**DEPARTMENT OF PHYSICS**

**FACULTY OF ENGINEERING AND TECHNOLOGY**

**SRMIST, RAMAPURAM**

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| **Subject Name:** | **Semiconductor Physics** |
| **Subject Code:** | **18PYB103J** |

**MODULE I**

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| Duration (hour) | | **18** | **Reference** |
|  |  |  |  |
|  | SLO-1 | Introduction to Classical Free electron theory | **Jasprit Singh, Semiconductor Devices (2001), Page 2-3** |
| **S-1** |
|  |  |
| SLO-2 | Introduction to Quantum Free electron theory |
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|  |
|  |  |  |
| **S-2** | SLO-1 | Density of states – Concepts and Derivation | **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 | Kronig-Penney Derivation |
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| **S-4** | SLO-1 | Solving problems |  |
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| SLO-2 | Solving problems |  |
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|  |  |  |  |
| S-5-6 | SLO-1 | Basics of Experimentation |  |
| SLO-2 |
|  | SLO-1 | E-k diagram – Basic concepts |  |
| **S-7** | **S.M. Sze, Semiconductor Devices, page 30-32** |
|  |  |
| SLO-2 | E-k diagram explanation Direct and Indirect band gap | **S.M. Sze, Semiconductor Devices, page 30-32** |
|  |
|  |  |  |  |
| **S-8** | SLO-1 | Concept of phonons | **H.P. Myers, Introductory Solid State Physics, Second edition, CRC press, page124-126.** |
|  |  |
| SLO-2 | Concept of Brillouin Zone |
|  |
|  |  |  |  |
| S-9 | SLO-1 | Energy band structure of semiconductor-  Brillouin zone (Si, GaAs) | **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 73** |
| S-10 | SLO-1 | Solving problems |  |
|  | SLO-2 | Solving problems |
| S  11-12 | SLO-1 | Determine Hall coefficient of Semiconductor material |  |
| SLO-2 |
| S-13 | SLO-1 | Classification of electronic materials: metals, semiconductor and insulators | **S.M. Sze, Semiconductor Devices, page 32-33** |
| SLO-2 | Concepts of Fermi-Dirac distribution function, Fermi level | **P. Battacharya, Semiconductor optoelectronic devices, page 74-75** |
| S-14 | SLO-1 | Probability of occupation |
| SLO-2 | Influence of doping in semiconductor: Donor (Qualitative Description) | **Donald A. Neamen, 3rd Edition, Semiconductor Physics and Devices, Tata McGraw-Hill, Page 115-117** |
| S-15 | SLO-1 | Influence of doping in semiconductor: Acceptor (Qualitative Description) |
| SLO-2 | Non-equilibrium properties of carriers (Elementary ideas) | [**ND Gupta**](https://www.google.com/search?biw=1517&bih=735&tbm=bks&tbm=bks&q=inauthor:%22NANDITA+DASGUPTA%22&sa=X&ved=0ahUKEwjTu7vjreTbAhUFv48KHd-XDhwQ9AgINDAC)**, ‎**[**AD G**](https://www.google.com/search?biw=1517&bih=735&tbm=bks&tbm=bks&q=inauthor:%22AMITAVA+DASGUPTA%22&sa=X&ved=0ahUKEwjTu7vjreTbAhUFv48KHd-XDhwQ9AgINTAC)**upta, Semiconductor Device: Modeling and Technology, page 30-31.** |
| S-16 | SLO-1 | Solving problems |  |
| SLO-2 | Solving problems |
| S  17-18 | SLO-1  SLO-2 | Determine Band Gap of semiconductor-  Post Office Box method |  |
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**MODULE II**

