R23 Regulations

B.Tech Curriculum - OPEN ELECTIVES

Offered by the department of **EEE**

S.No	Category	Titles
1	Open Elective -1	1. Entrepreneurship Development & Venture Creation 2. Renewable Energy Sources 3. Concepts of Energy Auditing & Management
2	Open Elective-2	1. Fundamentals of Electric Vehicles 2. Electrical Wiring Estimation and Costing
3	Open Elective-3	1. Battery Management Systems and Charging Stations 2. Concepts of Smart Grid Technologies
4	Open Elective-4	1. Concepts of Power Quality 2. Intelligent Control Systems 3. Quantum Science and Technology

III Year I Semester	RENEWABLE ENERGY SOURCES	L	T	P	C
		3	0	0	3

Pre-requisite: Basic Electrical Engineering

Course Objectives:

- To study the solar radiation data, equivalent circuit of PV cell and its I-V & P-V characteristics.
- To understand the concept of Wind Energy Conversion & its applications.
- To study the principles of biomass, hydel and geothermal energy.
- To understand the principles of ocean Thermal Energy Conversion, waves and power associated with it.
- To study the various chemical energy sources such as fuel cell and hydrogen energy along with their operation and equivalent circuit.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Analyze solar radiation data, extra-terrestrial radiation, radiation on earth's surface and solar Energy Storage.
CO2: Illustrate the components of wind energy systems.
CO3: Illustrate the working of biomass, hydel plants and Geothermal plants.
CO4: Demonstrate the principle of Energy production from OTEC, Tidal and Waves.
CO5: Evaluate the concept and working of Fuel cells & MHD power generation.

UNIT–I

Solar Energy

Introduction - Renewable Sources - prospects, solar radiation at the Earth Surface - Equivalent circuit of a Photovoltaic (PV) Cell - I-V & P-V Characteristics - Solar Energy Collectors: Flat plate Collectors, concentrating collectors - Solar Energy storage systems and Applications: Solar Pond - Solar water heating - Solar Green house.

UNIT–II

Wind Energy

Introduction - basic Principles of Wind Energy Conversion, the nature of Wind - the power in the wind - Wind Energy Conversion - Site selection considerations - basic components of Wind Energy Conversion Systems (WECS) - Classification - Applications.

UNIT–III

Biomass, Hydel and Geothermal Energy

Biomass: Introduction - Biomass conversion technologies- Photosynthesis. Factors affecting Bio digestion.

Hydro plants: Basic working principle – Classification of hydro systems**:** Large, small, micro hydel plants.

Geothermal Energy: Introduction, Geothermal Sources – Applications - operational and Environmental problems.

UNIT–IV

Energy From oceans, Waves & Tides:

Oceans: Introduction - Ocean Thermal Electric Conversion (OTEC) – methods - prospects of OTEC in India.

Waves: Introduction - Energy and Power from the waves - Wave Energy conversion devices.

Tides: Basic principle of Tide Energy -Components of Tidal Energy.

UNIT–V

Chemical Energy Sources:

Fuel Cells: Introduction - Fuel Cell Equivalent Circuit - operation of Fuel cell - types of Fuel Cells - Applications.

Hydrogen Energy: Introduction - Methods of Hydrogen production - Storage and Applications

Magneto Hydro Dynamic (MHD) Power generation: Principle of Operation - Types.

Text Books:

1. G.D.Rai, Non-Conventional Energy Sources, Khanna Publications, 2011.
2. John Twidell& Tony Weir, Renewable Energy Sources, Taylor & Francis, 2013.

Reference Books:

1. S.P.Sukhatme&J.K.Nayak, Solar Energy-Principles of Thermal Collection and Storage, TMH, 2011.
2. John Andrews & Nick Jelly, Energy Science- principles, Technologies and Impacts, Oxford, 2nd edition, 2013.
3. ShobaNath Singh, Non- Conventional Energy Resources, Pearson Publications, 2015.

