B.Tech. IV Year-I Semester

S. No.	Category	Title	Subject Code	L	T	P	C
1	Professional Core	Power System Operation and Control	V231410231	3	0	0	3
2	Management Course-II	Energy Management &Auditing	V2314102M1	2	0	0	2
3	Professional Elective-IV	1. EHVAC&HVDC Transmission Systems	V231410241	3	0	0	3
		2. Programmable Logic Controllers	V231410242				
		3. Electrical Distribution System	V231410243				
		4. 12 weeks MOOCs Swayam/NPTEL course recommended by the BOS	V231410244				
4	Professional Elective-V	1. Electric Vehicles	V231410245	3	0	0	3
		2. Switched Mode Power Conversion	V231410246				
		3. Design of PV systems	V231410247				
		4. 12 weeks MOOCs Swayam/NPTEL course recommended by the BOS	V231410248				
5	Open Elective-III	1. Battery Management Systems and Charging Stations	V231410251	3	0	0	3
		2. Concepts of Smart Grid Technologies	V231410252				
6	Open Elective-IV	1. Concepts of Power Quality	V231410253	3	0	0	3
		2. Quantum Science and Technology	V231410254				
7	Skill Enhancement Course	Power Systems Simulation Lab	V231410261	0	0	4	2
8	Audit Course	Constitution of India	V2314102C1	2	0	0	-
9	Internship	Evaluation of Industry Internship	V231410181	-	-	-	2
Total					**1**	**16**	**21**

B.Tech. IV Year-II Semester

S. No.	Category	Title	Subject Code	L	T	P	C
1	PR	Internship and Project	V2314202A1	-	-	**24**	**12**

OPENELECTIVES

S.No.	Category	Title	L	T	P	C
1	Open Elective-I (III-I)	1. Renewable Energy Sources 2. Concepts of Energy Auditing & Management	3	0	0	3
2	Open Elective–II (III-II)	1. Fundamentals of Electric Vehicles 2. Electrical Wiring Estimation and Costing	3	0	0	3
3	Open Elective–III (IV-I)	1. Battery Management Systems and Charging Stations 2. Concepts of Smart Grid Technologies	3	0	0	3
4	Open Elective-IV (IV-I)	1. Concepts of Power Quality 2. Intelligent Control Systems	3	0	0	3

IV Year–I Semester	POWER SYSTEM OPERATION AND CONTROL (V231410231)	L	T	P	C
		3	0	0	3

Pre-requisite: Power Systems, Power Systems Analysis.

Course Outcomes:

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

1. Compute optimal load scheduling of Generators.
2. Formulate hydro thermal scheduling and unit commitment problem.
3. Analyse effect of Load Frequency Control for single area systems
4. Analyse effect of Load Frequency Control for two area systems.
5. Describe the effect of reactive power control for transmission lines.

UNIT-I

Economic Operation of Power Systems

Optimal operation of Generators in Thermal power stations—Heat rate curve–Cost Curve – Incremental fuel and Production costs – Input–output characteristics. -Optimum generation allocation with line losses neglected.

Optimum generation allocation including the effect of transmission line losses – Loss Coefficients – General transmission line loss formula.

UNIT-II

Hydro thermal Scheduling

Introduction -Mathematical Formulation–Short term Solution Technique.

Unit Commitment

Need for unit commitment–Constraints in unit commitment–Cost function formulation–Solution methods – Priority ordering – Dynamic programming.

UNIT– III

Load Frequency Control-I

Modelling of steam turbine – Generator – Mathematical modelling of speed governing system–Transfer function – Necessity of keeping frequency constant. Definitions of Control area – Single area control system–

Block diagram representation of an isolated power system–Steady state analysis – Dynamic response – Uncontrolled case. Proportional plus Integral control of single area and its block diagram representation – Steady state response.

UNIT-IV

Load Frequency Control-II

Block diagram development of load frequency control of two area system: uncontrolled case and controlled case – Tie-line bias control – Load frequency control and economic dispatch control.

UNIT-V

Compensation in Power Systems

Overview of Reactive Power control– Reactive power compensation in transmission systems– Advantages and disadvantages of different types of compensating equipment for transmission systems –

Load compensation – Specifications of load compensator – Compensated transmission lines. Introduction of FACTS devices – Need of FACTS controllers – Types of FACTS devices.

Text Books:

1. Power Generation-Operation and Control by Allen J Wood-Bruce F Wollen Berg 3rdEdition -Wiley Publication 2014.
2. Electric Energy systems Theory–by O.I.Elgerd-Tata Mc Graw–hill Publishing Company Ltd. -Second edition.
3. Modern Power System Analysis–byI.J.Nagrath&D.P.KothariTata McGraw Hill Publishing Company Ltd -2nd edition.

Reference Books:

1. Power System Analysis and Stability by S.S.Vadhera- Khanna Publications -4thedition-2005.
2. Power System Analysis by Grainger and Stevenson-Tata Mc Graw Hill.
3. Power System Analysis by Hadi Saadat – – Tata McGraw–Hill 3rdedition - 2010.
4. PowerSystemstability&control-PrabhaKundur-TMH-1994.

