the second examiner)

Assessment Areas/Issues	Assessor	Assessment Methods
Effectiveness of students' assessment	- Instructors	Direct (exams, HW, project, ...)
Quality of learning resources	- Faculty - Students	Indirect (surveys)
The extent to which CLOs have been achieved	- Instructors - Program Leaders	Direct (excel sheet)
Other		

Assessor (Students, Faculty, Program Leaders, Peer Reviewer, Others (specify)

Assessment Methods (Direct, Indirect)

G. Specification Approval Data:

COUNCIL /COMMITTEE	Quality Unit-Physics Department
REFERENCE NO.	Department council No. 6
DATE	26/09/2024