Course Code	21PYB102J	Course Name	SEMICONDUCTOR PHYSICS AND COMPUTATIONAL METHODS	Course Category	B	Basic Sciences	L	T	P	C
							3	1	2	5

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Physics and Nanotechnology*	Data Book / Codes/Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Introduce band gap and Fermi level in semiconductors and how to compute those properties*
CLR-2 :	*Explain the concept of carrier transport mechanism in p-n and metal semiconductor junction*
CLR-3 :	*Provide an insight on semiconductor optical transitions and photovoltaic effect*
CLR-4 :	*Procure knowledge of electrical and optical measurements in semiconductor and to instigate the concepts of TCAD*
CLR-5 :	*Develop necessary skills for low dimensional semiconductor material processing and characterization and to introduced the basic of machine learning in image processing*
CLR-6 :	*Utilize the concepts in semiconductors physics and computational methods for the application in engineering and technology*

Program Outcomes (PO)

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning
CO-1 :	*Understand and compute energy band in solids and electron occupation probability*	3	-	-	-	-	-	-	-	-	-		-
CO-2 :	*Understand and analyze the working of optoelectronic devices*	3	-	-	-	-	-	-	-	-	-		-
CO-3 :	*Apply the knowledge to the development of new and novel optoelectronic devices*	-	-	3	-	-	-	-	-	-	-		-
CO-4 :	*Understand the working mechanism of electrical and optical measurements and gain the fundamentals of TCAD*	3	-	-	-	-	-	-	-	-	-		-
CO-5 :	*Acquire knowledge of the low dimensional semiconductor material fabrication and characterization and gain insights of the concepts of machine learning*	-	3	-	-	-	-	-	-	-	-		-
CO-6 :	*Apply the concepts of semiconductors physics and computational methods in real time applications*	3	-	3	-	-	-	-	-	-	-		-

Unit-1: ENERGY BANDS IN SOLIDS **18 Hours**

Introduction to Classical Free electron theory-Introduction to Quantum Free electron theory-Density of states-Concepts-Energy band in solids-Kronig-Penney model–E-k diagram-Direct and Indirect band gap-Concept of phonons-Concept of Brillouin Zone-Computational determination of Band Structure – Concepts , Eigenvalue equations- (STIE) Classification of electronic materials-Fermi level-Probability of occupation-Numerical determination of probability of occupation and carrier concentration-Concept of Fermi surface of a metal-Computational determination of Fermi Surface of Cu as example.

Experiments

1. Determination of Hall coefficient of Semiconductor material
2. Determination of Band Gap of semiconductor-Post Office Box method

Unit-2: CARRIER TRANSPORT MECHANISM IN SEMICONDUCTORS	**18 Hours**
Intrinsic semiconductor-Dependence of Fermi level on carrier-concentration-and temperature in Intrinsic semiconductor-Extrinsic semiconductors-Dependence of Fermi level on carrier-concentration-and temperature in extrinsic semiconductors-Explanation for carrier generation-Explanation for recombination processes -Carrier transport - diffusion and drift current-Continuity equation-p-n junction-Biasing concept in p-n junction-Metal-semiconductor junction -Ohmic contact -Semiconductor materials of interest for optoelectronic devices-Photocurrent in a P-N junction diode- Light emitting diode- Classification of Light emitting diode-Optoelectronic integrated circuits-Organic light emitting diodes Experiments 3. Determination of Band Gap of semiconductor-Four probe method 4. Study of I-V characteristics of a light dependent resistor (LDR) 5. Study of V-I and V-R characteristics , Efficiency of a solar cell	
Unit-3: OPTOELECTRONIC PROPERTIES OF SEMICONDUCTORS	**18 Hours**
Concept of optical transitions in bulk semiconductor- Optical absorption process-Concept of recombination process-Optical recombination process-Explanation for spontaneous emission-Explanation for stimulated emission-Joint density of states in semiconductor-Density of states for photons-Explanation of transition rates-Numerical computation of optical loss-Finite element method to calculate Photon density of states -Basic concepts of Photovoltaic-Photovoltaic effect-Applications of Photovoltaic effect-Determination of efficiency of a PV cell-Computational approach to calculate optical excitations-Example: optical excitation in BN (Boron nitride) Experiments 6. Characterization of pn junction diode (Forward and reverse bias) 7. Verify Inverse square law of light using a photo cell.	
Unit-4: ELECTRICAL AND OPTICAL MEASUREMENTS	**18 Hours**
Concept of electrical measurements-Two point probe technique-Four point probe technique-linear method-Four point probe technique-Vander Pauw method-Significance of carrier density-Significance of resistivity and Hall mobility-Hot-point probe measurement-Capacitance-voltage measurements-Extraction of parameters in a diode-I-V characteristics of a diode-Introduction of TCAD in basic level- Significance of band gap in semiconductors-Concept of absorption and transmission-Boltzmann Transport Equation-Scattering Mechanisms-Monte Carlo method- Concept only-Example only Monte Carlo Methods for Solution of BTE(Boltzmann equation) Experiments 8. Determination of electron and hole mobility versus doping concentration using GNU Octave 9. Determination of Fermi function for different temperature using GNU Octave 10. Study of attenuation and propagation characteristic of optical fiber cable using laser source	
Unit-5: LOW DIMENSIONAL SEMICONDUCTOR MATERIALS	
Density of states in 2D-Density of states in 1D and 0D-Introduction to low dimensional systems-Quantum well-Quantum wire and dots-Introduction to novel low dimensional systems -CNT- properties and synthesis-Applications of CNT-Fabrication technique-CVD-Fabrication technique-PVD-Characterizations techniques for low dimensional systems-Principle of electron microscopy-Scanning electron microscopy-Transmission electron microscopy-Atomic force microscope-Computational and machine learning approach for electron microscopy image processing – Concepts, overview-Example of Graphene Experiments 11. Plotting and interpretation of I-V characteristics of Diode GNU Octave	

12. Determination of lattice parameters using powder XRD 13. Mini Project

Learning Resources		
Learning Resources	1 J. Singh, "*Semiconductor Optoelectronics*": *Physics and Technology*, McGraw-Hill Inc. 1995. 2. B. E. A. Saleh and M. C. Teich, "*Fundamentals of Photonics*", John Wiley & Sons, Inc., 2007. 3. S. M. Sze, "*Semiconductor Devices*" Physics and Technology, Wiley 2008.	4. A. Yariv and P. Yeh, Photonics:" Optical Electronics in Modern Communications", Oxford University Press, New York 2007. 5. Computational Materials Science: An Introduction by June Gunn Lee, Chapter 7, Page 227- 230 (Quantum Espresso)and Page 300-307 (VASP) 6. Finite Element Method GouriDhatt, Emmanuel Lefrançois, Gilbert Touzot, Wiley Publication, ISBN: 978-1-848-21368-5

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA) - By the Course Faculty				By The CoE	
		Formative CLA-1 Average ofunit test (45%)		Life LongLearning CLA-2- Practice (15%)		Summative FinalExamination (40% weightage)	
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20	-	-	10	20	-
Level 2	Understand	20	-	-	30	20	-
Level 3	Apply	30	-	-	20	30	-
Level 4	Analyze	30	-	-	40	30	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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