Online Learning Resources:

1. https://nptel.ac.in/courses/108104191
2. https://nptel.ac.in/courses/108104052

IV Year–I Semester	ENERGY MANAGEMENT & AUDITING (V2314102M1)	L	T	P	C
		2	0	0	2

Pre-requisite: Power Systems, Electrical Measurements and Instrumentation, Utilization of Electrical Energy, Analytical Skills.

Course Outcomes:

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

1. Understand the principles of energy audit along with various Energy related terminologies.
2. Asses the role of Energy Manager and Energy Management program.
3. Design an energy efficient motors and good lighting system.
4. To understand the significance of Demand side management and identify the energy instruments for various real time applications.
5. Evaluate the computational techniques about economic aspects.

Unit–I

Basic Principles of Energy Audit

Energy audit-definitions- concept-types of 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

Demand Side Management and Energy Instruments

Introduction to DSM - concept of DSM - benefits of DSM - Different techniques of DSM –time of day pricing - multi-utility power exchange model - time of day models for planning. Load management - load priority technique - peak clipping - peak shifting -valley filling - strategic conservation– Energy Instruments-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 - life cycle costing analysis – Energy efficient motors. Calculation of simple payback method - net present value method – 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.C Turner -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. Energymanagementandgoodlightingpractice:fuelefficiency-booklet12-EEO

Online Learning Resources:

1. https://nptel.ac.in/courses/112105221
2. https://nptel.ac.in/courses/109106161

IV Year–I Semester	EHVAC & HVDC TRANSMISSION SYSTEMS (PE-IV: V231410241)	L	T	P	C
		3	0	0	3

Pre-requisite: Power Systems, Power Electronics.

Course Outcomes:

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

1. Acquaint with HV transmission system with regard to power handling capacity, losses, conductor resistance and electrostatic field associate with HV. Further knowledge is gained in area of bundle conductor system to improve electrical and mechanical performance.
2. Develop ability for determining corona, radio interference, audible noise generation and frequency spectrum for single and three phase transmission lines.
3. Understand the basic concepts, economic considerations, and terminal equipment of HVDC transmission systems, including different types of HVDC and MTDC links.
4. Analyze and compare the configurations and characteristics of HVDC converters such as 6-pulse and 12-pulse Graetz circuits, and explain the principles and methods of DC link control.
5. Evaluate the origin and effects of harmonics in HVDC systems, calculate harmonic components, and design appropriate AC filters including single-tuned and high-pass filters.

Unit–I:

Introduction of EHVAC transmission

Necessity of EHV AC transmission – Advantages and problems– Power handling capacity and line losses– Mechanical considerations in line performance –Electrostatics – Field of spheregap–Fieldoflinechargesandproperties–Charge–potentialrelationsformulti–conductors – Surface voltage gradient on conductors – Bundle spacing and bundle radius– Examples – Distribution of voltage gradient on sub conductors of bundle – Examples.

Unit–II:

Corona effects

Power loss and audible noise (AN) – Corona loss formulae – Charge voltage diagram – Generation – Characteristics – Limits and measurements of AN – Relation between 1–phaseand 3–phase AN levels – Examples – Radio interference (RI) – Corona pulses and thier generation – Properties and limits – Frequency spectrum – Modes of propagation – Excitation function – Measurement of RI, RIV and excitation functions – Examples.

UNIT–III:

Basic Concepts of DC Transmission

Economics & Terminal equipment of HVDC transmission systems**:** Types of HVDC Links – Apparatus required for HVDC Systems – Comparison of AC &DC transmission – Application of DC Transmission System – Planning & Modern trends in DC transmission – Types of MTDC systems.

UNIT–IV:

Analysis of HVDC Converters and System Control

Choice of Converter configuration – Analysis of Graetz circuit – Characteristics of 6 Pulse &12 Pulse converters — Principal of DC Link Control – Converters Control Characteristics – Firing angle control –Constant Current and extinction angle control –Starting and stopping of DC link – Power Control.

UNIT–V:

Harmonics in HVDC System

Generation of Harmonics – Characteristics harmonics – Calculation of AC Harmonics – Non–Characteristics harmonics – Adverse effects of harmonics – Calculation of voltage & current harmonics – Effect of Pulse number on harmonics. Types of AC filters, Design of Single tuned filters –Design of High pass filters.

Text Books:

1. HVDC Power Transmission Systems: Technology and system Interactions – by K.R.Padiyar, New Age International (P) Limited, and Publishers.
2. Direct Current Transmission–by E.W.Kimbark,JohnWiley&Sons.
3. EHVAC Transmission Engineering by R. D. Begamudre, New Age International (p)Ltd.

Reference Books:

1. EHV AC and HVDC Transmission Engineering and Practice–Sunil S. Rao.
2. Power Transmission by Direct Current–by E.Uhlmann,B.S.Publications
3. HVDC Transmission–J.Arrillaga.

Online Learning Resources:

1. https://nptel.ac.in/courses/108104013
2. https://nptel.ac.in/courses/108108099

IV Year–I Semester	PROGRAMMABLE LOGIC CONTROLLERS (PE-IV: V231410242)	L	T	P	C
		3	0	0	3

Pre-requisite: Boolean algebra and Basic of Microprocessor.