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/103/103/103103206
2. https://archive.nptel.ac.in/courses/103/107/103107157

III Year I Semester	CONCEPTS OF ENERGY AUDITING & MANAGEMENT	L	T	P	C
		3	0	0	3

Pre-requisite:

Basics of Conservation of Electrical Energy

Course Objectives:

- To understand basic concepts of Energy Audit & various Energy conservation schemes.
- To design energy an energy management program.
- To understand concept of Energy Efficient Motors and lighting control efficiencies.
- To estimate/calculate power factor of systems and propose suitable compensation techniques.
- To calculate life cycle costing analysis and return on investment on energy efficient technologies.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Understand the principles of energy audit along with various Energy related terminologies.
CO2: Asses the role of Energy Manager and Energy Management program.
CO3: Design a energy efficient motors and good lighting system.
CO4: Analyse the methods to improve the power factor and identify the energy instruments for various real time applications.
CO5: Evaluate the computational techniques with regard to economic aspects.

UNIT–I
Basic Principles of Energy Audit

Energy audit- definitions - concept - types of **Energy** audit - energy index - cost index - pie charts - Sankey diagrams and load profiles - Energy conservation schemes- Energy audit of industries- energy saving potential - energy audit of process industry, thermal power station - building energy audit - Conservation of Energy Building Codes (ECBC-2017)

UNIT–II:
Energy Management

Principles of energy management - organizing energy management program - initiating - planning - controlling - promoting - monitoring - reporting. Energy manager - qualities and functions - language - Questionnaire – check list for top management.

UNIT–III:

Energy Efficient Motors and Lighting

Energy efficient motors - factors affecting efficiency - loss distribution - constructional details - characteristics – variable speed - RMS - voltage variation-voltage unbalance-over motoring-motor energy audit. lighting system design and practice - lighting control - lighting energy audit.

UNIT–IV

Power Factor Improvement and Energy Instruments

Power factor – methods of improvement - location of capacitors - Power factor with non-linear loads - effect of harmonics on power factor - power factor motor controllers – Energy Instruments- watt meter - data loggers - thermocouples - pyrometers - lux meters - tongue testers.

UNIT–V

Economic Aspects and their Computation

Economics Analysis depreciation Methods - time value of money - rate of return - present worth method - replacement analysis - lifecycle costing analysis – Energy efficient motors. Calculation of simple payback method - net present value method- Power factor correction - lighting – Applications of life cycle costing analysis - return on investment.

Text Books:

1. Energy management by W.R.Murphy & G.Mckay Butter worth - Heinemann publications - 1982.
2. Energy management hand book by W.CTurner - John wiley and sons - 1982.

Reference Books:

1. Energy efficient electric motors by John.C.Andreas - Marcel Dekker Inc Ltd-2nd edition - 1995
2. Energy management by Paul o' Callaghan - Mc-graw Hill Book company-1st edition - 1998
3. Energy management and good lighting practice : fuel efficiency- booklet12-EEO

Online Learning Resources:

1. https://nptel.ac.in/courses/108106022

https://archive.nptel.ac.in/courses/108/106/108106022

III Year II Semester	FUNDAMENTALS OF ELECTRIC VEHICLES	L	T	P	C
		3	0	0	3

Pre-requisite:

Basic knowledge in Physics, Chemistry and Basics of Electrical and Electronics.

Course Objectives:

- To familiarize the students with the need and advantages of electric and hybrid electric vehicles.
- To understand various power converters used in electric vehicles.
- To be familiar all the different types of motors suitable for electric vehicles.
- To know various architecture of hybrid electric vehicles.
- To have knowledge on latest developments in batteries and other storage systems.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Illustrate the use and advantages of different types of electric vehicles.
CO2: Use suitable power converters for EV application.
CO3: Select suitable electric motor for EV power train.
CO4: Design HEV configuration for a specific application.
CO5: Analyse various storage systems and battery management system for EVs.

