DEPARTMENT OF PHYSICS AND NANOTECHNOLOGY

SRM Institute of Science and Technology

18PYB103J - PHYSICS: SEMICONDUCTOR PHYSICS

(Offered to I Year B.Tech students of School of Computing Sciences)

Lesson Plan

Module - I				
Duration (Hour)		**Lecture**	**Topic**	**Reference**
S1	***SLO-1***	***Lecture -1***	*Classical Free electron theory*	*Jasprit Singh, Semiconductor Devices (2001), Page 2-*
	SLO-2		*Quantum Free electron theory*	
S2	***SLO-1***	***Lecture -2***	*Density of states*	*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*
S3	***SLO-1***	***Lecture -3***	*Kronig-Penney model*	*Donald A. Neamen, 3rd Edition, Semiconductor Physics and Devices, Page 61-65*
	SLO-2		*Kronig-Penney model*	
S4	***SLO-1***	***Lecture -4***	*Solving Problems*	*Jaspreeth Singh, Semiconductor Optoelectronics: Physics and Technology, McGraw-Hill Inc.1995.*
	SLO-2		*Solving Problems*	
S5-6	***SLO-1***	***Lab -1***	***Basics of experimentation***	***Labortory Manual***
	SLO-2			
S7	***SLO-1***	***Lecture -5***	*E-k diagram*	*S.M. Sze, Semiconductor Devices, page 30-32*
	SLO-2		*Direct and Indirect band gap*	
S8	***SLO-1***	***Lecture -6***	*Concept of phonons*	*H.P. Myers, Introductory Solid State Physics, Second edition, CRC press, page124-126.*
	SLO-2		*Concept of Brillouin Zone*	
S9	***SLO-1***	***Lecture -7***	*Energy band structure of semiconductor-Brillouin zone*	*Donald A. Neamen, 3rd Edition, Semiconductor Physics and Devices, Tata McGraw-Hill, Page 81-82*
	SLO-2		*Concept of effective mass*	*Donald A. Neamen, 3rd Edition, Semiconductor Physics and Devices, Tata McGraw-Hill, Page 81-82*
S10	***SLO-1***	***Lecture -8***	*Solving Problems*	*Jaspreeth Singh, Semiconductor Optoelectronics: Physics and Technology, McGraw-Hill Inc.1995.*
	SLO-2		*Solving Problems*	
S11-12	***SLO-1***	***Lab -2***	***Determine Hall coefficient of Semiconductor material***	***Labortory Manual***
	SLO-2			
S13	***SLO-1***	***Lecture -9***	*Classification of electronic materials*	*S.M. Sze, Semiconductor Devices, page 32-33*
	SLO-2		*Fermi level*	*P. Battacharya, Semiconductor optoelectronic devices, page 74-75*
S14	***SLO-1***	***Lecture -10***	*Probability of occupation*	
	SLO-2		*Influence of donors in semiconductor*	*Donald A. Neamen, 3rd Edition, Semiconductor Physics and Devices, Tata McGraw-Hill, Page 115-117*
S15	***SLO-1***	***Lecture -11***	*Influence of acceptors in semiconductor*	
	SLO-2		*Non-equilibrium properties of carriers*	*ND Gupta, AD Gupta, Semiconductor Device: Modeling and Technology, page 30-31.*
S16	***SLO-1***	***Lecture -12***	*Solving Problems*	*Jaspreeth Singh, Semiconductor Optoelectronics: Physics and Technology, McGraw-Hill Inc.1995.*
	SLO-2		*Solving Problems*	
S17-18	***SLO-1***	***Lab -3***	***Determine Band Gap of semiconductor- Post Office Box method***	***Labortory Manual***
	SLO-2			

