BS-115 A	Semiconductor Physics						
L	**T**	**P**	**Credit**	**Major Test**	**Minor Test**	**Total**	**Time**
3	**1**	**-**	**4**	**75**	**25**	**100**	**3h**
Purpose	**To introduce the fundamentals of solid state physics and its applications to the students.**						

Course Outcomes	
CO1	**To study basics of crystal structure and to discuss defects in solids.**
CO 2	**To introduce elementary quantum mechanics and to study uncertainty principle and its applications.**
CO 3	**To discuss classical free electron theory and its applications.**
CO 4	**To make the students aware of band theory of solid and to study Hall effect.**
CO5	**To study basics of intrinsic and extrinsic semiconductor.**
CO6	**To make the students aware of basic devices of semiconductor.**

Unit - I

Crystal Structure: Crystalline and Amorphous solids, Crystal Structure: lattice translation vector, symmetry operations, space lattice, basis; Unit cell and Primitive cell, Fundamental types of lattices: two-dimensional and three dimensional Bravais lattices; Characteristics of Unit cells: Simple Cubic (SC), Body Centred Cubic (BCC), Face Centred Cubic (FCC), Hexagonal Close Packed (HCP) structure; Simple crystal structures: Sodium Chloride, Cesium Chloride, Diamond, Cubic Zinc Sulfide; Miller Indices, Bonding in Solids, Point defects in crystals: Schottky and Frenkel defects.

Unit – II

Quantum Theory: Need and origin of Quantum concept, Wave-particle duality, Phase velocity and group velocity, Uncertainty Principle and Applications; Schrodinger's wave equation: time-dependent and time –independent; Physical Significance of wave function ψ.

Unit – III

Free Electron Theory: Classical free electron theory: electrical conductivity in metals, thermal conductivity in metals, Wiedemann-Franz law, success and drawbacks of free electron theory; Quantum free electron theory: wave function, eigen values; Fermi-Dirac distribution function, Density of states, Fermi energy and its importance, Thermionic Emission (qualitative).

Band theory of Solids: Bloch theorem, Kronig-Penney Model (qualitative), E versus k diagram, Brillouin Zones, Concept of effective mass of electron, Energy levels and energy bands, Distinction between metals, insulators and semiconductors, Hall effect and its Applications.

Unit –IV

Semiconductors: Conduction in Semiconductors, Intrinsic Semiconductors: Conductivity of charge carriers, Carrier concentration in intrinsic semiconductors; Extrinsic Semiconductors: n-

type semiconductors, p-type semiconductors, charge carrier concentration in extrinsic semiconductors.

Semiconductor Devices: The p-n junction, Current-voltage characteristics of p-n junction; The Transistor: Bipolar Junction Transistor (BJT), Field Effect Transistor (FET), Metal-Semiconductor Junction (Ohmic and Schottky); Semiconductor Laser.

Suggested Books:

1. Applied Physics for Engineers, Wiley India Pvt. Ltd.
2. Introduction to Solid State Physics, John Wiley & Sons. .
3. Concepts of Modern Physics (5^{th} edition), Tata McGraw-Hill Publishing Company Limited.
4. Solid State Physics, New Age International (P) Limited.
5. A Textbook of Quantum Mechanics, McGraw Hill Education (India) Private Limited.

Note: The paper setter will set the paper as per the question paper templates provided.

Lecture Plan

Month	Topic /chapter covered	Academic Activity	Test /Assignment
Day 1	Crystalline and Amorphous solids, Crystal structure: lattice translation vector	Lecture	
Day 2	Symmetry operations	Lecture	
Day 3	Space lattice, basis; Unit cell and Primitive cell	Lecture	
Day 4	Two and three dimensional Bravais lattices	Lecture	
Day 5	Characteristics of Unit cells: SC, BCC, FCC structure	Lecture	
Day 6	HCP structure	Lecture	
Day 7	Simple crystal structure: NaCl, CsCl structure	Lecture	
Day 8	Diamond, ZnS structure	Lecture	
Day 9	**Revision**		**Assignment/Test**
Day 10	Miller Indices	Lecture	
Day 11	Miller Indices	Lecture	
Day 12	Bonding in Solids	Lecture	
Day 13	Point defects in crystals: Schottky defect	Lecture	
Day 14	Frenkel defect	Lecture	
Day 15	**Revision**		**Assignment/Test**
Day 16	Need and origin of Quantum concept	Lecture	
Day 17	Need and origin of Quantum concept	Lecture	
Day 18	Wave-particle duality, Phase velocity	Lecture	
Day 19	and group velocity	Lecture	
Day 20	Uncertainty Principle and applications	Lecture	
Day 21	Schrodinger's time-independent & time-dependent wave equation Physical significance of wave function	Lecture	
Day 22	**Revision**		**Assignment/Test**
Day 23	Classical free electron theory	Lecture	
Day 24	Electrical conductivity in metals	Lecture	
Day 25	Thermal conductivity in metals, Wiedmann- Franz law, Success and drawbacks of free electron theory	Lecture	