Course Outcomes:

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

1. Illustrate I/O modules of PLC systems and Input/output devices.
2. Demonstrate various the programming instructions and ladder diagram construction in the PLC.
3. Examine various types of PLC functions and counters and their applications.
4. Assess different data handling functions and its applications.
5. Describe the analog operations and PID modules.

UNIT–I

PLC Basics:

PLC Advantages and disadvantages – Overall PLC system – Central Processing Unit - I/O modules Power supplies- programming Equipment - programming formats - construction of PLC ladder diagrams – Input On/Off Switching Devices – Input Analog Devices -Output On/Off Switching Devices – Output Analog Devices.

UNIT– II

PLC Programming:

PLC Input instructions - outputs - operational procedures - programming examples using contacts and coils - Drill press operation. Digital logic gates - Boolean algebra PLC programming - conversion examples- Ladder diagrams and sequence listings - ladder diagram construction and flowchart for spray process system.

UNIT– III

Basic and Intermediate PLC Functions:

GeneralCharacteristicsofRegisters-moduleaddressing-holdingregisters-InputRegisters - Output Registers. PLC Timer functions & Industrial applications - counters –counter function industrial applications -Arithmetic functions -Number comparison functions - number conversion functions.

UNIT– IV

Data Handling functions:

SKIP - Master control Relay - Jump - Move -FIFO - FAL - ONS - CLR & Sweep functions and their applications. Bit Pattern and changing a bit shift register - sequence functions and applications - controlling of two-axis& three axis Robots with PLC- Matrix functions.

UNIT–V

Analog PLC operation:

Analog modules & systems -Analog signal processing -Multi bit Data Processing -Analog output Application Examples -PID principles -position indicator with PID control -PID Modules -PID tuning -PID functions.

Textbooks:

1. Programmable Logic Controllers- Principles and Applications by John W. Webb & Ronald A. Reiss -Fifth Edition -PHI
2. Programmable Logic Controllers-Programming Method and Applications– JR.Hack worth &F.D Hackworth Jr. –Pearson -2004

Reference Books:

1. Introduction to Programmable Logic Controllers- Gary A. Dunning- 3rdedition -Cengage Learning -2005.
2. ProgrammableLogicControllers–W.Bolton-5thEdition-Elsevierpublisher -2009.

Online Learning Resources:

1. https://nptel.ac.in/courses/108105062
2. https://nptel.ac.in/courses/108105063

IV Year–I Semester	ELECTRICAL DISTRIBUTION SYSTEM (PE-IV: V231410243)	L	T	P	C
		3	0	0	3

Pre-requisite: Basic concepts of Electric circuits and power systems.

Course Outcomes:

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

1. Discriminate various factors of distribution system-load modelling and characteristic of loads.
2. Know the concept of design considerations of substation and feeders.
3. Determine the voltage drop and power loss for different types of distribution loads.
4. Analyse the protection and its coordination for distribution systems.
5. Analyse the effect of compensation for p.f improvement and voltage improvement.

UNIT-I

General Concepts

Introduction to distribution systems - Distribution system losses – Coincidence factor – Contribution factor – loss factor – Relationship between the load factor and loss factor – Numerical Problems– Load modeling and characteristics– Classification and characteristics of loads (Residential -Commercial -Agricultural and Industrial).

UNIT-II

Substations

Selection for location of substations **-** Rating of distribution substation – Service area with 'n' primary feeders – Benefits and methods of optimal location of substations.

Distribution Feeders

Design Considerations of distribution feeders**:** Radial and loop types of primary feeders– Voltage levels – Feeder loading – Basic design practice of the secondary distribution system.

UNIT-III

System Analysis

Voltage drop and power loss calculations**:** Derivation for voltage drop and power loss in lines– Uniformly distributed loads and non-uniformly distributed loads – Three phase balanced primary lines and Non three phase balanced primary lines.

UNIT-IV

Protection

Objectives of distribution system protection –Time current characteristics – Protective devices**:** Principle of operation of fuses – Circuit reclosures – Line sectionaliser and circuit breakers - Earth leakage circuit breakers – Protection schemes of parallel & Ring-main feeders.

Coordination of protective devices

General coordination procedure–Various types of co-ordinate operation of protective devices -Residual Current Circuit Breaker.

UNIT-V

Compensation for Power Factor Improvement

Capacitive compensation for power factor control –Different types of power capacitors– shunt and series capacitors – Effect of shunt capacitors (Fixed and switched) – Power factor correction – Capacitor allocation – Economic justification – Procedure to determine the best capacitor location.

Voltage Control

Equipment for voltage control – Effect of series capacitors – Effect of AVB/AVR – Line drop compensation.

Text Book:

1. "Electric Power Distribution system-Engineering"–by Turan Gonen-McGraw–hill - 2nd edition -2008.

Reference Books:

1. Electrical Distribution Systems by Dale R.Patrick and Stephen W.Fardo- CRC press - 2nd edition.
2. Electric Power Distribution – by A.S. Pabla - Tata McGraw–hill Publishing Company - 4th edition -1997.
3. Electrical Power Distribution Systems by V.Kamaraju-Right Publishers.