|  |  |  |  |
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| Duration (hour) | | **18** | **Reference** |
|  |  |  |  |
|  | SLO-1 | Intrinsic semiconductor | **S.M. Sze, Semiconductor Devices, page 34-36.** |
| **S-1** |
|  |  |
| SLO-2 | Concept of carrier concentration, variation of Fermi level with temperature in intrinsic semiconductor | **S.M. Sze, Semiconductor Devices, page 34-36.** |
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|  |  |  |
| **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 | Concepts of recombination processes |
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| **S-4** | SLO-1 | Solving problem |  |
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| SLO-2 | Solving problem |
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| S-5-6 | SLO-1 |  |  |
| SLO-2 | Study of I-V characteristics of Light dependent resistor (LDR) |
|  | SLO-1 | Concepts of Carrier transport - diffusion and drift – Derivation of Continuity equation |  |
| **S-7** | **S.M. Sze, Semiconductor Devices, page 66-68.** |
|  |  |
| SLO-2 | Concepts of Carrier transport - diffusion and drift – Derivation of Continuity equation | **S.M. Sze, Semiconductor Devices Physics and Technology, Second Edition, John Wiley & Sons, page 66-68.** |
|  |
|  |  |  |  |
| **S-8** | SLO-1 | Basic structure of p-n junction | **S.M. Sze, Semiconductor Devices, page 88-89.** |
|  |  |
| SLO-2 | Band diagram of p-n junction in thermal equilibrium |
|  |
|  |  |  |  |
| S-9 | SLO-1 | Metal-semiconductor junction –Ohmic Contact | **Donald A. Neamen, 3rd Edition, Semiconductor Physics and Devices, Page 344-346.** |
|  |  |  |
| SLO-2 | Metal-semiconductor junction -Schottky | **Donald A. Neamen, 3rd Edition, Semiconductor Physics and Devices, Page 327-329.** |
|  |  |  |  |
| S-10 | SLO-1 | Solving Problem |  |
| SLO-2 | Solving Problem |
| S  11-12 | SLO-1 | Determine Band gap of Semiconductor – Four probe method |  |
| SLO-2 |
| S-13 | SLO-1 | Semiconductor material for optoelectronic applications - Introduction | **Jasprit singh, page 455** |
| SLO-2 | Photocurrent in a P-N junction diode | **Jasprit singh, page 463-464** |
| S-14 | SLO-1 | Light emitting diode – Construction & Working | **S.M. Sze, Semiconductor Devices Physics and Technology, Second Edition, John Wiley & Sons, page 288-294.** |
| SLO-2 | Classification of Light emitting diode (edge and surface) |
| S-15 | SLO-1 | Introduction to Optoelectronic integrated circuits | **P. Battacharya, page 466** |
| SLO-2 | Organic light emitting diodes – basic concepts | **S.M. Sze, Semiconductor Devices Physics and Technology, Second Edition, John Wiley & Sons, page 294-295.** |
| S-16 | SLO-1 | Solving problem |  |
| SLO-2 | Solving problem |
| S  17-18 | SLO-1  SLO-2 | Study of I-V and I-R characterizes of solar cell |  |
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**MODULE III**

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| Duration (hour) | | **18** | **Reference** |
|  |  |  |  |
|  | SLO-1 | Concepts of optical transition in bulk semiconductor | **Saleh & Teich, Fundamentals of photonics, Second edition, page 660-661.** |
| **S-1** |
|  |  |
| SLO-2 | Optical absorption process and emission process |
|  |
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|  |  |  |
| **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 |
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| **S-4** | SLO-1 | Solving problem |  |
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| SLO-2 | Solving problem |
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| S-5-6 | SLO-1 | Characterization of pn junction diode (forward bias) |  |
| SLO-2 |
|  | SLO-1 | Joint density of states (Conservation of energy and momenta of electron with photon interacts) |  |
| **S-7** | **Saleh & Teich, Fundamentals of photonics, Second edition, page 665.** |
|  |  |
| SLO-2 | Density of states for photon | **Shun Lien Chuang, Physics of Photonic Devices, page 353-354** |
|  |
|  |  |  |  |
| **S-8** | SLO-1 | Explanation of transition rates using Fermi’s golden rule | **Shun Lien Chuang, Physics of Photonic Devices, page 349-350.** |
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| SLO-2 | Explanation of transition rates using Fermi’s golden rule |
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|  |  |  |  |
| S-9 | SLO-1 | Concepts of optical loss | **P. Bhatacharya, page 250-252** |
|  |  |  |
| SLO-2 | Concepts of optical gain |
|  |  |  |  |
| S-10 | SLO-1 | Solving Problem |  |
| SLO-2 | Solving Problem |
| S  11-12 | SLO-1 | Repeat and Revision experiments |  |
| SLO-2 |
| S-13 | SLO-1 | Basics concepts of photovoltaics | **Chetan Singh Solanki, Solar Photovoltaics, 2rd Edition, page 89-94** |
| SLO-2 | Photovoltaic effect – pn junction under illumination |
| S-14 | SLO-1 | Application of photovoltaic effect solar cell | **Jasprit singh, page 465-468** |
| SLO-2 | Determination of efficiency of a PV cell |
| S-15 | SLO-1 | Theory of Drude model | **Jasprit singh, page 4-6** |
| SLO-2 | Determination of conductivity | [**www.physics.iisc.ernet.in/~aveek\_bid/PH208/Lecture%201%20Drude%20model**](http://www.physics.iisc.ernet.in/~aveek_bid/PH208/Lecture%201%20Drude%20model)**.** |
| S-16 | SLO-1 | Solving problem |  |
| SLO-2 | Solving problem |
| S  17-18 | SLO-1  SLO-2 | Study of I-V and I-R characterizes of solar cell |  |
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**MODULE IV**

