Minor Stream Courses: Intelligent and Integrated Power Systems

Course Code	Course Name	Level	L	T	P	C	CIE	SEE	Total	Pre-requisite
241EE022	Electrical Machine Design	FC	2	1		3	50	50	100	-
241EE027	Utilization of Electrical Energy	FC	3			3	50	50	100	DCMT
241EE024	Electrical Distribution System	IC	3			3	50	50	100	EPGDS
241EE026	HVDC Transmission	IC	3			3	50	50	100	PE
241EE030	Methods & Algorithms for Intelligent Control	IC	3			3	50	50	100	-
241EE023	High Voltage Engineering	IC	3			3	50	50	100	EPTS
241EE028	Restructured Power Systems	AC	3			3	50	50	100	EPTS
241EE031	Advance Control Systems	AC	2	1		3	50	50	100	CE
241EE032	Concept of Smart Grid Technology	AC	2			2	50	50	100	PSA
241EE025	Flexible Alternating Current Transmission Systems	AC	3			3	50	50	100	PE
241EE029	Soft Computing Techniques in Power Systems	AC	2		1	3	50	50	100	PSA
	Total		**29**	**2**	**1**	**32**				

Minor Stream Courses: Power Electronics and Energy Systems

Course Code	Course Name	Level	L	T	P	C	CIE	SEE	Total	Pre-requisite
241EE022	Electrical Machine Design	FC	2	**1**		3	50	50	100	-
241EE034	Alternative Energy Sources	FC	3			3	50	50	100	-
241EE027	Utilization of Electrical Energy	FC	3			3	50	50	100	DCMT
241EE035	Special Electrical Machines	IC	3			3	50	50	100	ISM
241EE036	Electric Energy Storage Systems	IC	3			3	50	50	100	AES
241EE038	Digital Control Systems	AC	2	1		3	50	50	100	CE
241EE015	Switch Gear & Protection	AC	3			3	50	50	100	EPTS
241EE033	Energy Audit, Conservation & Management	AC	3			3	50	50	100	EPGDS
241EE032	Concept of Smart Grid Technology	AC	2			2	50	50	100	PSA
241EE040	Power Quality	AC	3			3	50	50	100	EPGDS
241EE037	Hybrid Electric Vehicles	AC	3			3	50	50	100	PE
	Total		**29**	**2**		**32**				

Minor Stream Courses: Advanced Specialization on Electric Vehicles (Industry Integrated Program- L & T)

Course Code	Course Name	Level	L	T	P	C	CIE	SEE	Total	Pre-requisite
241EE043	Electrical safety	FC	3			3	50	50	100	-
241EE047	Finance for Professionals	FC	3			3	50	50	100	
241EE041	Foundations of EV & Hybrid Vehicles	FC	3			3	50	50	100	PE
241EE035	Special Electrical Machines	IC	3			3	50	50	100	ISM
241EE044	EV Power Electronics & Embedded Systems	IC	3			3	50	50	100	EVBT
241EE042	EV Battery Technology & Power train Development	IC	3			3	50	50	100	PE
241EE045	EV Design & Analysis	IC	3			3	50	50	100	
241EE033	Energy Audit, Conservation & Management	AC	3			3	50	50	100	EPGDS
241ME043	EV Charging Infrastructure, Vehicle Testing & Homologation	AC	3			3	50	50	100	-
241EE046	EV PCB Design & Data Analytics	AC	3			3	50	50	100	
241EE032	Concept of Smart Grid Technology	AC	2			2	50	50	100	PSA
	Total		**32**			**32**				

Minor Stream Courses: Design of Electrical System for Smart Buildings (Industry Integrated Program- L & T)