UNIT – I

Introduction

Fundamentals of vehicles – Vehicle model – Calculation road load and tractive force –Components of conventional vehicles – Drawbacks of conventional vehicles – Need for electric vehicles– Advantages and applications of Electric Vehicles – History of Electric Vehicles – EV Market in India and outside India –Types of Electric Vehicles.

UNIT – II

Components of Electric Vehicles

Main components of Electric Vehicles – Electric Traction MotorandController – Power Converters – Rectifiers used in EVs – Bidirectional DC–DC Converters – Voltage Source Inverters – PWM inverters used in EVs.

UNIT – III

Motors for Electric Vehicles

Characteristics of traction drive – requirements of electric machines for EVs – Comparison of Different motors for Electric and Hybrid Vehicles – Induction Motors – Synchronous Motors – Permanent Magnetic Synchronous Motors – Brushless DC Motors – Switched Reluctance Motors (Construction details and working only).

UNIT – IV

Hybrid Electric Vehicles

Evolution of Hybrid Electric Vehicles – Advantages and Applications of Hybrid Electric Vehicles – Architecture of HEVs – Series and Parallel HEVs – Complex HEVs – Range extended HEVs – Examples – Merits and Demerits.

UNIT – V

Energy Sources for Electric Vehicles

Batteries– Types of Batteries – Lithium-ion – Nickel-metal hydride – Lead-acid – Comparison of Batteries – Battery Charging – Fast Charging –Battery Management System – Ultra capacitors – Flywheels – Compressed air energy storage (CAES)– Fuel Cell – it's working.

Text Books

1. Iqbal Hussein - Electric and Hybrid Vehicles: Design Fundamentals - CRC Press - 2021.
2. Tom Denton, Hayley Pells - Electric and hybrid vehicles, Third Edition, 2024

Reference Books:

1. Kumar - L. Ashok - and S. Albert Alexander. Power Converters for Electric

Vehicles. CRC Press - 2020.
2. Chau - Kwok Tong. Electric vehicle machines and drives: design - analysis and application. John Wiley & Sons - 2015.
3. Berg - Helena. Batteries for electric vehicles: materials and electrochemistry. Cambridge university press - 2015.

Online Learning Resources:

1. MOOC at https://www.edx.org/learn/electric-cars
2. https://archive.nptel.ac.in/courses/108/106/108106170

III Year II Semester	ELECTRICAL WIRING ESTIMATION AND COSTING	L	T	P	C
		3	0	0	3

Pre-requisite:

Electrical Circuits, Basics of Power Systems and Electrical Machines.

Course Objectives:

- Introduce the electrical symbols and simple electrical circuits
- Able to learn the design of electrical installations.
- Able to learn the design of electrical installation for different types of buildings and small industries.
- Learn the basic components of electrical substations.
- Familiarize with the motor control circuits

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Demonstrate the various electrical apparatus and their interconnections.
CO2: Examine various components of electrical installations.
CO3: Estimate the cost for installation of wiring for different types of building and small industries.
CO4: Illustrate the components of electrical substations.
CO5: Design suitable control circuit for starting of three phase induction motor and synchronous motor.

UNIT - I

Electrical Symbols and Simple Electrical Circuits

Identification of electrical symbols - Electrical wiring Diagrams - Methods of representation of wiring diagrams - introduction to simple light and fan circuits - system of connection of appliances and accessories.

UNIT - II

Design Considerations of Electrical Installations

Electric supply system - Three-phase four wire distribution system - protection of electric installation against overload - short circuit and earth fault - earthing -

neutral and earth wire - types of loads - systems of wiring - permissible of voltage drops and sizes of wires - estimating and costing of electrical installations.

UNIT - III

Electrical Installation for Different Types of Buildings and Small Industries

Electrical installations for electrical buildings - estimating and costing of material - simple examples on electrical installation for residential buildings - electrical installations for commercial buildings - electrical installation for small industries-case study.

UNIT - IV

Substations

Introduction - types of substations - outdoor substations-pole mounted type - indoor substations-floor mounted type - simple examples on quantity estimation-case study.

