DEPARTMENT OF PHYSICS AND NANOTECHNOLOGY
SRM INSTITUTE OF SCIENCE AND TECHNOLOGY
SRM NAGAR, KATTANKULATHUR – 603 203
B.Tech – School of Computing- First Year/ First Semester

LESSON PLAN

Subject Name: SEMICONDUCTOR PHYSICS AND COMPUTATIONAL METHODS
Subject Code: 21PYB102J

Module I			
Lecture Hour		**Description**	**Reference**
S-1	SLO-1	Introduction to Classical Free electron theory	**Jasprit Singh, Semiconductor Devices (2001), Page 2-3**
	SLO-2	Introduction to Quantum Free electron theory	
S-2	SLO-1	Density of states – Concepts	**Donald A. Neamen, 3rd Edition, Semiconductor Physics and Devices, page 83-85**
	SLO-2	Energy band in solids	**S.M. Sze, Semiconductor Devices, 2nd Edition, page 28-30**
S-3	SLO-1	Kronig-Penney model	**Donald A. Neamen, 3rd Edition, Semiconductor Physics and Devices, Page 61-65**
	SLO-2	Solving problems	
S-4-5		**Lab 1: Basics of experimentation**	**Lab**
S-6	SLO-1	Direct and Indirect band gap	**S.M. Sze, Semiconductor Devices, page 30-32**
	SLO-2	Concept of phonons-Concept of Brillouin Zone	
S-7	SLO-1	E-k diagram – Basic concepts	**S.M. Sze, Semiconductor Devices, page 30-32**
	SLO-2	Concepts, Eigen value equations	Computational Materials Science: An Introduction by June Gunn Lee, Chapter 7, Page 227- 230 (Quantum Espresso) and Page 300 - 307 (VASP)

			And Chapter 4 page 108-120
S-8	SLO-1	Computational determination of Band Structure	**http://physics.unl.edu/tsymbal/teaching/SSP-927/Section%2011_Methods_for_calculating_band_structure.pdf** **https://www.iue.tuwien.ac.at/phd/ghosh/diss_htmse6.html**
	SLO-2	Classification of electronic materials	**S.M. Sze, Semiconductor Devices, page 32-33**
S-9-10		**Lab 2: Determination of Hall coefficient of Semiconductor material**	**Lab**
S11	SLO-1	Fermi level	**S.M. Sze, Semiconductor Devices, page 32-33**
	SLO-2	Probability of occupation	
S-12	SLO-1	Numerical determination of probability of occupation and carrier concentration	**https://khitguntur.ac.in/shmat/AP%20UNIT%20IV%20PPT%20II%20(Quantitative).pdf** **https://www.ias.ac.in/article/fulltext/boms/045/0112**
	SLO-2	Concept of Fermi surface of a metal	**http://www-personal.umich.edu/~sunkai/teaching/Winter_2015/chapter08.pdf**
S-13	SLO-1	Computational determination of Fermi Surface of Cu as example	**http://physics.unl.edu/tsymbal/teaching/SSP-927/Section%2011_Methods_for_calculating_band_structure.pdf** **https://iopscience.iop.org/article/10.1088/1367-2630/14/4/043009/pdf** **https://www.ias.ac.in/article/fulltext/boms/045/0112** **https://phy.ntnu.edu.tw/~changmc/Teach/SS/SS_note/chap09.pdf**

	SLO-2	Solving problems.	**https://www.physics.udel.edu/~msafrono/425-2010/Lecture%208.pdf**
S-14-15		**Lab 3: Determination of Band Gap of semiconductor-Post Office Box method**	**Lab**

Module II			
Lecture Hour		**Description**	**Reference**
S-1	SLO-1	Intrinsic semiconductor	**S.M. Sze, Semiconductor Devices, page 34-36.**
	SLO-2	Concept of carrier concentration, variation of Fermi level with temperature in intrinsic semiconductor	**S.M. Sze, Semiconductor Devices, page 34-36.**
S-2	SLO-1	Extrinsic semiconductors	**Donald A. Neamen, 3rd Edition, Semiconductor Physics and Devices, Page 139-144.**
	SLO-2	Concepts of carrier concentration, variation of Fermi level with temperature in n and p type semiconductor	**Donald A. Neamen, 3rd Edition, Semiconductor Physics and Devices, Page 139-144.**
S-3	SLO-1	Explanation for carrier generation	**S.M. Sze, Semiconductor Devices, page 60-66.**
	SLO-2	Solving problem	
S - 4, 5		**Lab 4: Determination of Band Gap of semiconductor-Four probe method**	**Lab**
S-6	SLO-1	Diffusion and drift current	**S.M. Sze, Semiconductor Devices Physics and Technology, Second Edition, John Wiley & Sons, page 66-68.**
	SLO-2	Continuity equation-p-n junction	
S-7	SLO-1	Biasing concept in p-n junction	**S.M. Sze, Semiconductor Devices, page 88-89.**
	SLO-2	Metal semiconductor junction	
S-8	SLO-1	Ohmic contact	**S.M. Sze, Semiconductor**