Course Code	Course Name	Level	L	T	P	C	CIE	SEE	Total	Pre-requisite
241EE043	Electrical safety	FC	3			3	50	50	100	-
241EE047	Finance for Professionals	FC	3			3	50	50	100	
241EC065	Applied Industrial IoT	FC	3			3	50	50	100	IOT
241EE048	Electrical Power Distribution & Automation	IC	3			3	50	50	100	EPGDS
241EE035	Special Electrical Machines	IC	3			3	50	50	100	ISM
241EE049	Integrated Approach to Building Services	IC	3			3	50	50	100	-
241EE033	Energy Audit, Conservation & Management	AC	3			3	50	50	100	EPGDS
241EE050	Building Information Modelling	AC	3			3	50	50	100	-
241EE051	Advanced Electrical System Design for Builders	AC	3			3	50	50	100	
241EE052	Extra Low Voltage System Design for Buildings	AC	3			3	50	50	100	
241EE032	Concept of Smart Grid Technology	AC	2			2	50	50	100	PSA
	Total		**32**			**32**				

#Syllabus for the industry partner courses will be released in the department as and when required.

Electrical Machine Design

	L	T	P	C
Course Code:241EE022	**3**	**0**	**0**	**3**

Course Outcomes:

At the end of the course, student will be able to:

CO1 Classify the materials used for construction of electrical machines.
CO2: Assess the overall dimensions of transformer.
CO3: Examine the design, performance of transformer.
CO4: Develop the overall dimensions of a rotating machine.
CO5: Analyze the design & performance of rotating machines.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	2	1	-	-	-	-	-	-	-	-
CO2	2	3	2	-	-	-	-	-	-	-	-
CO3	3	2	2	-	-	-	-	-	-	-	-
CO4	2	3	2	-	-	-	-	-	-	-	-
CO5	3	2	2	-	-	-	-	-	-	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	1	1
CO2	2	1
CO3	2	1
CO4	2	1
CO5	2	1

UNIT – I

Fundamental Aspects of Electrical Machine Design

Design of machines - design factors - limitation in design - modern trends in electrical machine design – types of magnetic, electric & insulating materials – modes of heat dissipation – cooling of rotating machines – methods of cooling.

UNIT – II

Design of Transformers

Transformer windings – output equation – design of main dimensions-– design of core - choice of flux density – determination of number of turns & length of mean term - resistance & leakage reactance – no load current calculation –cooling of transformers-calculation of number of tubes.

UNIT -III

Design of DC Machines

Output equation –selection of specific magnetic & electric loadings - separation of D & L – estimation of number of conductors, armature slots & conduct dimensions – choice of number of poles & calculation of length of airgap – design of field systems, interpoles & brushes.

UNIT - IV

Design of Induction motors

Output equation -main dimensions – choice of average flux density & ampere conduction for meter — design of stator slots & rotor slots- design of rotor bars end rings– design of wound rotor –calculation of no-load current.

UNIT - V

Design of Synchronous Machines

Types of construction – output equation - main dimensions – short circuit ratio & its effects on the performance – design of rotor –Design of field winding – Design of turbo alternators – Rotor design temperature rise & its effects.

Text Books:

1	A Course in Electrical Machines Design by A.K.Sawhney, Dhan path Rai & Co (ISBN: 9788177001013).
2	The Performance & Design of Direct Current Machines by AE Clayton & NN Hancock, CBS Publishers (ISBN-13: 9788123909271).

Reference Books:

1	Performance & Design of A.C. Machines by M.G. Say, ELBS & Pitman & Sons, 4th edition (ISBN:9788123910277).
2	Principles of Electrical Machine Design with computer programmes by S. K. Sen, Oxford & IBH Company Pvt. Ltd. New Delhi (ISBN:9788120415218).