Online Learning Resources:

1. https://nptel.ac.in/courses/108107112
2. https://www.mooc-list.com/tags/electrical-distribution

IV Year–I Semester	ELECTRIC VEHICLES (PE-V: V231410245)	L	T	P	C
		3	0	0	3

Pre-requisite: Basics of Electrical Machines and Electronics

Course Outcomes:

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

1. Know the concept of electric vehicles and hybrid electric vehicles.
2. Familiar with different configuration of hybrid electric vehicles.
3. Choose an effective motor for EV and HEV application
4. Underst and the power converters used in hybrid electric vehicles
5. Know different batteries and other energy storage systems.

UNIT-I

Introduction

Fundamentals of vehicle -components of conventional vehicle and propulsion load; Drive cycles and drive terrain; Concept of electric vehicle and hybrid electric vehicle; History of hybrid vehicles -advantages and applications of Electric and Hybrid Electric Vehicles.

UNIT-II

Hybridization of Automobile

Architectures of HEVs - series and parallel HEVs - complex HEVs. Plug-in hybrid vehicle (PHEV) -constituents of PHEV -comparison of HEV and PHEV; Extended range hybrid electric vehicles (EREVs) -blended PHEVs -Fuel Cell vehicles and its constituents.

UNIT-III

Special Machines for EVand HEVs

Characteristics of traction drive - requirement of electric motors for EV/HEVs. Induction Motor drives - their control and applications in EV/HEVs. Permanent magnet Synchronous motor: configuration - control and applications in EV/HEVs. Brushless DC Motors: Advantages-control of application in EV/HEVs. Switch reluctance motors: Merits limitations
-converter configuration-control of SRM for EV/HEVs.

UNIT-IV

Power Electronics in HEVs

Boost and Buck-Boost converters -Multi Quadrant DC-DC converters -DC-AC Inverter for EV and HEV applications -Three Phase DC-AC inverters -Voltage control of DC-AC inverters using PWM -EV and PHEV battery chargers.

UNIT-V

Energy Sources for HEVs

Energy Storage - Battery based energy storage and simplified models of battery - fuel cells - their characteristics and simplified models -super capacitor based energy storage -its analysis and simplified models -flywheels and their modeling for energy storage in EV/HEV - Hybridization of various energy storage devices.

Text Books

1. AliEmadi-AdvancedElectricDriveVehicles-CRCPress-2014.
2. Iqbal Hussein -Electric and Hybrid Vehicles: Design Fundamentals -CRC Press - 2003.

Reference Books:

1. Mehrdad Ehsani -YimiGao -Sebastian E. Gay -Ali Emadi -Modern Electric - Hybrid Electric and Fuel Cell Vehicles: Fundamentals -Theory and Design -CRC Press - 2004.
2. James Larminie -John Lowry -Electric Vehicle Technology Explained -Wiley - 2003.
3. H.Partab:ModernElectricTraction-DhanpatRai&Co-2007.
4. Pistooa G. -"Power Sources-Models -Sustainability -Infrastructure and the market" - Elsevier 2008
5. Mi Chris -Masrur A. -and Gao D.W. -" Hybrid Electric Vehicle: Principles and Applications with Practical Perspectives" 1995.

Online Learning Resources:

1. https://nptel.ac.in/courses/108106182
2. https://nptel.ac.in/courses/108102121

IV Year–I Semester	SWITCHED MODE POWER CONVERSION (PE-V: V231410246)	L	T	P	C
		3	0	0	3

Pre-requisite: Power electronics, Control Systems.

Course Outcomes:

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

1. Design and analyse the operation of non-isolated switch mode converters.
2. Analyze the operation of isolated switch mode converters.
3. Illustrate the operation of resonant converters.
4. Analyse the control schemes of converters and design transformer and inductor.
5. Model the converters and design controller for closed loop operation.

UNIT–I

Non-Isolated Switch Mode Converters

Control of DC-DC converters: Buck converters - Boost converters - Buck-Boost converter – CUK Converter- continuousanddiscontinuousoperation-Converterrealizationwithnon-ideal components.

UNIT– II

Isolated Switched Mode Converters

Forwarded converter – fly back converter - push-pull converter - half-bridge converter - full bridge converter.

UNIT– III

Resonant Converters

Basic resonant circuit concepts - series resonant circuits - parallel resonant circuits - zero current switching quasi-resonant buck converter - zero current switching quasi-resonant boost converter - zero voltage switching quasi-resonant buck converter - zero voltage switching quasi-resonant boost converter.

UNIT– IV

Control Schemes of Converters and Magnetic Design

Voltage mode control-Current mode control-Current control mode instability.

Magnetic Design: Transformer design-inductor and capacitor design.

UNIT–V

Modelling of Converters and Controller Design Based on Linearization:

Formulation of large signal models for buck and boost converters using state space analysis-derivation of averaged large signal model using circuit averaging method-small signal model derivation- average switch modelling technique to obtain small signal models of buck and boost converters- Transfer function of converters-Controller design based on linearization.