Day 26	Quantum free electron theory: wave function, eigen values	Lecture	
Day 27	Quantum free electron theory: wave function, eigen values	Lecture	
Day 28	Fermi – Dirac distribution function	Lecture	
Day 29	Density of states	Lecture	
Day 30	Fermi energy and its importance	Lecture	
Day 31	Thermionic Emission	Lecture	
Day 32	**Revision**		**Assignment/Test**
Day 33	Bloch theorem	Lecture	
Day 34	Kronig-Penney model (qualitative)	Lecture	
Day 35	Kronig-Penney model (qualitative)	Lecture	
Day 36	E versus K diagram, Brillouin Zones	Lecture	
Day 37	Concept of effective mass of electron	Lecture	
Day 38	Energy levels and energy bands	Lecture	
Day 39	Distinction between metals, insulators and semiconductors	Lecture	
Day 40	Hall effect and its applications	Lecture	
Day 41	**Revision**		**Assignment/Test**
Day 42	Conduction in Semiconductor	Lecture	
Day 43	Intrinsic Semiconductors: Conductivity of charge carriers	Lecture	
Day 44	Carrier concentration in intrinsic semiconductors	Lecture	
Day 45	Carrier concentration in intrinsic semiconductors	Lecture	
Day 46	Extrinsic Semiconductors: n-type semiconductors	Lecture	
Day 47	p-type semiconductors	Lecture	
Day 48	Charge carrier concentration in extrinsic semiconductors	Lecture	
Day 49	**Revision**		**Assignment/Test**
Day 50	The pn junction, current voltage characteristics of pn junction	Lecture	
Day 51	BJT	Lecture	
Day 52	FET	Lecture	

Day 53	Metal-Semiconductor junction: Schottky	Lecture	
Day 54	Metal-Semiconductor junction: Ohmic	Lecture	
Day 55	Semiconductor Laser	Lecture	
Day 56	**Revision**		**Assignment/Test**

Tutorial Sheet 1

Part 1

1. a. What are crystalline and amorphous solid?
   b. Write note on translation vector, space lattice and Unit cell.
2. a. Discuss symmetry operation. Why 5-fold rotation symmetry is not possible?
   b. Explain different types of bravais lattice in 3 dimensions.
3. Discuss hcp, diamond and NaCl structure.

Part 2

1. What do you understand by Miller Indices? Derive expression for interplanar spacing. Draw Planes and Direction for (210), (102) and (011).
2. Discuss various bonds in solids and give 2 examples of each.
3. What is point defect? Discuss different types of it. Derive concentration of Frenkel defects in ionic crystal.

Tutorial Sheet 2

1. What is Planck's quantum hypothesis to explain the observed spectrum of a blackbody?
2. a. Write note on wave-particle duality.
   b. Discuss phase velocity and group velocity and establish relationship between them.
3. What is wave function? Derive time independent and time dependent Schrodinger wave equations.
4. What do you understand by uncertainty principle? Discuss its 3 applications.

Tutorial Sheet 3

Part 1

1. a. Discuss Drude and Lorentz model with its main assumptions and drawbacks.
   b. Explain 2 applications of it.
2. Discuss the behavior of an electron in a potential box.
3. a. Write note on FD distribution function and density of states.
   b. Calculate concentration and average energy of free electrons at absolute zero temperature.
4. What is thermionic emission? Derive Richardson equation. Name some application of it.

Part 2

1. a. What is Bloch function? Discuss the behavior of an electron in periodic potential wells.
   b. Write note on EK diagram and Brillouin zones.
2. a. Calculate number of possible wave functions in a completely filled band.
   b. What is Hall Effect? Calculate various parameters experimentally. Give its some applications.
3. a. What do you mean by effective mass of electron?
   b. How degree of freedom helps in distinction of various types of solid?