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Module- II

Duration (hour)		Date and Day order	Topic	Reference
S1	***SLO-1***	***Lecture -13***	*Intrinsic semiconductor*	S.M. Sze, Semiconductor Devices, page 34-36.
	SLO-2		*Fermi level on carrier-concentration and temperature in Intrinsic semiconductor*	
S2	***SLO-1***	***Lecture -14***	*Extrinsic semiconductors*	Donald A. Neamen, 3rd Edition, Semiconductor Physics and Devices, Page 139-144.
	SLO-2		*Fermi level on carrier-concentration and temperature in extrinsic semiconductors*	
S3	***SLO-1***	***Lecture -15***	*Explanation for carrier generation*	S.M. Sze, Semiconductor Devices, page 60-66.
	SLO-2		*Explanation for recombination processes*	*S.M. Sze, Semiconductor Devices Physics and Technology, Second Edition, John Wiley & Sons, page 66-68.*
S4	***SLO-1***	***Lecture -16***	*Solving Problems*	*Jaspreeth Singh, Semiconductor Optoelectronics: Physics and Technology, McGraw-Hill Inc.1995.*
	SLO-2		*Solving Problems*	
S5-6	***SLO-1***	***Lab -4***	***Study of I-V characteristics of a light dependent resistor (LDR)***	***Labortory Manual***
	SLO-2			
S7	***SLO-1***	***Lecture -17***	*Carrier transport - diffusion and drift current*	*S.M. Sze, Semiconductor Devices, page 66-68.*
	SLO-2		*Continuity equation*	
S8	***SLO-1***	***Lecture -18***	*p-n junction*	*S.M. Sze, Semiconductor Devices, page 88-89.*
	SLO-2		*Biasing concept in p-n junction*	
S9	***SLO-1***	***Lecture -19***	*Metal-semiconductor junction -Ohmic contact*	*Donald A. Neamen, 3 rd Edition, Semiconductor Physics and Devices, Page 344-346.*
	SLO-2		*Metal-semiconductor junction - Schottky junction*	*Donald A. Neamen, 3 rd* Edition, Semiconductor Physics and Devices, Page 327-329.
S10	***SLO-1***	***Lecture -20***	*Solving Problems*	*Jaspreeth Singh, Semiconductor Optoelectronics: Physics and Technology, McGraw-Hill Inc.1995.*
	SLO-2		*Solving Problems*	
S11-12	***SLO-1***	***Lab -5***	***Determine Band Gap of semiconductor Four probe method***	***Labortory Manual***
	SLO-2			
S13	***SLO-1***	***Lecture -21***	*Semiconductor materials of interest for*	*Jasprit singh, page 455*
	SLO-2		*optoelectronic devices*	*Jasprit singh, page 463-464*
S14	***SLO-1***	***Lecture -22***	*Photocurrent in a P-N junction diode*	*S.M. Sze, Semiconductor Devices Physics and Technology, Second Edition, John Wiley & Sons, page 288-294.*
	SLO-2		*Light emitting diode*	
S15	***SLO-1***	***Lecture -23***	*Classification of Light emitting diode*	*P. Battacharya, Semiconductor optoelectronic devices, page 466*
	SLO-2		*Optoelectronic integrated circuits*	*S.M. Sze, Semiconductor Devices Physics and Technology, Second Edition, John Wiley & Sons, page 294-295.*
S16	***SLO-1***	***Lecture -24***	*Organic light emitting diodes*	*Jaspreeth Singh, Semiconductor Optoelectronics: Physics and Technology, McGraw-Hill Inc.1995.*
	SLO-2		*Solving Problems*	
S17-18	***SLO-1***	***Lab -6***	***Study of V-I and V-R characteristics of a solar cell***	***Labortory Manual***
	SLO-2			