UNIT - V

Motor control circuits

Introduction to AC motors - starting of three phase squirrel cage induction motors - starting of wound rotor motors - starting of synchronous motors - contractor control circuit components - basic control circuits - motor protection – Schematic and wiring diagrams for motor control circuits.

Text Books:

1. Electrical Design and Estimation Costing - K. B. Raina and S.K.Bhattacharya – New Age International Publishers - 2007.

References Books:

1. Electrical wiring estimating and costing – S.L.Uppal and G.C.Garg – Khanna publishers - 6th edition - 1987.
2. A course in electrical installation estimating and costing – J.B.Gupta – Kataria SK & Sons - 2013.

Online Learning Resources:

https://onlinecourses.swayam2.ac.in/nou25_ec07/preview

IV Year – I Semester	BATTERY MANAGEMENT SYSTEMS AND CHARGING STATIONS	L	T	P	C
		3	0	0	3

Pre-requisite: Electric Circuits and Power Electronics

Course objectives:

- To understand the fundamentals of batteries, configurations, and charging processes.
- To learn the functional requirements and architecture of a Battery Management System (BMS).
- To explore methods for estimating battery state of charge and health, along with balancing techniques.
- To study modeling approaches for simulating batteries and electric vehicle performance. To Analyze design considerations for practical implementation of BMS in multi-battery systems.
- To understand the charging infrastructure and its various types

Course Outcomes:

After the completion of the course the student should be able to:

- Describe the construction and operation of different batteries for EV applications
- Describe charging algorithms of different batteries and balancing methods of battery packs
- Describe the different kinds of infrastructure needed in the charging stations
- Describe the requirements of battery management and their maintenance. obtain the modelling of batteries and develop their simulation models.
- Develop various charging types and their usage for different applications

Unit - I:

Introduction

Introduction to Battery Management System, Cells & Batteries, Nominal voltage and capacity, C rate, Energy and power, Cells connected in series, Cells connected in parallel, Electrochemical and lithium-ion cells, Rechargeable cells, Charging and Discharging Process, Overcharge and Undercharge, Modes of Charging

Unit - II:

Battery Management System Requirement

Introduction and BMS functionality, Battery pack topology, BMS Functionality, Voltage Sensing, Temperature Sensing, Current Sensing, BMS Functionality, High-voltage contactor control, Isolation sensing, Thermal control, Protection, Communication Interface, Range estimation, State-of charge estimation, Cell total energy and cell total power.

Unit -III:

Battery State of Charge and State of Health Estimation, Cell Balancing

Battery state of charge estimation (SOC), voltage-based methods to estimate SOC, Model-based state estimation, Battery Health Estimation, Lithium-ion aging: Negative electrode, Lithium-ion aging: Positive electrode, Cell Balancing, Causes of imbalance, Circuits for balancing.

Unit - IV:

Modelling and Simulation

Equivalent-circuit models (ECMs), Physics-based models (PBMs), Empirical modelling approach, Physics-based modelling approach, simulating an electric vehicle, Vehicle range calculations, simulating constant power and voltage, Simulating battery packs.

Battery-Management-System Requirements

Unit - V:

Charging Infrastructure

Domestic Charging Infrastructure, Public charging Infrastructure, Normal Charging Station, Occasional Charging Station, Fast Charging Station, Battery Swapping Station, Move-and-charge zone

Text Books:

1. Plett, Gregory L. Battery management systems, Volume I: Battery modeling. Artech House, 2015.
2. Plett, Gregory L. Battery management systems, Volume II: Equivalent-circuit methods. Artech House, 2015.

Reference Books:

1. Bergveld, H.J., Kruijt, W.S., Notten, P.H.L “Battery Management Systems -Design

by Modelling" Philips Research Book Series 2002.
2. Davide Andrea," Battery Management Systems for Large Lithium-ion Battery Packs" Artech House, 2010
3. Pop, Valer, et al. Battery management systems: Accurate state-of-charge indication for battery-powered applications. Vol. 9. Springer Science & Business Media, 2008.

