هيئة تقويم التعليم والتدريب
Education & Training Evaluation Commission

اعتماد
NCAAA
T4
2020

Course Specifications

Course Title:	**Solid State Physics 2**
Course Code:	**471 PHYS**
Program:	**Physics**
Department:	**Physics**
College:	**Science**
Institution:	**Jazan University**

Table of Contents

A. Course Identification

1. Credit hours:	
2. Course type	
a. University ☐ College ☐ Department ☑ √ Others ☐	
b. Required √ Elective ☐	
3. Level/year at which this course is offered: Level 8 / Year 4	
4. Pre-requisites for this course (if any)**: Solid State Physics 1 (371 PHYS)**	
5. Co-requisites for this course (if any)**: NIL**	

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	42	46.6 %
2	Blended	6	6.8 %
3	E-learning		
4	Distance learning		
5	Other	42	46.6 %

7. Contact Hours (based on academic semester)

No	Activity	Contact Hours
1	Lecture	45
2	Laboratory/Studio	45
3	Tutorial	0
4	**Others** (specify): Preparations for various assignments, quizzes, exams, office Hours.	50
	Total	**140**

B. Course Objectives and Learning Outcomes

1. Course Description

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

2. Course Main Objective

This course is designed to provide students by knowledge about:

- The basic concepts of quantum mechanics and statistical mechanics.
- Free electron theory according to the quantum theory.
- Band theory of solids, Bloch theorem and Kronig-Penny model.
- Classification of solids according to their band gabs.
- Semiconductors and conduction mechanisms.

- Dielectrics and ferroelectric materials.
- Experiments related to the above topics.

3. Course Learning Outcomes

	CLOs	Aligned PLOs
1	**Knowledge and Understanding**	
1.1	**Define:** 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**
1.2	**Describe:** 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**
1.3	**Discuss**: 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 in semiconductors, Lorentz field, different types of polarizability, polarization mechanism in dielectric materials, and hysteresis loop of a ferroelectric material.	**PLO 1.2**
1...		
2	**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**
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**
2.3	**Perform:** some experiments to justify and prove different phenomena related to the course contents.	**PLO 2.3**
2.4	**Develop** competencies in critical thinking, analyzing the obtained data, communication and writing lab reports.	**PLO 2.4**
3	**Values:**	
3.1	**Develop** ability to work in groups and bear individual responsibility during lab work, interactive discussion and group assignments.	**PLO3.1**
3.2	**Demonstrate** awareness of safety for own and others competencies during lab work.	**PLO3.3**
3...		

C. Course Content

Theoretical Part

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 TIIREE 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	**9**
3	**Semiconductor Crystals** - EQUATIONS OF MOTION Physical derivation of **hk** = F Holes Effective mass 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	**12**
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 - STRUCTURAL PHASE TRANSITIONS - FERROELECTRIC CRYSTALS Classification of ferroelectric crystals Ferroelectric hysteresis Ferroelectric domains Piezoelectricity	**9**
5	Review, Homework correction, Midterm exams	**6**
…		
Total		**45**

Experimental Part:

No	List of Topics	Contact Hours
1	**Determination of Seebeck coefficients of thermocouples.**	**3**
2	**Linear absorption coefficient of dielectric material.**	**3**
3	**Solar cell characteristics.**	**3**
4	**Detection of X-rays using an ionization chamber.**	**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	**Energy gap of Si using PN junction.**	**3**
9	**Determination of Boltzmann Constant.**	**3**
10	**Ferromagnetic hysteresis**	**3**
11	**Introduction, review, and various exams**	**15**
Total		**45**

D. Teaching and Assessment

1. Alignment of Course Learning Outcomes with Teaching Strategies and Assessment Methods

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
1.0	**Knowledge and Understanding**		
1.1	**Define:** 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.	Lectures, Open discussion, interactive comparisons, Question-answer method	**Direct**: Homework assignment, Quizzes, mid-term and final exam **Indirect**: student survey
1.2	**Describe:** 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.	Lectures, Open discussion, interactive comparisons, Question-answer method	**Direct**: Homework assignment, Quizzes, mid-term exam and final exam **Indirect**: student survey
1.3	**Discuss**: 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	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	Teaching Strategies	Assessment Methods
	extrinsic semiconductors, thermoelectric effects, degenerate and non-degenerate semiconductors, conduction mechanism 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	**<u>Solve</u>**: 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.	Lectures, Open discussion, interactive comparisons. Brain storming	**Direct**: Homework assignment, Quizzes, mid-term exam and final exam **Indirect**: student survey
2.2	**<u>Derive</u>** 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.	Lectures, Open discussion, interactive comparisons, individual solving problem.	**Direct**: Homework assignment, Quizzes, mid-term exam and final exam **Indirect**: student survey
2.3	**<u>Perform:</u>** some experiments to justify and prove different phenomena related to the course contents.	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
2.4	**<u>Develop</u>** competencies in critical thinking, analyzing the obtained data, communication and writing lab reports.	Interactive discussion- Case study, group assignment, open discussion, individual presentation.	**Direct**: Observation questioning, Discussion, individual presentation. **Indirect**: student survey
2.5			
3.0	**Values**		

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
3.1	**Develop** the ability to work in groups and bear individual responsibility during lab work, interactive discussion and group assignments.	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 others competencies during lab work.	Lab work- guidelines, Safety presentation in the first lab lectures.	**Direct**: Observation questioning, discussion, **Indirect**: student survey
3.3			

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	**Homework Assignment**	**2,5,8,10**	**5%**
2	**Lecture Quizzes 1,2**	**3,9**	**4%**
3	**First Mid-term exam**	**6**	**7%**
4	**Second Mid-term exam**	**11**	**7%**
5	**Contribution in interactive discussion- Group work-essay or Project discussion Lecture web-based essay.**	**12**	**2%**
6	**Lab Report, communication and lab competence**	**14**	**10%**
7	**Practical exam**	**14**	**15%**
8	**Final Exam**	**16**	**50%**

***Assessment task** (i.e., written test, oral test, oral presentation, group project, essay, etc.)

E. Student Academic Counseling and Support

Arrangements for availability of faculty and teaching staff for individual student consultations and academic advice :

Each group of students is assigned to a staff member who will be available for help and academic guidance office hours at specific 2h on daily basis.

F. Learning Resources and Facilities

1.Learning Resources

Required Textbooks	**Introduction to Solid States; C. Kittel, 7th Edition, John-Wiley and Sons Inc., 1997.**
Essential References Materials	• **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. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	**1 Lecture room(s) for 30 students.** **1 Laboratory for 15 students.**
Technology Resources (AV, data show, Smart Board, software, etc.)	**Data show- smart board**
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	**Library**

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students, Peer and program leader	Indirect (CES)- Indirect peer evaluation
Assessment	Students, Program assessment committee	Direct/ Indirect
Extent of achievement of course learning outcomes	Instructor	Direct/Indirect
Quality of learning resources	Students, Faculty members	Indirect
Effectiveness of teaching	Students, Peer and program leader	Indirect (CES)- Indirect peer evaluation

Evaluation areas (e.g., Effectiveness of teaching and assessment, Extent of achievement of course learning outcomes, Quality of learning resources, etc.)
Evaluators (Students, Faculty, Program Leaders, Peer Reviewer, Others (specify)
Assessment Methods (Direct, Indirect)

H. Specification Approval Data

Council / Committee	**Department council**
Reference No.	**8**
Date	**16/4/1442**