		Concepts of Carrier transport - diffusion and drift – Derivation of Continuity equation.	**Devices, page 66-68.**
	SLO-2		
	SLO-1 SLO-2	**Lab 5: Study of I-V characteristics of a light dependent resistor (LDR)**	**Lab**
	SLO-1	Semiconductor materials of interest for optoelectronic devices	**S.M. Sze, Semiconductor Devices, page 88-89.**
S-11	SLO-2 SLO-1	Photocurrent in a P-N junction diode Light emitting diode	**Jasprit singh, page 463-464** **S.M. Sze, Semiconductor Devices Physics and Technology, Second Edition, John Wiley & Sons, page 288-294.**
S-12	SLO-2	Classification of Light emitting diode	
	SLO-1	Optoelectronic integrated circuits	**Jasprit singh, page 455**
S-13	SLO-2	Organic light emitting diodes-Solving problem	**Jasprit singh, page 463-464**
S-14-15		**Lab 6: Study of V-I and V-R characteristics, Efficiency of a solar cell**	**Lab**

Module III			
Lecture Hour		**Description**	**Reference**
S-1	SLO-1	Concepts of optical transition in bulk semiconductor	**Saleh & Teich, Fundamentals of photonics, Second edition, page 660-661.**
	SLO-2	Optical absorption process and emission process	
S-2	SLO-1	Concepts of Recombination process	**P. Battacharya, page 116-118**
	SLO-2	Optical recombination process	
S-3	SLO-1	Explanation of spontaneous emission	**P. Battacharya, page 244-245**
	SLO-2	Explanation of stimulated emission	

S-4-5		**Lab 7: Characterization of pn junction diode**	**Lab**
	SLO-1	Solving problem	**Saleh & Teich, Fundamentals of photonics, Second edition, page 665.**
S-6	SLO-2	Joint density of states (Conservation of energy and momenta of electron with photon interacts)	
S-7	SLO-1	Density of states for photon	**Shun Lien Chuang, Physics of Photonic Devices, page 353-354**
	SLO-2	Explanation of transition rates using Fermi's golden rule	
S-8	SLO-1	Numerical computation of optical loss	**https://nanohub.org/resources/4883/download/tutorial_semiempirical_bandstructure_methods.pdf**
	SLO-2	Finite element method to calculate Photon density of states	**https://opg.optica.org/oe/fulltext.cfm?uri=oe-15-1-207&id=122646**
S-9-10		**Lab 8: Repeat/Revision of experiments**	**Lab**
	SLO-1	Solving Problem	**Chetan Singh Solanki, Solar Photovoltaics, 2rd Edition, page 89-94**
S-11	SLO-2	Basic concepts of Photovoltaic	
S-12	SLO-1	Photovoltaic effect, Applications of Photovoltaic effect	
	SLO-2	Determination of efficiency of a PV cell	
	SLO-1	Computational approach to calculate optical excitations, Example: optical excitation in BN	**https://www.nature.com/articles/s41598-021-90804-4**
S-13	SLO-2	Solving Problem	**https://nanohub.org/resources/4883/download/tutorial_semiempirical_bandstructure_methods.pdf** **https://khitguntur.ac.in/shmat/AP%20UNIT%20IV%20PPT%20II%20(Quantitative).pdf** **https://www.ias.ac.in/article/fulltext/boms/045/0112**
S-14-		**Lab 9: To verify Inverse square law of light**	

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Module IV			
Lecture Hour		**Description**	**Reference**
S-1	SLO-1	Concepts of Electrical measurements	**ELTON .N. KOUFMANN Characterization of Materials, Volume I**
	SLO-2	Two point probe technique	**1)ELTON .N. KOUFMANN Characterization of Materials, Volume I, Page 401**
S-2	SLO-1	Four-point probe technique-linear method	**ELTON .N. KOUFMANN Characterization of Materials, Volume I ,Page 404**
	SLO-2	Four-point probe technique-Van der Pauw method	
S-3	SLO-1	Significance of carrier density and Significance of resistivity and Hall mobility	**S.M. Sze, page 55-56**
	SLO-2	Solving problem	
S-4-5	SLO-1	**Lab 10: Determination of electron and hole mobility versus doping concentration using GNU Octave**	**Lab**
	SLO-2		
S-6	SLO-1	Hot-point probe measurement	**FACTA UNIVERSITATIS Series: Electronics and Energetics Vol. 26, No 3, December 2013, pp. 187 - 195 DOI: 10.2298/FUEE1303187A**
	SLO-2	Capacitance-voltage measurements	**ELTON .N. KOUFMANN Characterization of Materials, Volume I ,Page 456**
S-7	SLO-1	Extraction of Parameters in a diode	**ELTON .N. KOUFMANN Characterization of Materials, Volume I Page 466**
	SLO-2	I-V characteristics in a diode	
S-8	SLO-1	Introduction of TCAD in basic level	**http://www.micro.deis.unibo.it/~rudan/MATERIALE_DIDATTICO/diapositive/TCAD/01_TCAD_laboratory_Introduction_GBB_20140303H1424.pdf**