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Module- III

Duration (hour)		Day order & Hour	Topic	Reference
S1	SLO-1	Lecture -25	Concept of optical transitions in bulk semiconductors	Saleh & Teich, Fundamentals of photonics, Second edition, page 660-661.
	SLO-2	Lecture -25	optical absorption process	Saleh & Teich, Fundamentals of photonics, Second edition, page 660-661.
S2	SLO-1	Lecture -26	Concept of recombination process	P. Battacharya, Semiconductor optoelectronic devices, page 116-118
	SLO-2		Optical recombination process	
S3	SLO-1	Lecture -27	Explanation for spontaneous emission	P. Battacharya, Semiconductor optoelectronic devices, page 244-245
	SLO-2		Explanation for stimulated emission	
S4	SLO-1	Lecture -28	Solving Problems	Jaspreeth Singh, Semiconductor Optoelectronics: Physics and Technology, McGraw-Hill Inc.1995.
	SLO-2		Solving Problems	
S5-6	SLO-1	Lab -7	**Characterization of pn junction diode (Forward Bias)**	**Labortory Manual**
	SLO-2			
S7	SLO-1	Lecture -29	Joint density of states in semiconductor	Saleh & Teich, Fundamentals of photonics, Second edition, page 665.
	SLO-2		Density of states for photons	Shun Lien Chuang, Physics of Photonic Devices, page 353-354
S8	SLO-1	Lecture -30	Explanation of transition rates	Shun Lien Chuang, Physics of Photonic Devices, page 349-350.
	SLO-2		Fermi's golden rule	
S9	SLO-1	Lecture -31	Concept of optical loss	P. Battacharya, Semiconductor optoelectronic devices, page 250-252
	SLO-2		Concept of optical gain	
S10	SLO-1	Lecture -32	Solving Problems	Jaspreeth Singh, Semiconductor Optoelectronics: Physics and Technology, McGraw-Hill Inc.1995.
	SLO-2		Solving Problems	
S11-12	SLO-1	Lab -8	**Repeat/Revision of experiments**	**Labortory Manual**
	SLO-2			
S13	SLO-1	Lecture -33	Basic concepts of Photovoltaics	Chetan Singh Solanki, Solar Photovoltaics, 2rd Edition, page 89-94
	SLO-2		Photovoltaic effect	
S14	SLO-1	Lecture -34	Applications of Photovoltaic effect	Jasprit singh, Semiconductor Optoelectronics: Physics and Technology, McGraw-Hill Inc., page 465-468
	SLO-2		Determination of efficiency of a PV cell	
S15	SLO-1	Lecture -35	Theory of Drude model	Semiconductor Optoelectronics: Physics and Technology, McGraw-Hill Inc., page 4-6
	SLO-2		Determination of conductivity	
S16	SLO-1	Lecture -36	Solving Problems	Jaspreeth Singh, Semiconductor Optoelectronics: Physics and Technology, McGraw-Hill Inc.1995.
	SLO-2		Solving Problems	
S17-18	SLO-1	Lab -9	**To verify Inverse square law of light using a photo cell.**	**Labortory Manual**
	SLO-2			

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Module - IV

Duration (hour)		Date and Day order	Topic	Reference
S1	**SLO-1**	**Lecture -37**	*Concept of electrical measurements*	*ELTON .N. KOUFMANN Characterization of Materials, Volume I*
	SLO-2		*Two-point probe technique*	
S2	**SLO-1**	**Lecture -38**	*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*	
S3	**SLO-1**	**Lecture -39**	*Significance of carrier density*	*S.M. Sze, Semiconductor Devices Physics and Technology, Second Edition, John Wiley & Sons, page 55-56*
	SLO-2		*Significance of resistivity and Hall mobility*	
S4	**SLO-1**	**Lecture -40**	*Solving Problems*	*Material Characterization Techniques By Sam Zhang, Lin Li, Ashok Kumar, CRC Press, Taylor and Francis, 2008.Material Characterization Techniques By Sam Zhang, Lin Li, Ashok Kumar, CRC Press, Taylor and Francis, 2008.*
	SLO-2		*Solving Problems*	
S5-6	**SLO-1**	**Lab -10**	***Determine Particle Size of Semiconductor Laser***	***Labortory Manual***
	SLO-2			
S7	**SLO-1**	**Lecture -41**	*Hot-point probe measurement*	*ELTON .N. KOUFMANN Characterization of Materials, Volume I ,Page 456*
	SLO-2		*capacitance-voltage measurements*	
S8	**SLO-1**	**Lecture -42**	*Extraction of parameters in a diode*	*ELTON .N. KOUFMANN Characterization of Materials, Volume I Page 466*
	SLO-2		*I-V characteristics of a diode*	
S9	**SLO-1**	**Lecture -43**	*Principle of Deep-level transient spectroscopy (DLTS)*	*ELTON .N. KOUFMANN Characterization of Materials, Volume I ,Page 418*
	SLO-2		*Instrumentation of DLTS*	*ELTON .N. KOUFMANN Characterization of Materials, Volume I ,Page 424*
S10	**SLO-1**	**Lecture -44**	*Solving Problems*	*Material Characterization Techniques By Sam Zhang, Lin Li, Ashok Kumar, CRC Press, Taylor and Francis, 2008.*
	SLO-2		*Solving Problems*	
S11-12	**SLO-1**	**Lab -11**	***Attenuation, propagation characteristic of optical fiber cable using laser source***	***Labortory Manual***
	SLO-2			
S13	**SLO-1**	**Lecture -45**	*Significance of band gap in semiconductors*	*Jaspirt singh, Semiconductor device, page 458-462*
	SLO-2		*Concept of absorption and transmission*	
S14	**SLO-1**	**Lecture -46**	*Fundamental laws of absorption*	*Material Characterization Techniques By Sam Zhang, Lin Li, Ashok Kumar, Page 257, Section 9.2.1 to 9.2.4*
	SLO-2		*Instrumentation of UV-Vis spectroscopy*	
S15	**SLO-1**	**Lecture -47**	*Determination of band gap by UV-Vis spectroscopy*	*Elementary Solid State Physics, By M. Ali Omar, Page -244, Ch-5,Section 5.20*
	SLO-2		*Concept of Photoluminescence*	*Solid State Physics-Structure & Properties of Materials, M.A.Wahab, Second edition*
S16	**SLO-1**	**Lecture -48**	*Solving Problems*	*Material Characterization Techniques By Sam Zhang, Lin Li, Ashok Kumar, CRC Press, Taylor and Francis, 2008.*
	SLO-2		*Solving Problems*	
S17-18	**SLO-1**	**Lab -12**	***Characteristic of p-n junction diode under reverse bias***	***Labortory Manual***
	SLO-2			