Online Learning Resources:

1. https://nptel.ac.in/courses/108106170
2. http://www.digimat.in/nptel/courses/video/108106170/L65.html

IV Year – I Semester	CONCEPTS OF SMART GRID TECHNOLOGIES	L	T	P	C
		3	0	0	3

Pre-requisite: Power Systems, Renewable Energy Technologies

Course Objectives:

- To understand the basic concepts of smart grid.
- To understand various smart grid technologies and its usage in smart applications.
- To realize substation automation with intelligent sensors and have an idea on battery energy storage systems.
- To have basic knowledge on micro grids and DG's.
- To have an idea on communication technologies used in smart grid.

Course Outcomes:

After the completion of the course the student should be able to:

- Know the concepts of smart grids and analyse the smart grid policies and developments in smart grids.
- Develop concepts of smart grid technologies in hybrid electrical vehicles etc.
- Know the concepts of smart substations - feeder automation - Battery Energy storage systems etc.
- Analyse micro grids and distributed generation systems.
- Analyse the effect of power quality in smart grid and to understand latest developments in ICT for smart grid.

UNIT – I

Introduction to Smart Grid

Evolution of Electric Grid - Concept of Smart Grid - Definitions - Need of Smart Grid - Functions of Smart Grid - Opportunities & Barriers of Smart Grid - Difference between conventional & smart grid - Concept of Resilient & Self-Healing Grid - Present development & International policies on Smart Grid.

UNIT – II

Smart Grid Technologies: Part 1

Introduction to Smart Meters - Real Time Pricing - Smart Appliances - Automatic Meter Reading(AMR) - Outage Management System(OMS) - Plug in Hybrid Electric Vehicles(PHEV)

- Vehicle to Grid - Smart Sensors - Home & Building Automation - Phase Shifting Transformers - Net Metering.

UNIT – III

Smart Grid Technologies: Part 2

Smart Substations - Substation Automation - Feeder Automation. Geographic Information System(GIS) - Intelligent Electronic Devices (IED) & their application for monitoring & protection.

Smart storage like Battery Energy Storage Systems (BESS) - Super Conducting Magnetic Energy Storage Systems (SMES) - Pumped Hydro - Compressed Air Energy Storage (CAES).

UNIT – IV

Micro grids and Distributed Energy Resources

Concept of micro grid - need & applications of microgrid - formation of microgrid - Issues of interconnection - protection & control of microgrid - Integration of renewable energy sources - Demand Response.

UNIT - V

Information and Communication Technology for Smart Grid

Advanced Metering Infrastructure (AMI) - Home Area Network (HAN) - Neighborhood Area Network (NAN) - Wide Area Network (WAN).

Text Books:

1. Integration of Green and Renewable Energy in Electric Power Systems - by Ali Keyhani - Mohammad N. Marwali - Min Dai Wiley - 2009.
2. The Smart Grid: Enabling Energy Efficiency and Demand Response - by Clark W.Gellings - Fairmont Press - 2009.
3. 3. Smart Grid: Technology and Applications - by Janaka B. Ekanayake - Nick Jenkins - Kithsiri Liyanage - Jianzhong Wu - Akihiko Yokoyama - Wiley publishers - 2012.
4. Smart Grids by Jean-Claude Sabonnadière - NouredineHadjsaïd - Wiley publishers – 2013.
5. Smart Power: Climate Changes - the Smart Grid - and the Future of Electric Utilities - by Peter S. Fox Penner - Island Press; 1st edition - 8 Jun 2010
6. Microgrids and Active Distribution Networks by S. Chowdhury - S. P. Chowdhury - P.Crossley - Institution of Engineering and Technology - 30 Jun 2009

Reference Books:

1. The Advanced Smart Grid: Edge Power Driving Sustainability:1 by Andres Carvallo - John Cooper - Artech House Publishers July 2011
2. Control and Automation of Electric Power Distribution Systems (Power Engineering) by James Northcote - Green - Robert G. Wilson - CRC Press - 2017.
3. Substation Automation (Power Electronics and Power Systems) by Mladen Kezunovic - Mark G. Adamiak - Alexander P. Apostolov - Jeffrey George Gilbert - Springer - 2010.
4. Electrical Power System Quality by R. C. Dugan - Mark F. McGranghan - Surya Santoso - H. Wayne Beaty - McGraw Hill Publication - 2nd Edition.