Text Books:

1. Fundamentals of Power Electronics-Erickson-Robert W.-Maksimovic- Dragan - Springer -2011.
2. Power switching converters- Simon Ang - Alejandro Oliva - CRC Press - 2010.
3. PowerElectronics:Essentials&Applications-L.Umanand,S.P.Bhat,John .Wiley&SonsAustralia,1992

Reference Books:

1. Switching Power Supply Design- Abraham I. Pressman - McGraw-Hill Ryerson - Limited - 1991.
2. Power Electronics: converters Applications & Design–Mohan-Undeland-Robbins-Wiley publications.
3. Design of Magnetic Components for Switched Mode Power Converters-Z Umanand - S.P. Bhat -John Wiley & Sons Australia -1992.
4. Elements of Power Electronics–PhilipT.Krein-OxfordUniversity press- 2014.

Online Learning Resources:

1. https://nptel.ac.in/courses/108108036
2. https://nptel.ac.in/courses/108105180

IV Year–I Semester	DESIGN OF PV SYSTEMS (PE-V: V231410247)	L	T	P	C
		3	0	0	3

Prerequisites: Basic knowledge of electrical circuits, power systems, and renewable energy fundamentals.

Course Outcomes:

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

1. Analyze solar radiation data and evaluate site conditions for PV applications.
2. Explain the operation and characteristics of various types of PV cells and modules.
3. Identify and select appropriate components for different PV system configurations.
4. Design and sizes and alone, hybrid, and grid-tied PV systems using analytical and simulation tools.
5. Apply standards and practices for the installation, testing, maintenance, and economic evaluation of PV systems.

UNIT1: Solar Energy Basics:

Solar radiation – Extraterrestrial and terrestrial, Solar geometry – Declination, altitude angle, hour angle, air mass Radiation measurement and estimation, Effect of tilt angle on radiation, Overview of solar energy conversion technologies, Introduction to PV effect and materials used

UNIT2: Solar Photovoltaic Cell Technologies

Types of solar cells: Crystalline silicon, thin-film, multi-junction, emerging technologies, Cell structure and working principle, I-V characteristics of solar cells – Effect of irradiance and temperature, Efficiency, fill factor, and performance parameters, Maximum Power Point Tracking (MPPT) – Algorithms and techniques

UNIT3: PV Module and System Components

PV module characteristics and rating, Module interconnections – Series and parallel configurations, Balance of System (BoS): Batteries, charge controllers, inverters, protection devices PV system configurations: Standalone, grid-connected, hybrid Energy storage options– Battery types and characteristics

UNIT4: PV System Design

Load estimation and energy requirement analysis-Sizing of PV array, battery bank, and inverter-Shadow analysis and tilt optimization -Wiring, cabling, earthing, and protection design-Simulation tools (e.g., PV syst, HOMER, SAM) – Basic introduction

UNIT5:Installation, Operation & Maintenance

Installation guidelines and standards (e.g., MNRE, IEC codes)-Testing, Commissioning, and troubleshooting of PV systems Maintenance strategies and fault diagnostics-Performance evaluation and economic analysis (Payback period, LCOE)-Environmental and safety considerations

Text Books

1. Chetan Singh Solanki,'Solar Photo voltaics: Fundamentals, Technologies and Applications', PHI Learning, 3rd Edition (or latest).
2. James P. Dunlop, 'Photo voltaic Systems', American Technical Publishers.

Reference Books

1. Mohanlal Kolhe, Pradip Bansal, T. K. Mallick, 'Design and Installation of Photovoltaic Systems', Springer.
2. JohnA.DuffieandWilliamA.Beckman,'SolarEngineeringofThermalProcesses', Wiley.
3. B.H.Khan, 'Renewable Energy Systems',Mc Graw Hill Education.
4. S.P.Sukhatme and J.K.Nayak,' Solar Energy: Principles of Thermal Collection and Storage', Tata McGraw Hill.

IV Year–I Semester	BATTERY MANAGEMENT SYSTEMS AND CHARGING STATIONS (Open Elective-III- V231410251)	L	T	P	C
		3	0	0	3

Pre-requisite: Electric Circuits and Power Electronics

Course Outcomes

After the completion of the course, the students should be able to:

1. Describe the construction and operation of different batteries for EV applications.
2. Describe charging algorithms of different batteries and balancing methods of battery packs.
3. Describe the different kinds of infrastructure needed in the charging stations.
4. Describe the requirements of battery management and their maintenance; obtain the modelling of batteries and develop their simulation models.
5. 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, 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.

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.

Textbooks

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. NPTEL Course – Battery Management Systems
2. NPTEL Video Lecture – L65

IV Year–I Semester	CONCEPTS OFSMART GRID TECHNOLOGIES (Open Elective-III- V231410252)	L	T	P	C
		3	0	0	3

Pre-requisite: Power Systems, Renewable Energy Technologies

Course Outcomes:

After the completion of the course, the students should be able to:

1. Know the concepts of smart grids and analyse the smart grid policies and developments in smart grids.
2. Develop concepts of smart grid technologies in hybrid electrical vehicles etc.
3. Know the concepts of smart substations, feeder automation, Battery Energy Storage Systems, etc.
4. Analyse microgrids and distributed generation systems.
5. Analyse the effect of power quality in smart grid and understand the 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 micro grid - formation of micro grid - Issues of interconnection - protection & control of microgram - 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).

