# Table of Contents

**CHAPTER 1 FUNDAMENTALS OF MODERN APPLIED PHYSICS AND QUANTUM MECHANICS** **01-27**

1.1 Introduction to Modern Applied Physics
1.2 Wave–Particle Duality and Quantum Principles
1.3 Heisenberg Uncertainty Principle and Schrödinger Wave Equation
1.4 Quantum States, Operators and Probability Density
1.5 Particle in a Potential Box and Quantum Tunnelling
1.6 Engineering Applications of Quantum Mechanics

**CHAPTER 2 QUANTUM COMPUTING AND QUANTUM INFORMATION SCIENCE** **28-58**

2.1 Introduction to Quantum Computing and Qubits
2.2 Quantum Superposition and Entanglement
2.3 Bloch Sphere and Quantum Measurement
2.4 Quantum Gates and Circuit Operations
2.5 Quantum Algorithms and Error Correction
2.6 Applications of Quantum Computing in Engineering

**CHAPTER 3 QUANTUM TECHNOLOGIES, COMMUNICATION AND SENSING** **59-88**

3.1 Fundamentals of Quantum Information and Communication
3.2 Quantum Teleportation and Quantum Cryptography
3.3 Quantum Key Distribution and Secure Networks
3.4 Principles of Quantum Sensing and Metrology
3.5 Quantum Computing Platforms: Superconducting, Trapped-Ion and Photonic Systems
3.6 Applications of Quantum Technologies

**CHAPTER 4 WAVE OPTICS, INTERFERENCE AND ADVANCED OPTICAL PHENOMENA** **89-110**

4.1 Nature and Propagation of Light Waves
4.2 Interference of Light and Thin Film Applications
4.3 Newton's Rings and Optical Interferometry
4.4 Fresnel and Fraunhofer Diffraction
4.5 Diffraction Gratings and Polarization of Light
4.6 Holography and Engineering Applications of Wave Optics

**CHAPTER 5 LASER PHYSICS AND PHOTONIC TECHNOLOGIES** **111-140**

5.1 Fundamentals of Laser Physics and Emission Processes
5.2 Einstein Coefficients and Population Inversion
5.3 Optical Resonators and Laser Characteristics
5.4 Types of Lasers: Solid-State, Gas, Fibre and Semiconductor
5.5 Nonlinear Optics, Photonic Crystals and Nanophotonics
5.6 Engineering, Medical and Industrial Applications of Lasers

**CHAPTER 6 FIBRE OPTICS AND OPTICAL COMMUNICATION SYSTEMS** **141-157**

6.1 Fundamentals of Optical Fibre and Light Propagation
6.2 Total Internal Reflection, Numerical Aperture and Acceptance Angle
6.3 Classification and Characteristics of Optical Fibres
6.4 Attenuation, Dispersion and Optical Signal Transmission
6.5 Optical Sources, Photodetectors and Modulation Techniques
6.6 Wavelength Division Multiplexing and Optical Communication Networks

**CHAPTER 7 ADVANCED SENSORS, TRANSDUCERS AND MEASUREMENT TECHNOLOGIES** **158-175**

7.1 Fundamentals and Classification of Sensors and Transducers
7.2 Resistive, Capacitive, Inductive and Piezoelectric Sensors
7.3 Optical, Fibre Optic and Semiconductor Sensors
7.4 Temperature, Pressure, Humidity and Chemical Sensors
7.5 MEMS, NEMS, Biosensors and Smart Sensor Technologies
7.6 Sensor Calibration, Signal Conditioning and Industrial Applications

**CHAPTER 8 SEMICONDUCTOR PHYSICS AND ELECTRONIC DEVICE TECHNOLOGIES** **176-196**

8.1 Fundamentals of Semiconductor Materials and Energy Bands
8.2 Intrinsic and Extrinsic Semiconductors
8.3 Fermi Energy, Carrier Concentration and Charge Transport
8.4 p-n Junction Diodes, Zener Diodes and Schottky Diodes
8.5 Bipolar Junction Transistors, MOSFETs and CMOS Technology
8.6 LEDs, Photodetectors and Solar Cell Technologies

**CHAPTER 9 NANOTECHNOLOGY, ADVANCED MATERIALS AND NANOELECTRONICS** **197-215**

9.1 Fundamentals of Nanoscience and Nanotechnology
9.2 Classification and Properties of Nanomaterials
9.3 Quantum Confinement and Low-Dimensional Structures

9.4 Carbon Nanotubes, Graphene and Two-Dimensional Materials
9.5 Thin Film Deposition, Nanoelectronics and Spintronics
9.6 Engineering Applications of Nanotechnology and Advanced Materials

**CHAPTER 10 EMERGING SEMICONDUCTOR DEVICES, PHOTONIC INTEGRATION AND FUTURE TECHNOLOGIES** **216-243**

10.1 Advanced Semiconductor Materials: GaN, SiC and GaAs
10.2 Heterojunction Devices and High Electron Mobility Transistors
10.3 Quantum Dot Devices and Advanced Optoelectronics
10.4 Integrated Photonic Circuits and Silicon Photonics
10.5 Neuromorphic Computing and Flexible Electronic Sensors
10.6 Quantum–Photonic Integration and Future Engineering Technologies