

NIRMA UNIVERSITY

Institute:	Institute of Technology
Name of Programme:	B Tech Electronics and Instrumentation Engineering
Semester:	VI
Course Code:	
Course Title:	Semiconductor Devices and Circuits
Course Type:	Department Elective - II
Year of Introduction:	2025-26

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Course Learning Outcomes (CLOs):

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

1. Explain important concepts related to semiconductor technology (BL2)
2. Extract device parameters by suitable analysis methods (BL2)
3. Design circuit using device specifications and analyse circuit behaviour (BL4)
4. Justify the concepts and analysis to advanced topics of semiconductor technology (BL5)

Unit	Contents	Teaching Hours (Total 45)
Unit-I	Fundamentals of Quantum and Solid State Physics Quantum mechanics for electronic devices, Schrödinger's equation, and tunneling. Crystal structures, energy bands, Brillouin zones in solids. Basic physics concepts for understanding semiconductor behavior.	08
Unit-II	Electronic Properties of Semiconductors Density of states, Fermi-Dirac function, intrinsic and extrinsic semiconductors. Doping, recombination and generation of charge carriers. Charge transport mechanisms and continuity equation.	08
Unit-III	Charge Transport Across Abrupt Semiconductor Interfaces Linearly graded junctions, Nonlinearly graded junctions, Metal-Semiconductor junctions, energy band diagrams, Schottky barriers. Carrier Injection and Diffusion-Drift Mechanisms, Junction Electrostatics and Poisson's Equation Solutions, High-Field Effects in Semiconductor Junctions and Electro-Thermal Phenomena, Breakdown Mechanisms and Thermally Induced Degradation in p-n Junctions	08
Unit-IV	MOS Capacitors MOS Capacitors, flat band condition and inversion condition, effect of oxide thickness and flat band voltage on threshold voltage, derivation threshold voltage. Energy band diagram for MOS-capacitor under inversion, differential charge distribution C-V characteristics and oxide capacitance analysis. High frequency and low frequency effects of C-V characteristics	08
Unit-V	Charge Transport and Electrostatics in Scaled MOSFET MOSFET structure, threshold voltage, and channel formation. Subthreshold slope, subthreshold conduction mechanisms, Subthreshold swing limits and Subthreshold engineering, Short-channel effects and device scaling, Drain-induced barrier lowering (DIBL), Channel length modulation and punch-through, charge sheet model, Impact of high-k dielectrics on threshold and reliability.	06

Unit-VI Device Applications and Emerging Technologies

07

Linking circuit design and semiconductor device physics. Thin Film Transistor (TFT) construction and working. Applications in displays and flexible electronics.

Self-Study:

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

Suggested Readings/References:

1. Donald A. Neamen, Semiconductor Physics and Devices, McGraw-Hill Education.
2. Ben G. Streetman and Sanjay Banerjee, Solid State Electronic Devices, Pearson Education.
3. Robert F. Pierret, Semiconductor Device Fundamentals, Addison-Wesley Publication.
4. Simon M. Sze and Kwok K. Ng, Physics of Semiconductor Devices, Wiley Publication.
5. Sima Dimitrijević, Principles of Semiconductor Devices, Oxford University Press.

Suggested List of Tutorial work will be based on above syllabus with minimum 05 tutorials to be incorporated.

Tutorials:

1. Explain the various type of bonds, junctions and energy band structures.
2. Explain the formation of energy bands and the significance of Brillouin zones in solids.
3. Apply Fermi-Dirac statistics to calculate carrier concentrations in semiconductors.
4. Analyze the electrical behaviour of PN junctions under different biasing conditions.
5. Evaluate the performance differences between Schottky and PN junctions for high-speed applications.
6. Design a doping profile for a semiconductor device to achieve desired electrical properties.
7. Apply drift and diffusion current equations to model charge transport in semiconductors.
8. Analyze the C–V characteristics of MOS capacitors to interpret accumulation, depletion, and inversion regions.
9. Evaluate the effects of device scaling and short-channel phenomena in MOSFETs.
10. Create a conceptual design for a TFT-based flexible electronic display.