

TABLE OF CONTENTS

Unit No.	Title	Page No.
1	Advanced Sensor Fundamentals and IoT Ecosystem 1.1 Smart Sensor Concepts and Classification Frameworks 1.2 Sensor Performance Metrics and Metrology Standards 1.3 Self-Calibration, Fault Tolerance, and Reliability Engineering 1.4 Environmental Influences and Digital Twin Concepts 1.5 IoT Architectures and Sensor Integration Models	1-21
2	Physics of Transduction and Advanced Sensing Materials 2.1 Principles of Physical Transduction 2.2 Electromechanical, Optical, and Chemical Sensing Mechanisms 2.3 Advanced Materials and Nanostructured Sensors 2.4 Nonlinear Effects and High-Sensitivity Transduction 2.5 Material Engineering for Performance Enhancement	22-40
3	Semiconductor and MEMS Sensor Physics 3.1 Semiconductor Fundamentals for Sensor Applications 3.2 MEMS and NEMS Operating Principles 3.3 Fabrication Technologies and SOI Platforms 3.4 Microfluidic and Bio-Inspired Sensor Systems 3.5 Modeling, Scaling, and System Integration Challenges	41-58
4	Low-Noise Electronics and Smart Signal Processing 4.1 Noise Sources, Modeling, and Signal Integrity 4.2 Signal Conditioning and Sensor Interface Circuits 4.3 Data Conversion and Calibration Techniques 4.4 Digital Signal Processing for Sensor Data 4.5 Smart Filtering and Embedded Intelligence	59-75
5	Wireless, RF, and Antenna Physics for IoT 5.1 Electromagnetic Foundations and Antenna Theory 5.2 RF Propagation and Communication Regimes 5.3 Low-Power Wireless Communication Protocols 5.4 Backscatter and Passive RF Systems 5.5 Antenna Design Considerations for IoT Sensors	76-92

6	Energy Harvesting, Storage, and Power Optimization 6.1 Energy Constraints in Autonomous Sensor Systems 6.2 Energy Harvesting Mechanisms and Architectures 6.3 Energy Storage Technologies and Characteristics 6.4 Power Management and Optimization Strategies 6.5 Ultra-Low-Power System Design Principles	93-108
7	Physics-Informed AI and Edge Intelligence 7.1 Role of Artificial Intelligence in Sensing Systems 7.2 Physics-Informed and Hybrid Machine Learning Models 7.3 Edge Computing Architectures for Sensors 7.4 Compressive Sensing and Data Reduction Methods 7.5 Uncertainty Modeling and Explainable AI	109-123
8	Emerging Applications, Ethics, and Research Trends 8.1 Biomedical and Wearable Sensor Technologies 8.2 Environmental, Industrial, and Infrastructure Monitoring 8.3 Space and Extreme-Environment Applications 8.4 Ethical, Privacy, and Sustainability Considerations 8.5 Emerging Research Directions and Innovations	124-138
9	Sensor Networks, Architectures, and System Integration 9.1 Fundamentals of Sensor Network Design 9.2 Network Topologies and Communication Protocols 9.3 Synchronization, Localization, and Data Management 9.4 Edge-Cloud Integration Architectures 9.5 Scalability, Reliability, and Performance Evaluation	139-153
10	Calibration, Testing, and Reliability Engineering 10.1 Calibration Standards and Traceability 10.2 Testing and Validation Methodologies 10.3 Reliability Analysis and Accelerated Aging 10.4 Failure Mechanisms and Diagnostic Techniques 10.5 Fault-Tolerant and Self-Healing Systems	154-172
11	Security, Privacy, and Trust in IoT Sensors 11.1 Threat Models and Security Challenges 11.2 Hardware Security and Cryptographic Foundations	173-190

	11.3 Secure Communication and Authentication Mechanisms 11.4 Privacy-Preserving Sensing Techniques 11.5 Trust Management and Regulatory Compliance	
12	Simulation, Modeling, and Digital Prototyping 12.1 Role of Simulation in Sensor System Design 12.2 Multiphysics Modeling and FEM Analysis 12.3 Digital Twins and Virtual Prototyping 12.4 Model Validation, Optimization, and Verification 12.5 Software Tools and Design Platforms	191-208
13	Standardization, Commercialization, and Future Outlook 13.1 Global Standards and Certification Frameworks 13.2 Technology Readiness Levels and Validation 13.3 Commercialization and Product Development Strategies 13.4 Innovation, Startups, and Industry Ecosystems 13.5 Future Trends and Societal Impact of Sensors	209-226
	Bibliography Glossary of Terms Index	227 229 233