Online Learning Resources:

1. https://nptel.ac.in/courses/108107113
2. https://online-learning.tudelft.nl/courses/smart-grids-the-basics/

IV Year – I Semester	CONCEPTS OF POWER QUALITY	L	T	P	C
		3	0	0	3

Pre-requisite: Concepts of Power Systems

Course Objectives:

- To learn different types of power quality phenomena.
- To identify sources for voltage sag, voltage swell, interruptions, transients, long duration over voltages and harmonics in a power system.
- To describe power quality terms and know the power quality standards.
- To learn the principle of voltage regulation and power factor improvement methods.
- To explain the relationship between distributed generation and power quality.
- To understand the power quality monitoring concepts and the usage of measuring instruments.

Course Outcomes: After the completion of the course the student should be able to:

- Differentiate between different types of power quality problems.
- Explain the sources of voltage sag - voltage swell - interruptions - transients - long duration over voltages and harmonics in a power system.
- Explain the principle of voltage regulation and improvement methods.
- Analyse voltage distortion and current distortion and their indices.
- Know the concepts of distributed generation technologies and power quality monitoring.

UNIT – I

Introduction - Terms & Definitions

Overview of power quality – Concern about the power quality – General classes of power quality and voltage quality problems – Transients – Long–duration voltage variations – Short–duration voltage variations – Voltage unbalance – Waveform distortion – Voltage fluctuation – Power frequency variations – Voltage Sags – Voltage Swell.

UNIT - II

Transient Over Voltages

Sources of Transient Over voltages - Principles of Over voltage protection- Devices for Over voltage protection – Utility Capacitor Switching Transients - Utility System Lightning Protection – Managing Ferro resonance – Switching Transient Problems with Loads.

UNIT - III

Long – Duration Voltage Variations

Principles of regulating the voltage – Device for voltage regulation – Utility voltage regulator application – Capacitor for voltage regulation – End–user capacitor application – Regulating utility voltage with distributed resources – Flicker.

UNIT - IV

Harmonic distortion and solutions

Voltage distortion vs. Current distortion –Harmonic indices: THD - TDD and True Power Factor– Sources of harmonics – Effect of harmonic distortion – Impact on capacitors - transformers - motors and meters – Concept of Point of common coupling – Passive and active filtering – Numerical problems.

UNIT - V

Distributed Generation and Monitoring

Resurgence of distributed generation – DG technologies – Interface to the utility system – Power quality issues and operating conflicts – DG on low voltage distribution networks.

Monitoring

Power quality monitoring and considerations – Historical perspective of PQ measuring instruments – PQ measurement equipment – Assessment of PQ measuring data.

Textbooks:

1. Electrical Power Systems Quality - Dugan R C - McGranaghan M F - Santoso S - andBeaty H W - Second Edition - McGraw–Hill - 2012 - 3rd edition.
2. Electric power quality problems –M.H.J.Bollen IEEE series-Wiley india publications - 2011.
3. Power Quality Primer - Kennedy B W - First Edition - McGraw–Hill - 2000.