Tutorial Sheet 4

Part 1

1. Write a note on intrinsic and extrinsic semiconductors.
2. a. Derive expressions for the concentration of electron in conduction band and holes in valence band in intrinsic semiconductor.
   b. Derive law of mass action.
3. a. Derive an expression for carrier concentration in n type semiconductor.

b. Derive an expression for carrier concentration in p type semiconductor.

Part 2

1. a. What is pn junction? Discuss its current-voltage characteristics.
   b. Discuss BJT and its characteristics.
2. a. What is Schottky contact? Discuss it under forward and reverse biasing.
   b. Discuss FET and its characteristics.
3. Explain semiconductor laser and write its application also.

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SEMICONDUCTOR PHYSICS

Paper BS-115A

Time: Three Hours] **[Maximum Marks: 75**

Note : Attempt five questions in all, selecting at least one question from each unit.

UNIT-I

1. (a) Explain various types of crystal system with example. (7)
   (b) What do you mean by point defects in solids? Derive an expression for concentration of Schottky in a crystal. (8)
2. (a) Explain the characteristics of the following unit cells with examples: SC, BCC and FCC. (8)
   (b) What are Miller Indices? Draw the following planes (110) (**111**) and (**11**0). (7)

UNIT-II

3. (a) What do mean by wave packet? Show that the De- Broglie group velocity associated with the wave packet is equal to velocity of the particle. (8)
   (b) Derive Schrodinger time independent equation for matter waves. Give physical significance of the wave function. (7)
4. (a) What is the need and origin of quantum mechanics? (7)
   (b) Explain group velocity and phase velocity. Derive the expression for group velocity with which a wave packet travels. (8)

UNIT-III

5. (a) Discuss Drude's electron gas model to explain electrical conduction in metals. (8)
   (b) What are Brillion Zones? Explain. (7)
6. (a) Based on band theory of solids, distinguish between conductors, semiconductors and insulators. (8)
   (b) What is Hall Effect? Mention applications of Hall effect. (7)

UNIT-IV

7. (a) What do you mean by intrinsic semiconductor? Derive an expression for carrier concentration in intrinsic semiconductor. (8)
   (b) Explain the working and characteristic of bipolar junction transistor. (7)
8. (a) Explain conductivity of charge carriers in n-type and p-type semiconductors. (8)
   (b) Describe the formation of p-n junction. Discuss its current voltage characteristic. (7)

BS-117LA	Semiconductor Physics Lab						
L	**T**	**P**	**Credit**	**Practical**	**Minor Test**	**Total**	**Time**
-	**-**	**3**	**1.5**	**30**	**20**	**50**	**3h**
Purpose	**To give the practical knowledge of handling the sophisticated instruments.**						

Course Outcomes	
CO1	**To introduce the experiments related with ionization potential, thermionic emission and temperature coefficient.**
CO2	**To give knowledge of working of photoelectric cell.**
CO3	**To understand V – I characteristics of p-n diode and band gap of semiconductors.**
CO4	**To understand Hall effects, Flashing & quenching of neon bulb**
CO5	**To give the knowledge of ultrasonic waves.**
CO6	**To give knowledge about variation of magnetic field and hysteresis loss.**

Note: Student will be required to perform at least 10 experiments out of the following list.

1. To study the V-I characteristics of a p-n diode.
2. To find the flashing and quenching potential of Argon and to find the capacitance of unknown capacitor.
3. To find the value of Planck's constant by using photoelectric cell.
4. To find the temperature coefficient of resistance by using Pt resistance thermometer by post office box.
5. To find the ionization potential of Argon/Mercury using a thyratron tube.
6. To study the variation of magnetic field with distance and to find the radius of coil by Stewart and Gee's apparatus.
7. To study the characteristics of (Cu-Fe, Cu-Constantan) thermocouple.
8. To find the value of Hall Coefficient of semiconductor.
9. To find the value of e/m for electrons by Helical method.
10. To find the band gap of intrinsic semiconductor using four probe method.
11. To calculate the hysteresis loss by tracing a B-H curve.
12. To find the frequency of ultrasonic waves by piezoelectric methods.
13. To verify Richerdson thermionic equation.
14.

Suggested Books:

1. C.L.Arora, B. Sc. Practical Physics, S. Chand.
2. B.L. Worshnop and H, T, Flint, Advanced Practical Physics, KPH.
3. S.L. Gupta & V. Kumar, Practical Physics, PragatiPrakashan.