هيئة تقويم التعليم والتدريب
Education & Training Evaluation Commission

T-104
2022

Course Specification

Course Title:	**Solid State Physics 2**
Course Code:	**471 PHYS**
Program:	**Physics**
Department:	**Physics**
College:	**Science**
Institution:	**Jazan University**
Version:	2022
Last Revision Date:	**21 December 2022**

Table of Contents:

A. General information about the course:

Course Identification					
1. Credit hours:	**4**				
2. Course type					
a.	University ☐	College ☐	Department☒	Track☐	Others☐
b.	Required ☒	Elective☐			
3. Level/year at which this course is offered: Level 11 / Year 4					

4. Course general Description

This course is a continuation of the solid-state physics 1 course. In its first part, it covers the quantum approach of free electron theory of solids and the band theory of solids. The second part deals with the semiconductor physics theory and applications which cover effective mass, holes, and carrier concentrations in semiconductors at equilibrium and carrier transport phenomena, dielectrics and ferroelectric materials.

5. Pre-requirements for this course (if any): Solid State Physics 1 (371 PHYS)

6. Co- requirements for this course (if any): NIL

7. Course Main Objective(s)

This course is designed to provide students by knowledge about:

This course is designed to provide student with:

- The free electron gas theory, the basic concepts of quantum mechanics,
- Nearly free electron approximation. Energy band theory, Formation of energy bands. Gaps at Brillouin zone boundaries, distinction between metal, insulator, Semiconductor, Bloch wave function and Kronig-Penny model.
- The theory of Semiconductors, the equations of motion, concept of the effective mass, concept of holes, intrinsic carrier concentration and impurity conductivity and thermoelectric effects of semimetals.
- Dielectrics and ferroelectric materials, dielectric constant and polarizability, ferroelectric crystals, ferroelectric hysteresis, ferroelectric domains, and piezoelectricity.
- Experiments included in the lab section to acquire the experience with the laboratory's apparatus, interpret different experimental results, write lab report, and justify different phenomena experimentally.

1. Teaching mode (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1.	Traditional classroom	33	50%
2.	Laboratory	33	50%
3.	E-learning		
4.	Hybrid • Traditional classroom • E-learning		
5.	Distance learning		

2. Contact Hours (based on the academic semester)

No	Activity	Contact Hours
1.	Lectures	33
2.	Laboratory/Studio	33
3.	Field	0
4.	Tutorial	0
5.	Others (specify)	0
	Total	66

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

Code	Course Learning Outcomes	Code of CLOs aligned with program	Teaching Strategies	Assessment Methods
1.0	Knowledge and understanding			
1.1	**<u>Define:</u>** Electrical parameters of conductors, Fermi-Dirac distribution function, density of states, degeneracy, Fermi energy, effective mass of electron, Brillouin zone, valence and conduction band edge, intrinsic and extrinsic semiconductors, drift current and holes, doping, acceptor and donor states, Peltier coefficient, thermoelectric power, dielectric parameters, polarization and dielectrics breakdown, piezoelectricity, Ferroelectricity, and curie temperature.	**PLO 1.1**	Lectures, Open discussion, interactive comparisons, Question-answer method	**Direct**: Homework assignment, Quizzes, mid-term, and final exam **Indirect**: student survey
1.2	**<u>Describe:</u>** Ohm 's law based on quantum free electron theory, Weidman-Franz law, Bloch theorem, Pauli exclusion principle, Matthiessen's rule, Fermi-Dirac distribution function and Clausius-Mossotti relation.	**PLO 1.1**	Lectures, Open discussion, interactive comparisons, Question-answer method	**Direct**: Homework assignment, Quizzes, mid-term exam and final exam **Indirect**: student survey
1.3	**<u>Discuss</u>**: Quantum theory of solids, band theory of solids, Hall effect, effective mass of electrons, origin of the band gab, Bloch theorem, Kronig Penny model, direct and indirect absorption process, intrinsic and extrinsic semiconductors, thermoelectric effects, degenerate and non-degenerate semiconductors, conduction mechanism	**PLO 1.2**	Lectures, Open discussion, interactive comparisons, Question-answer method	**Direct**: Homework assignment, Quizzes, mid-term exam and final exam **Indirect**: student survey

Code	Course Learning Outcomes	Code of CLOs aligned with program	Teaching Strategies	Assessment Methods
	in semiconductors, Lorentz field, different types of polarizability, polarization mechanism in dielectric materials, and hysteresis loop of a ferroelectric material.			
2.0	Skills			
2.1	**Solve**: problems related to electrical conduction, heat capacity and thermal conductivity in metals, drift velocity, mean free path, mean thermal velocity, relaxation time, Hall coefficient, Fermi Dirac distribution, semiconductors and dielectrics, concentration of charge carriers in semiconductors, Fermi energy, relative permittivity, dielectric constant, electric susceptibility, electric polarization, polarizability.	**PLO 2.1**	Lectures, Open discussion, interactive comparisons. Brainstorming	**Direct**: Homework assignment, Quizzes, mid-term exam and final exam **Indirect**: student survey
2.2	**Derive** Expressions for the electronic specific heat of metals, density of state, effective mass of the electron, electrical conductivity of metals and semiconductors, charge carriers, position of Fermi levels in different types of semiconductors and dielectric parameters, equations of motion in crystals.	**PLO 2.2**	Lectures, Open discussion, interactive comparisons, individual solving problems.	**Direct**: Homework assignment, Quizzes, mid-term exam and final exam **Indirect**: student survey
2.3	**Perform:** some experiments to justify and prove different phenomena related to the course contents.	**PLO 2.3**	demonstrations of laboratory equipment and experiments- Hands-on lab work	**Direct**: Direct evaluation of assignments, Step-by-step checkpoint assessment of experiment, Final Practical Exam. **Indirect**: student survey

