

Summary :

Chapter 1: Introduction to Nuclear Energy

1. History of Nuclear Energy
2. Fundamental Principles of Nuclear Fission
3. Role of Nuclear Power Plants in Global Electricity Generation
4. Advantages and Limitations of Nuclear Energy

Chapter 2: Nuclear Reactor Physics

1. Atomic Structure and Radioactivity
2. Chain Fission Reactions
3. Neutrons and Moderation
4. Reactor Criticality and Control
5. Reactor Kinetics

Chapter 3: Nuclear Fuel

1. Uranium and Thorium
2. Fuel Enrichment
3. Fuel Assembly Manufacturing
4. Nuclear Fuel Cycle
5. Spent Fuel Management

Chapter 4: Types of Nuclear Reactors

1. Pressurized Water Reactors (PWR)
2. Boiling Water Reactors (BWR)
3. Heavy Water Reactors (CANDU)
4. Gas-Cooled Reactors
5. Fast Reactors
6. Generation IV Reactors
7. Small Modular Reactors (SMRs)

Chapter 5: Components of a Nuclear Power Plant

1. Reactor Vessel
2. Primary Circuit
3. Steam Generators
4. Turbines and Generators
5. Condensers and Cooling Systems
6. Containment Building

Chapter 6: Energy Conversion and Electricity Generation

1. Heat Production in the Reactor Core
2. Thermodynamic Cycles
3. Steam-to-Electricity Conversion
4. Energy Efficiency
5. Production Optimization

Chapter 7: Nuclear Safety Systems

1. Defense-in-Depth Concept
2. Containment Barriers
3. Emergency Shutdown Systems
4. Emergency Core Cooling Systems
5. Accident Analysis

Chapter 8: Instrumentation and Control

1. Reactor Parameter Measurement
2. Control Systems
3. Power Plant Automation
4. Radiation Monitoring
5. Modern Digital Systems

Chapter 9: Nuclear Power Plant Operation

1. Reactor Startup and Shutdown
2. Normal Operating Conditions
3. Preventive and Corrective Maintenance
4. Incident Management
5. Capacity Factor and Performance

Chapter 10: Radiation Protection

1. Sources of Radiation
2. Biological Effects of Radiation
3. Worker Protection
4. Environmental Monitoring
5. Standards and Regulations

Chapter 11: Radioactive Waste Management

1. Waste Classification
2. Treatment and Conditioning
3. Temporary Storage
4. Deep Geological Disposal
5. Recycling and Reprocessing

Chapter 12: Environmental Impact

1. Carbon Emissions and Carbon Footprint
2. Natural Resource Utilization
3. Thermal Discharges
4. Life-Cycle Assessment
5. Comparison with Other Energy Sources

Chapter 13: Economics of Nuclear Power Plants

1. Construction Costs
2. Operating Costs
3. Fuel Cycle Costs
4. Profitability and Competitiveness
5. Project Financing

Chapter 14: Major Nuclear Accidents

1. Three Mile Island accident
2. Chernobyl disaster
3. Fukushima Daiichi nuclear disaster
4. Lessons Learned from Nuclear Accidents

Chapter 15: Nuclear Power Plant Decommissioning

1. Decommissioning Strategies
2. Facility Decontamination
3. Radioactive Material Management
4. Costs and Planning

Chapter 16: Future Perspectives

1. Advanced Reactors
2. Nuclear Fusion
3. Technological Innovations
4. The Role of Nuclear Energy in the Energy Transition

Appendices

- Physical Constants and Nuclear Data
- Major Safety Standards
- Glossary of Nuclear Terms
- Solved Exercises and Case Studies
- Bibliography

