NIRMA UNIVERSITY

Institute:	Institute of Technology
Name of Programme:	MTech Semiconductor Technology
Course Code:	6EC301CC24
Course Title:	Semiconductor Physics
Course Type:	Core
Year of Introduction:	2024-25

L	T	Practical component				C
		LPW	PW	W	S	
3	1	-	-	-	-	4

Course Learning Outcomes (CLOs)

At the end of the course, students will be able to

1. analyse the limitation of traditional technology and its possible solution with the help of semiconductor physics (BL3)
2. apply the concepts of semiconductor physics to comprehend the governing mechanism of the electronic devices (BL4)
3. develop the ideas for novel semiconductor devices (BL5)
4. optimize the performance of the existing devices. (BL5)

	Contents	Teaching hours (Total 45)
Unit I	**Fundamentals of Semiconductors** Energy bands, direct and indirect band gap semiconductors, concept of density of states and Fermi-level, carrier concentrations at equilibrium, temperature dependence of carrier concentrations, conductivity and mobility, effects of temperature and doping on mobility, excess carriers, recombination mechanisms, carrier lifetime, steady state carrier generation, concept of quasi-Fermi level, drift and diffusion of carriers, Einstein relation, continuity equation, solution of diffusion equation for steady state carrier injection, diffusion length, Haynes-Shockley experiment.	**15**
Unit II	**Junctions** Homo p-n junctions at equilibrium, forward and reverse biased p-n junction, carrier injection across p-n junction under forward bias, derivation of ideal p-n diode current equation; reverse saturation current, real p-n diode V-I characteristics, reverse breakdown, capacitances in p-n diode, hetero p-n junctions, metal-semiconductor contacts. Bipolar Junction Transistors: minority carrier distributions and terminal currents, Heterojunction Bipolar Transistors.	**10**
Unit III	**Field Effect Transistors: Junction Field Effect Transistor (JFET)** Structures of n and p- channel JFET, pinch-off and saturation, gate control, current voltage characteristics, Metal- Semiconductor FET (MESFET): GaAs MESFET, High Electron Mobility Transistor (HEMT). Metal Oxide Semiconductor FETS (MOSFETs): structure and working principle of enhancement type and depletion type	**10**

MOSFETs, ideal MOS diode, inversion layer, threshold voltage, MOS capacitor and C-V curve, effects of work function difference and interface charge on threshold voltage, output and transfer characteristics of enhancement MOSFET, control of threshold voltage, charge-coupled devices (CCD)

Unit IV **Quantum Effect and Hot Electron Devices** **10**

Tunnel diode, resonant tunneling diode (RTD), unipolar resonant tunnelling transistor, Hot Electron Heterojunction Bipolar Transistors, (HEHBT), transferred electron devices, Gunn diode, IMPATT diode and their applications

Self Study:

The self-study contents will be declared at the commencement of the semester. Around 10% of the questions will be asked from self-study content.

Tutorial Work: This shall consist of at least 10 tutorials based on the above syllabus

Suggested Readings/References:

1. B. Streetman and S. Banerjee, Solid State Electronic Devices, Prentice Hall.
2. S. O. Kasap, Principles of Electronic Materials And Devices, McGraw Hill.
3. S. O. Kasap, Optoelectronics and Photonics: Principles and Practices, Prentice Hall.
4. S.M.Sze, Semiconductor Devices: Physics and Technology, John Wiley and Sons.
5. M.S. Tyagi, Semiconductor Materials and Devices, John Wiley and Sons.
6. J Millman, C.C.Halkias, J.Satyabrata J, Electronic Devices & Circuits, Tata McGraw Hill.

Details of Tutorial
Suggested list of Tutorials

Sr. No	Tutorials	No. of Hours
1.	Hall Effect based numerical and case study	01
2.	Charge carriers scattering mechanisms and numerical: Part 1	01
3.	Charge carriers scattering mechanisms and numerical: Part 2	01
4.	Fermi Energy and Fermi level variations with doping and temperature	01
5.	Charge carrier density variation with temperature and doping: Part 1	01
6.	Charge carrier density variation with temperature and doping: Part 2	01
7.	Gunn diode and IMPAAT diode with NDR in various semiconductors	01
8.	MOSFET numerical and case study: Part 1	01
9.	MOSFET numerical and case study: Part 2	01
10.	High electron mobility transistor (HEMT) V-I characteristics: Part 1	01
11.	High electron mobility transistor (HEMT) V-I characteristics: Part 2	01
12.	Case studies and numerical on Tunnel diode	01
13.	Band gap tuning with various mechanisms	01
14.	P-n diode case studies- V- I characteristics and concerned numerical: Part 1	01
15.	P-n diode case studies- V- I characteristics and concerned numerical: Part 1	01