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| Duration (hour) | | **18** | **Reference** |
|  |  |  |  |
|  | SLO-1 | Concepts of Electrical measurements | **ELTON .N. KOUFMANN Characterization of Materials, Volume I** |
| **S-1** |
|  |  |  |
| 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 | **ELTON .N. KOUFMANN Characterization of Materials, Volume I, Page 404** |
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|  |  |  |  |
| **S-3** | SLO-1 | Significance of carrier density | **S.M. Sze, page 55-56** |
|  |  |
| SLO-2 | Significance of resistivity and Hall mobility |
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| **S-4** | SLO-1 | Solving problem |  |
|  |  |  |
| SLO-2 | Solving problem |  |
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| S-5-6 | SLO-1 | Determination of Particle size of semiconductor | **Lab** |
| SLO-2 |
|  | SLO-1 | Hot-point probe measurement |  |
| **S-7** | **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-8** | SLO-1 | Extraction of Parameters in a diode |  |
|  |  |  |
| SLO-2 | I-V characteristics in a diode | **ELTON .N. KOUFMANN Characterization of Materials, Volume I Page 466** |
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|  |  |  |  |
| S-9 | SLO-1 | Principle of Deep-level transient spectroscopy(DLTS) | **ELTON .N. KOUFMANN Characterization of Materials, Volume I ,Page 418** |
|  |  |  |  |
| SLO-2 | Instrumentation of Deep-level transient spectroscopy(DLTS) | **ELTON .N. KOUFMANN Characterization of Materials, Volume I ,Page 424** |
|  |  |  |  |
| S-10 | SLO-1 | Solving Problem |  |
| SLO-2 | Solving Problem |  |
| S  11-12 | SLO-1 | Lab |  |
| SLO-2 |
| S-13 | SLO-1 | Significance of band gap in semiconductors | **Jaspirt singh, Semiconductor device, page 458-462** |
| SLO-2 | Concept of absorption and emission | **Jaspirt singh, Semiconductor device, page 458-462** |
| S-14 | SLO-1 | 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 |
| S-15 | SLO-1 | 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**  **Ch-5, Page-489, Section 15.5 to 15.8** |
| S-16 | SLO-1 | Solving problem |  |
| SLO-2 | Solving problem |  |
| S  17-18 | SLO-1  SLO-2 | Characteristic of PN junction diode under forward bias | **Lab** |
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**MODULE V**

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| Duration (hour) | | **18** | **Reference** |
|  |  |  |  |
|  | SLO-1 | Density of states in 2D (Qualitative treatment) | **Solid State Physics-Principles and Applications, by R. Asokmani, Page-220, Section-7.3 & Section 7.5** |
| **S-1** |
|  |  |
| SLO-2 | Density of states in 1D and 0 D (Qualitative treatment) |
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| **S-2** | 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 | **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 | 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 |
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| **S-4** | SLO-1 | Solving problems |  |
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| SLO-2 | Solving problems |  |
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| S-5-6 | SLO-1 | Determine of efficiency of solar cell | **Lab** |
| SLO-2 |
|  | SLO-1 | CNT- properties and synthesis |  |
| **S-7** | **Nanotechnology VOl.1, By.W.M.Berck, First edition,Page 60 to 76** |
|  |  |
| SLO-2 | Applications of CNTs |
|  |
|  |  |  |  |
| **S-8** | 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** |
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|  |  |  |  |
| S-9 | SLO-1 | Characterization techniques for low  dimensional system |  |
|  |  |  |
| 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** |
|  |  |  |  |
| S-10 | SLO-1 | Solving problem |  |
| SLO-2 | Solving problem |  |
| S  11-12 | SLO-1 | Determination of lattice Parameters using Powder XRD | **Lab** |
| SLO-2 |
| S-13 | SLO-1 | 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 (SEM) |
| S-14 | SLO-1 | TEM | **Material Characterization Techniques By Sam Zhang, Lin Li, Ashok Kumar, Page 153, Section 6.1 to 6.3** |
| SLO-2 | AFM-Principle, Instrumentation-Tip and cantilever, Piezoelectric scanner, Modes of contact | **Material Characterization Techniques By Sam Zhang, Lin Li, Ashok Kumar,Page 98, Section 4.2.2 to 4.4.2.3** |
| S-15 | SLO-1 | Band diagrams of Heterojunctions | **Mesoscopic Electronics in Solid state Nanostructures,By Thomas Heinzel, Second , Revised Edition, P-74 to 77 ,Section 3.3,** |
| SLO-2 | Band diagrams of Heterojunctions | **Mesoscopic Electronics in Solid state Nanostructures,By Thomas Heinzel, Second , Revised Edition, P-75** |
| S-16 | SLO-1 | Solving problem |  |
| SLO-2 | Solving problem |  |
| S  17-18 | SLO-1  SLO-2 | Mini Project |  |
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COURSE COORDINATOR

Dr.T.Beena HOD