Code	Course Learning Outcomes	Code of CLOs aligned with program	Teaching Strategies	Assessment Methods
2.4	**Develop** competencies in critical thinking, analyzing the obtained data, communication and writing lab reports.	**PLO 2.4**	Interactive discussion- Case study, group assignment, open discussion, individual presentation.	**Direct**: Observation questioning, Discussion, individual presentation. **Indirect**: student survey
3.0	Values, autonomy, and responsibility			
3.1	**Develop** the ability to work in groups and bear individual responsibility during lab work, interactive discussion, and group assignments.	**PLO3.1**	Group discussion during the lecture and in the lab, Direct evaluation	**Direct**: Observation questioning, discussion **Indirect**: student survey
3.2	**Demonstrate** awareness of safety for own and other competencies during lab work.	**PLO3.3**	Lab work- guidelines, Safety presentation in the first lab lectures.	**Direct**: Observation questioning, discussion, **Indirect**: student survey
...				

C. Course Content

No	List of Topics	Contact Hours
1.	**Free Electron Fermi Gas:** - ENERGY LEVELS IN ONE DIMENSION - EFFECT OF TEMPERATURE ON THE FERMI-DIRAC DISTRIBUTION - FREE ELECTRON GAS IN THREE DIMENSIONS - ELECTRICAL CONDUCTIVITY AND OHM'S LAW - MOTION IN MAGNETIC FIELDS (Hall effect) - THERMAL CONDUCTIVITY OF METALS Ratio of thermal to electrical conductivity	9
2.	**Energy Bands** - NEARLY FREE ELECTRON MODEL: Origin of the energy gap Magnitude of the energy gap - BLOCH FUNCTIONS - EQUATION OF ELECTRON IN A PERIODIC POTENTIAL Restatement of the Bloch theorem Crystal momentum of an electron Solution of the central equation Kronig-Penney model in reciprocal space - NUMBER OF ORBITALS IN A BAND Metals and insulators	6
3.	**Semiconductor Crystals** - EQUATIONS OF MOTION Physical derivation of hk = F Holes Effective mass	9

	Physical interpretation of the effective maw Effective masses in semiconductors - INTRINSIC CARRIER CONCENTRATION Intrinsic mobility - IMPURITY CONDUCTIVITY Donor states Acceptor states Thermal ionization of donors and acceptors - THERMOELECTRIC EFFECTS SEMIMETALS	
4.	**Dielectrics and Ferroelectrics** - MACROSCOPIC ELECTRIC FIELD Depolarization field, E, - LOCAL ELECTRIC: FIELD AT AN ATOM Lorentz field, E, Field of dipoles inside cavity, E, - DIELECTRIC CONSTANT AND POLARIZABILITY Electronic polarizability Classical theory - FERROELECTRIC CRYSTALS Classification of ferroelectric crystals Ferroelectric hysteresis Ferroelectric domains Piezoelectricity	9
Total		33

Experimental Part:

No	List of Topics	Contact Hours
1	Determination of Seebeck coefficients of thermocouples	3
2	Linear absorption coefficient of a dielectric material	3
3	Detecting x-rays using an ionization chamber.	3
4	Solar cell characteristics	3
5	Carrier concentration of metal using Hall Effect	3
6	Electrical characteristics of semiconductor photo-resistor	3
7	Planck constant using light emitting diodes	3
8	Boltzmann Constant Using a PN Junction Diode.	3
9	Determination of the band gap of a semiconductor by using the four-probe method.	3
10	Noble-metal resistor as a Function of the temperature	3
11	Final Lab exam	3
Total		**33**

D. Students Assessment Activities

No	Assessment Activities *	Assessment timing (in week no)	Percentage of Total Assessment Score
1.	**Mid-term exam**	**6**	**15%**
2.	**Student activities (Assignments, Quizzes, group work etc…)**	**Distributed over the semester**	**10 %**
3.	**Lab work**		**25%**
4.	**Final Exam**	**12**	**50%**

*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	**Introduction to Solid States; C. Kittel, 7th Edition, John-Wiley and Sons Inc., 1997.**
Supportive References	• **Principles of the Solid State; H. V. Keer, Wiley Eastern Limited, London, 1993.** • **The Solid State; H. M. Rosenberg, Oxford press, 1988.**
Electronic Materials	http://ocw.mit.edu/courses/physics/ http://www.physics.org/explore.asp https://web.njit.edu/~sirenko/Phys-446/PHYS446SSP.htm
Other Learning Materials	

2. Required Facilities and equipment

Items	Resources
facilities (Classrooms, laboratories, exhibition rooms, simulation rooms, etc.)	**1 Lecture room(s) for 30 students.** **1 Laboratory for 15 students.**
Technology equipment (Projector, smart board, software)	**Data show- smart board**
Other equipment (Depending on the nature of the specialty)	**Library**

F. Assessment of Course Quality

Assessment Areas/Issues	Assessor	Assessment Methods
Effectiveness of teaching	Effectiveness of teaching	Students, Peer, and program leader
Effectiveness of students assessment	Students, Program assessment committee	Direct/ Indirect
Quality of learning resources	Students, Faculty members	Indirect
The extent to which CLOs have been achieved	Instructor	Direct/Indirect
Other		

Assessor (Students, Faculty, Program Leaders, Peer Reviewer, Others (specify)
Assessment Methods (Direct, Indirect)

G. Specification Approval Data

COUNCIL /COMMITTEE	DEPARTMENT BOARD
REFERENCE NO.	PHYS2304
DATE	28/2/2023