Reference Books:

1. Understanding Power Quality Problems: Voltage Sags and Interruptions - Bollen M HJ - First Edition - IEEE Press; 2000.
2. Power System Harmonics - Arrillaga J and Watson N R - Second Edition - John Wiley & Sons - 2003.
3. Electric Power Quality control Techniques - W. E. Kazibwe and M. H. Sendaula - Van Nostrad Reinhold - New York.
4. Power Quality c.shankaran - CRC Press - 2001

5. Harmonics and Power Systems –Franciso C.DE LA Rosa–CRC Press (Taylor & Francis)

6. Power Quality in Power systems and Electrical Machines–EwaldF.fuchs - Mohammad A.S.Masoum–Elsevier.

Online Learning Resources:

1. https://nptel.ac.in/courses/108106025
2. https://nptel.ac.in/courses/108107157

IV Year – I Semester	QUANTUM SCIENCE AND TECHNOLOGY	L	T	P	C
		3	0	0	3

Prerequisites: Basic Physics, Linear Algebra, and Introduction to Modern Physics

Course Objectives:

1. To introduce fundamental concepts of quantum mechanics and its mathematical formalism.
2. To explore quantum computing and communication principles and technologies.
3. To understand the physical implementation and limitations of quantum systems.
4. To enable students to relate quantum theory to practical applications in computing, cryptography, and sensing.
5. To familiarize students with the emerging trends in quantum technologies.

Course Outcomes:

After completing this course, students will be able to:
CO1. Explain core principles of quantum mechanics and their technological implications.
CO2. Analyze quantum phenomena like superposition and entanglement.
CO3. Apply mathematical tools to model and solve quantum systems.
CO4. Demonstrate understanding of quantum algorithms and quantum circuits.
CO5. Evaluate potential applications and challenges in quantum communication and sensing.

Unit 1: Fundamentals of Quantum Mechanics: Historical background: Blackbody radiation, photoelectric effect, and Compton scattering; Dual nature of light and matter; De Broglie hypothesis; Schrödinger equation; Free particle, infinite potential well, step potential; Operators and observables: position, momentum, Hamiltonian; Commutation relations and uncertainty principle; Quantum postulates and measurement theory; Eigenvalues, eigenfunctions.

Unit 2: Quantum Information Theory: Classical vs. quantum information; Qubit representation using Bloch sphere; Quantum superposition and quantum entanglement; Dirac notation (bra-ket), tensor products, and composite systems; Bell states and EPR paradox; Quantum gates: Pauli-X, Y, Z; Hadamard; Phase; T; CNOT; Quantum circuit models and notation; Measurement in computational basis; Quantum teleportation and no-cloning theorem; Quantum state tomography (introductory)

Unit 3: Quantum Computing: Classical computing review and limitations; Quantum parallelism and interference; Deutsch and Deutsch-Jozsa algorithms; Grover's search algorithm, Oracle and amplitude amplification; Shor's factoring algorithm (overview and significance); Quantum Fourier Transform (QFT); Quantum error correction: Bit-flip, phase-flip, and Shor's 9-qubit code; Introduction to quantum programming: Qiskit, Cirq, IBM Quantum Experience (overview)

Unit 4: Quantum Communication: Introduction to quantum cryptography; Quantum key distribution (QKD): BB84 protocol; Entanglement-based QKD: Ekert protocol (E91); Eavesdropping and security of QKD; Quantum teleportation (circuit and protocol); Quantum dense coding; Quantum networks and entanglement swapping; Role of quantum repeaters; Single-photon sources and detectors; Implementation challenges (loss, decoherence, noise)

Unit 5: Quantum Technologies and Applications: Quantum sensors: magnetometry, gravimetry; Quantum metrology: standard time, atomic clocks; Quantum imaging and lithography; Quantum materials: topological insulators, graphene, quantum dots; NV centers in diamonds for sensing; Hardware platforms: Superconducting qubits, Trapped ions, Photonic quantum processors; Quantum supremacy and NISQ era; Global initiatives: IBM, Google, D-Wave, IonQ, India's NQM; Ethical concerns and future prospects

Text Books:

1. **"Quantum Computation and Quantum Information"** by Michael A. Nielsen and Isaac L. Chuang
2. **"Quantum Mechanics: Concepts and Applications"** by Nouredine Zettili

Online Learning Resources:

1. https://nptel.ac.in/courses/104104082
2. https://nptel.ac.in/courses/115104096
3. https://nptel.ac.in/courses/122106034