Textbooks:

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. 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 - Nouredine Hadjsaïd - 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 - 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. McGranaghan - Surya Santoso - H. Wayne Beaty - McGraw Hill Publication - 2nd Edition.

Online Learning Resources:

1. NPTEL – Smart Grid Course
2. TU Delft – Smart Grids: The Basics

IV Year–I Semester	CONCEPTS OF POWER QUALITY (Open Elective-IV- V231410253)	L	T	P	C
		3	0	0	3

Pre-requisite: Concepts of Power Systems

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

1. Differentiate between different types of power quality problems.
2. Explain the sources of voltage sag, voltage swell, interruptions, transients, long-duration over voltages, and harmonics in a power system.
3. Explain the principle of voltage regulation and improvement methods.
4. Analyse voltage distortion and current distortion and their indices.
5. 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 Overvoltage protection – Devices for Overvoltage 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. and Beaty 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. H. J. - 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 Nostrand Reinhold - New York.
4. Power Quality - C. Shankaran - CRC Press - 2001.
5. Harmonics and Power Systems - Francisco C. De La Rosa - CRC Press (Taylor & Francis).
6. Power Quality in Power Systems and Electrical Machines - Ewald F. Fuchs and Mohammad A. S. Masoum - Elsevier.

Online Learning Resources:

1. NPTEL – Power Quality Course
2. NPTEL – Power Quality Course

IV Year–I Semester	QUANTUM SCIENCE AND TECHNOLOGY (Open Elective-IV- V231410254)	L	T	P	C
		3	0	0	3

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

Course Outcomes:

After completing this course, students will be able to:

1. Explain core principles of quantum mechanics and their technological implications.
2. Analyze quantum phenomena like superposition and entanglement.
3. Apply mathematical tools to model and solve quantum systems.
4. Demonstrate understanding of quantum algorithms and quantum circuits.
5. 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; Eigen values, eigen functions.

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,andShor's9-qubitcode;Introductiontoquantumprogramming: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, grapheme, 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

IV Year–I Semester	POWER SYSTEMS SIMULATION LAB (V231410261)	L	T	P	C
		0	0	4	2

Pre-requisite: Power System Analysis, Operation and Control.

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

1. Distinguish between different load flow methods.
2. Build and analyze Y-Bus & Z-Bus algorithms.
3. Practice and analyze the symmetrical & unsymmetrical faults.
4. Recognize the importance of Load Flow Control and Economic Load Dispatch.
5. Recognize the importance of Economic Load Dispatch and Transient Stability Analysis.

List of Experiments

Any 10 of the following experiments are to be conducted

1. Formation of Y-Bus by Direct-Inspection Method.
2. Load Flow Solution Using Gauss-Seidel Method.
3. Load Flow Solution Using Newton-Raphson Method.
4. Load Flow Solution Using Decoupled Method.
5. Load Flow Solution Using Fast Decoupled Method.
6. Formation of Z-Bus by Z-Bus Building Algorithm.
7. Symmetrical Fault Analysis Using Z-Bus.
8. Unsymmetrical Fault Analysis Using Z-Bus.
9. Economic Load Dispatch with & without Transmission Losses.
10. Transient Stability Analysis Using Point-by-Point Method.
11. Load Frequency Control of Single Area Control & Two Area Control System with and without Controllers.

IV Year–I Semester	12 WEEKS MOOCS SWAYAM/NPTEL COURSE RECOMMENDED BY THE BOS	L	T	P	C
		3	0	0	3

A Student has to pursue and complete one course compulsorily through MOOCs approved by the BOS Members. A student can pursue courses other than core through MOOCs and it is mandatory to complete one course successfully through MOOCs for awarding the degree. A student is not permitted to register and pursue core courses through MOOCs.

A student shall register for the course (Minimum of 12 weeks) offered through MOOCs with the approval of Head of the Department. The Head of the Department shall appoint one mentor to monitor the student's progression. The student needs to earn a certificate by passing the exam. The student shall be awarded the credits assigned in the curriculum only by submission of the certificate. Examination fee, if any, will be borne by the student.

Students who have qualified in the proctored examinations conducted through MOOCs platform can apply for credit transfer as specified and are exempted from appearing internal as well as external examination

12 WEEKS MOOCS SWAYAM/NPTEL COURSE RECOMMENDED BY THE BOS

1. Introduction to Internet of Things
2. Artificial Intelligence: Foundations and Algorithms
3. Introduction to Industry 4.0 and Industrial Internet of Things.
4. Software Engineering
5. Artificial Intelligence: Concepts and Techniques.
6. Machine Learning and Deep learning - Fundamentals and Applications.
7. Fundamentals of Artificial Intelligence.

Title: Note on MOOC Courses

The list of MOOC courses offered through **SWAYAM/NPTEL** has been provided by the **Director of Academics, JNTUK**, and the same courses have been recommended and approved by the **Board of Studies (BOS)**. The list of courses is enclosed at the end of the syllabus.