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Lesson Plan

Module - V

Duration (hour)		Date and Day order	Topic	Reference
S1	SLO-1	Lecture -49	Density of states in 2D	Solid State Physics-Principles and Applications, by R. Asokmani, Page-220, Section-7.3 & Section 7.5
	SLO-2		Density of states in 1D and 0 D	
S2	SLO-1	Lecture -50	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	Introduction to Nanotechnology , by Charles P.Poole,Jr.,Frank J.Owens Ch-9,Section 9.3,3,9.3.5 and 9.3.6
S3	SLO-1	Lecture -51	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
	SLO-2		Introduction to novel low dimensional systems	
S4	SLO-1	Lecture -52	Solving Problems	Introduction to Nanotechnology , by Charles P.Poole,Jr.,Frank J.Owens
	SLO-2		Solving Problems	
S5-6	SLO-1	Lab -13	**Determination of efficiency of solar cell**	**Labortory Manual**
	SLO-2			
S7	SLO-1	Lecture -53	CNT- properties and synthesis	Nanotechnology VOl.1, By.W.M.Berck, First edition,Page 60 to 76
	SLO-2		Applications of CNT	
S8	SLO-1	Lecture -54	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
S9	SLO-1	Lecture -55	Characterizations techniques for low dimensional systems	Solid State Physics-Structure & Properties of Materials, M.A.Wahab, Second edition Ch-8, Page-281 to 285, Section 8.15-8.16
	SLO-2		XRD-Powder method	Solid State Physics-Structure & Properties of Materials, M.A.Wahab, Second edition Ch-8, Page-281 to 285, Section 8.15-8.16
S10	SLO-1	Lecture -56	Solving Problems	Introduction to Nanotechnology , by Charles P.Poole,Jr.,Frank J.Owens
	SLO-2		Solving Problems	
S11-12	SLO-1	Lab -14	**Determine lattice parameters using powder XRD**	**Labortory Manual**
	SLO-2			
S13	SLO-1	Lecture -57	Principle of electron microscopy	Principle of 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		Scanning electron microscopy	
S14	SLO-1	Lecture -58	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

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S15	***SLO-1***	***Lecture -59***	*Heterojunctions*	*Mesoscopic Electronics in Solid state Nanostructures,By Thomas Heinzel, Second , Revised Edition, P-74 to 77 ,Section 3.3,*
	SLO-2	***Lecture -59***	*Band diagrams of heterojunctions*	*Mesoscopic Electronics in Solid state Nanostructures,By Thomas Heinzel, Second , Revised Edition, P-75*
S16	***SLO-1***	***Lecture -60***	*Solving Problems*	*Introduction to Nanotechnology , by Charles P.Poole,Jr.,Frank J.Owens*
	SLO-2		*Solving Problems*	
S17-18	***SLO-1***	***Lab -15***	***Mini Project***	***Student Activity***
	SLO-2			

References:

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,2007.