			https://www.eng.auburn.edu/~niuguof/elec6710dev/html/fundamental.html
S-9-10	SLO-2 SLO-1 SLO-2	Solving problem **Lab 11: Determination of Fermi function for different temperature using GNU Octave**	**Lab**
S-11	SLO-1 SLO-2	Significance of band gap in semiconductors Concept of absorption and emission	**Jaspirt singh, Semiconductor device, page 458-462** **Jaspirt singh, Semiconductor device, page 458-462**
S-12	SLO-1	Boltzmann Transport Equation; Scattering Mechanisms	**https://courses.physics.ucsd.edu/2010/Winter/physics211b/LECTURES/CH01.pdf**
	SLO-2	Monte Carlo method- Concept only	Computational Materials Science: An Introduction by June Gunn Lee, Chapter 7, Page 227- 230 (Quantum Espresso) and Page 300 - 307 (VASP) and page 6
S-13	SLO-1	Example only Monte Carlo Methods for Solution of BTE	Computational Materials Science: An Introduction by June Gunn Lee, Chapter 7, Page 227- 230 (Quantum Espresso) and Page 300 - 307 (VASP) and Page 6
	SLO-2	Solving problem	
S-14-15	SLO-1 SLO-2	**Lab 12: Study of attenuation and propagation characteristic of optical fiber cable using laser source**	**Lab**

Module V			
Lecture Hour		**Description**	**Reference**
S-1	SLO-1	Density of states in 2D	**Solid State Physics-Principles**

S-2	SLO-2	Density of states in 1D and 0D-Introduction to low dimensional systems	**and Applications, by R. Asokmani, Page-220, Section-7.3 & Section 7.5**
	SLO-1	Introduction to low dimensional systems	**1)Physical Methods for material Characterization ,Ed 2,By-Flewitt and Wild, Ch- Physics of Low dimensional Semiconductors,Sec 7.3 to 7.5 (page 223)** **2)Introduction to Nanotechnology , by Charles P.Poole,Jr.,Frank J.Owens**
	SLO-2	Quantum well, Quantum wire, and dots	**Introduction to Nanotechnology , by Charles P.Poole,Jr.,Frank J.Owens Ch-9,Section 9.3,3,9.3.5 and 9.3.6**
S-3	SLO-1	Solving problems	**Introduction to Nanotechnology , by Charles P.Poole,Jr.,Frank J.Owens Ch-9,Section 9.3,3,9.3.5 and 9.3.6**
	SLO-2	CNT- properties and synthesis	
S-4-5	SLO-1 SLO-2	**Lab 13: Plotting and interpretation of I-V characteristics of Diode GNU Octave**	**Lab**
	SLO-1	CNT- properties and synthesis	**Nanotechnology VOl.1, By.W.M.Berck, First edition,Page 60 to 76**
S-6	SLO-2	Applications of CNTs	
S-7	SLO-1	Fabrication technique-CVD	**Nanotechnology and Nanomaterials-Synthesis, Properties and Applications,By Guozhong Cao, Page189 -195,Section 5.5 to 5.5.4**
	SLO-2	Fabrication technique-PVD	**Nanotechnology and Nanomaterials-Synthesis, Properties and Applications ,By Guozhong Cao, Page182 - 185,Section 5.4**
S-8	SLO-1	Characterization techniques for low dimensional system	
	SLO-2	Solving problem	

S 09-10	SLO-1 SLO-2	**Lab 14: Determination of lattice parameters using powder XRD**	**Lab**
S-11	SLO-1	Scanning electron microscopy	**Material Characterization Techniques By Sam Zhang, Lin Li, Ashok Kumar,Page 177 to 190, Section 7.1.2 to 7.2.3**
	SLO-2	Transmission electron microscopy	
S-12	SLO-1	Transmission electron microscopy	**Material Characterization Techniques By Sam Zhang, Lin Li, Ashok Kumar, Page 153, Section 6.1 to 6.3**
	SLO-2	Atomic force microscope	**Material Characterization Techniques By Sam Zhang, Lin Li, Ashok Kumar,Page 98, Section 4.2.2 to 4.4.2.3**
S-13	SLO-1	Computational and machine learning approach for electron microscopy image processing Concepts, overview	**https://www.sciencedirect.com/science/article/pii/S2666386422002995**
	SLO-2	Example of Graphene	**https://www.sciencedirect.com/science/article/pii/S2666386422002995**
S 14-15	SLO-1 SLO-2	Mini Project	**Lab**

Course Coordinator **HOD/Physics and Nanotechnology**

(Dr.T.Kalaivani)