IV Year–I Semester	CONSTITUTION OF INDIA (Audit Course: V2314102C1)	L	T	P	C
		2	0	0	--

Course Outcomes

After the completion of the course, the students should be able to:

1. **CO1:** Explain the historical background, drafting process, philosophy, salient features, and significance of the Indian Constitution.
2. **CO2:** Identify and explain the Fundamental Rights, Directive Principles of State Policy, and Fundamental Duties enshrined in the Indian Constitution.
3. **CO3:** Describe the composition, powers, functions, and roles of the Legislature, Executive, and Judiciary in the Indian system of governance.
4. **CO4:** Explain the structure and functioning of local administration, Panchayati Raj Institutions, municipalities, and the importance of grassroots democracy.
5. **CO5:** Analyze the role and functioning of the Election Commission, State Election Commission, and constitutional/statutory bodies working for the welfare of SCs, STs, OBCs, and women.

UNIT–I:
History of Making of the Indian Constitution: History, Drafting Committee, (Composition & Working), Philosophy of the Indian Constitution- Preamble, Salient, Features
UNIT–II:
Contours of Constitutional Rights & Duties: Fundamental Rights, Right to Equality, Rightto Freedom, right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.
UNIT–III:
Organs of Governance: Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive- President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions
UNIT–IV:
Local Administration: District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative CEO of Municipal Corporation, Pachayati raj: Introduction, PRI: Zila Pachayat, Elected officials and their roles, CEO ZilaPachayat: Position and role, Block level: Organizational Hierarchy (Different departments),Village level: Role of Elected and Appointed officials, Importance of grass root democracy
UNIT–V:
Election Commission: Election Commission: Role and Functioning, Chief Election Commissioner and Election Commissioners, State Election Commission: Role and Functioning, Institute and Bodies for the welfare of SC/ST/OBC and women.

Text Books:
1. The Constitution of India, 1st Edition, (Bare Act), Government Publication, 1950
2. Framing of Indian Constitution, 1st Edition, Dr. S. N. Busi, Dr. B. R. Ambedkar, 2015
Reference Books:
1. Indian Constitution Law, 7th Edition, M. P. Jain, Lexis Nexis, 2014.

IV Year –I SEMESTER	EVALUATION OF INDUSTRY INTERNSHIP (V231410181)	L	T	P	C
		-	-	-	2

IV Year–II SEMESTER	INTERNSHIP AND PROJECT (V2314202A1)	L	T	P	C
		-	-	24	12

11. Massive Open Online Courses (MOOCs):

A Student has to pursue and complete one course compulsorily through MOOCs approved by the University. A student can pursue courses other than core through MOOCs and it is mandatory to complete one course successfully through MOOCs for awarding the degree. A student is not permitted to register and pursue core courses through MOOCs.

A student shall register for the course (Minimum of either 8 weeks or 12 weeks) offered through MOOCs with the approval of Head of the Department. The Head of the Department shall appoint one mentor to monitor the student's progression. The student needs to earn a certificate by passing the exam. The student shall be awarded the credits assigned in the curriculum only by submission of the certificate. Examination fee, if any, will be borne by the student.

Students who have qualified in the proctored examinations conducted through MOOCs platform can apply for credit transfer as specified and are exempted from appearing internal as well as external examination (for the specified equivalent credit course only) conducted by the university.

W.r.t. the above, following is the suggested SWAYAM / NPTEL MOOC Courses to pursue, III B.Tech I Sem and onwards (*under Program Electives / Open Electives*), under R23 regulations. While allocating SWAYAM/NPTEL MOOC courses, the HoD/Coordinator should ensure due diligence to avoid any overlap/duplication with regular curriculum courses, including Minor and Honors programmes:

B.Tech *Civil Engineering*

1. Energy Efficiency, Acoustics and Daylighting in Building
2. Applied Seismology for Engineers
3. Structural Dynamics for Civil Engineers
4. Free Surface Flows
5. Industrial Wastewater treatment
6. Retrofitting and Rehabilitation of Civil Infrastructure
7. Soil Structure Interaction
8. Urban Transportation Systems Planning
9. Soil Dynamics
10. Geosynthetics and Reinforced Soil Structures
11. Structural Dynamics
12. Analysis and Design of Bituminous pavements
13. Air pollution and Control
14. Rock Engineering
15. Smart Cities
16. *Municipal Solid Waste Management*

17. *Indoor Air Pollution Control: Sources Effects, Monitoring, Control and Modelling*
18. *Introduction to Multimodal Urban Transportation Systems*
19. *Integrated Waste Management for Smart Cities*
20. *Introduction to Engineering Seismology*
21. *Pavement Materials (Under Pavement Engineering)*
22. *Wastewater Treatment and Recycling*
23. *Subsurface Exploration: Importance and Techniques Involved*
24. *Municipal Solid Waste Management*
25. *Sustainable Materials and Green Buildings*
26. *Ground Improvement*
27. *Natural Resource Management*
28. *Introduction to Machine Learning*
29. *Explosions and safety*
30. *Sustainable Energy Technology*
31. *Disaster Recovery and build back better*
32. *Building Energy systems and auditing*

B.Tech *Electrical and Electronics Engineering*

1. Fundamentals of Semiconductor Devices (Offered by, IISc., Bangalore)
2. EV – Vehicle Dynamics and Electric Motor Drives (IIT Delhi)
3. Semiconductor Device Modeling and Simulation (IIT Kharagpur)
4. State Space Approach to Control System Analysis and Design (IIT Madras)
5. Smart Grid: Basics to Advanced Technologies (IIT Roorkee)
6. Electric Vehicle: Its Components, Charging Infrastructure and Grid Integration Solution
7. *Electronic Systems Design: Hands-on Circuits and PCB design with CAD software*
8. *Fundamentals of Solar Photovoltaics and Technologies*
9. *Line Commutated and PWM Rectifiers*
10. *Machine Learning and Deep learning - Fundamentals and Applications*
11. *Microelectronics: Devices to Circuits*
12. *Introduction to wireless and cellular communication*
13. *Semiconductor devices to sensors*
14. *Fundamentals of solar photovoltaics and Technologies*
15. *Charging infrastructure*
16. *Design of photovoltaic system*
17. *Machine learning and deep learning*

B.Tech *Mechanical Engineering*

1. Dynamics and Control of Mechanical Systems (Course No. as per NPTEL 721)
2. Fundamentals of Compressible Flow (738)
3. Advanced Robotics (752)
4. Elements of Solar Energy Conversion (760)
5. Failure Analysis and Prevention (794)
6. Industrial Hydraulics and Automation (769)
7. Introduction to Mechanical Micro Machining

B.Tech *Electronics and Communication Engineering*

1. Digital Communication using GNU Radio
2. Computer Vision and Image Processing - Fundamentals and Applications
3. Fuzzy Sets, Logic and Systems & Applications
4. Embedded Sensing, Actuation and Interfacing Systems
5. Biomedical Signal Processing
6. Spread Spectrum Communications and Jamming
7. Multirate DSP
8. Optical Wireless Communications for Beyond 5G Networks and IoT
9. Physics of Nanoscale Devices
10. VLSI Physical Design with Timing Analysis

B.Tech (CSE, IT, Allied, Emerging and Computer Science and Design)

1. Advanced Computer Networks
2. Artificial Intelligence: Knowledge Representation and Reasoning
3. Cloud Computing
4. Cryptography and Network Security
5. Data Analytics with Python
6. Deep Learning
7. Computer Networks and Internet Protocols
8. Advanced R Programming for Data Analytics in Business
9. Introduction to game theory and mechanism design
10. Distributed optimization and mission learning
11. Advanced distributed systems
12. Multi core computer architecture
13. Introduction to Blockchain technologies and its applications
14. Foundation of cloud IoT edge ML
15. Human Computer Interaction (*for other than CSD*)
16. Mathematics for Machine Learning
17. Essential Mathematics for Machine Learning
18. Business Analytics and Text Mining Modeling using Python
19. Social Network Analysis
20. Privacy and Security in Online Social Media
21. Responsible and Safe AI Systems
22. Introduction to Large Language Models (LLMs)
23. Artificial Intelligence: Search methods for problem solving
24. Practical Cyber Security for Cyber Security Practitioners
25. Design and implementation of Human-Computer Interfaces.
26. Introduction to Industrial 4.0 and Industrial IoT.
27. Computer Vision
28. Foundation for Virtual and Augmented Reality Systems
29. *Applied Accelerated Artificial Intelligence*
30. *Advanced Distributed Systems*
31. *Advanced R Programming for Data Analytics in Business*
32. *Artificial Intelligence: Concepts and Techniques*
33. *Artificial Intelligence: Search Methods for Problem Solving*
34. *Computer Vision*

35. *Cyber Security and Privacy*
36. *Deep Learning for Computer Vision*
37. *Ethical Hacking*
38. *Generative AI for Computer Vision*

The following **SWAYAM / NPTEL MOOC** courses may be utilized by students of branches such as Agricultural Engineering, Mining Engineering, Automobile Engineering, etc., under Open Electives–III or IV. **Students from any engineering branch may opt for these courses, ensuring that there is no duplication in course selection**.

1. Artificial Intelligence (AI) for Management
2. Operations Management
3. International Human Resource Management
4. AI in Human Resource Management
5. Business Fundamentals for Entrepreneurs
6. Quantum Computation and Quantum Information (by IISER)
7. Quantum Mechanics I
8. Introduction to Environmental Engineering and Science - Fundamental and Sustainability Concepts
9. Entrepreneurship Essentials
10. Non-conventional Energy Resources
11. Introduction to Indian Psychology
12. Energy Resources, Economics and Environment
13. *Artificial Intelligence: Foundations and Algorithms*
14. *Computer Architecture and Organization*
15. *Cyber Security and Privacy*
16. *Foundations of Machine Learning*
17. *Ethical Hacking*
18. *Introduction to Internet of Things*
19. *Introduction to Algorithms and Analysis*
20. *Operating System Fundamentals*
21. *Human Resource Development*
22. *Understanding Incubation and Entrepreneurship*
23. *Introduction to Semiconductor Devices*
24. *Dairy and Food Process and Products Technology*
25. *Energy Conservation and Waste Heat Recovery*

Director, Academics