Web Links:

1. https://cusp.umn.edu/electric-machine-design-videos
2. https://nptel.ac.in/courses/108102146
3. https://nptel.ac.in/courses/108/105/108105017

High Voltage Engineering

	L	T	P	C
Course Code:241EE023	**3**	**0**	**0**	**3**

Course Outcomes:

At the end of the course, student will be able to:

CO1	Recognise the dielectric properties of gaseous materials used in HV equipment.
CO2	Differentiate the break down phenomenon in liquid & solid dielectric materials.
CO3	Acquaint with the techniques of generation of high AC & DC voltages.
CO4	Acquaint with the techniques of generation of high Impulse voltages & currents.
CO5	Getting the knowledge of measurement of high AC - DC - Impulse voltages & current.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	2	1	-	-	-	-	-	-	-	-
CO2	2	3	1	-	-	-	-	-	-	-	-
CO3	3	2	2	-	-	-	-	-	-	-	-
CO4	3	2	1	-	-	-	-	-	-	-	-
CO5	3	2	2	-	-	-	-	-	-	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	-	1
CO2	-	1
CO3	-	1
CO4	-	1
CO5	-	1

UNIT – I

Break down phenomenon in Gaseous: Insulating Materials: Types - applications & properties. Gases as insulating media – Collision process – Ionization process – Townsend's criteria of breakdown in gases & its limitations – Streamers Theory of break down – Paschen's law- Paschen's curve.

UNIT – II

Break down phenomenon in Liquids: Liquid as Insulator – Pure & commercial liquids – Breakdown in pure & commercial liquids. Break down phenomenon in Solids: Intrinsic breakdown – Electromechanical breakdown – Thermal breakdown –Breakdown of composite solid dielectrics.

UNIT – III

Generation of High DC voltages: Voltage Doubler Circuit - Voltage Multiplier Circuit – V&e- Graaff Generator. Generation of High AC voltages: Cascaded Transformers – Resonant Transformers –Tesla Coil.

UNIT – IV

Generation of Impulse voltages: Specifications of impulse wave – Analysis of RLC circuit only- Marx Circuit.Generation of Impulse currents: Definitions – Circuits for producing Impulse current waves – Wave shape control - Tripping & control of impulse

UNIT – V

Measurement of High DC & AC Voltages: Resistance potential divider - Generating Voltmeter - Capacitor Voltage Transformer (CVT) - Electrostatic Voltmeters – Sphere Gaps. Measurement of Impulse Voltages & Currents: Potential dividers with CRO - Hall Generator - Rogowski Coils.

Text Books:

1. High Voltage Engineering: Fundamentals by E.Kuffel - W.S.Zaengl - J.Kuffel Elsevier (ISBN: 9780750636346).
2. High Voltage Engineering & Technology by Ryan - IET Publishers (ISBN: 9780852967751).

Reference Books:

1. High Voltage Engineering by M.S.Naidu & V. Kamaraju – TMH Publications (ISBN: 9789383286515).
2. High Voltage Engineering by C.L.Wadhwa - New Age Internationals (P) Limited (ISBN-13: 9781906574727).

Web Links:

1. https://nptel.ac.in/courses/108104048
2. https://bharatsrajpurohit.weebly.com/high-voltage-engineering-course.html
3. http://biet.ac.in/pdfs/EEE-IV-HVE.pdf

Electrical Distribution Systems

	L	T	P	C
Course Code:241EE024	**3**	**0**	**0**	**3**

Course Outcomes:

At the end of the course, student will be able to:

CO1	Identify various factors of distribution system
CO2	Design the substation & feeders
CO3	Determine the voltage drop & power loss
CO4	Explain the different protection & its coordination
CO5	Explain the effect of compensation for p.f improvement & different methods of voltage control

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	2	3	2								
CO2	3	2	2								
CO3	2	3	2								
CO4	3	2	2								
CO5	3	2	2								

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	2	
CO2	2	
CO3	1	
CO4	2	
CO5	2	

UNIT – I

General Concepts: Introduction to distribution systems - Distribution system losses – Coincidence factor – Contribution factor loss factor – Numerical Problems – Load Modelling & Characteristics – Relationship between the load factor & loss factor – Classification & characteristics of loads (Residential, commercial, Agricultural & Industrial)

UNIT – II

Substations & Distribution Feeders: Location of substations: Rating of distribution substation – Service area with 'n' primary feeders – Benefits & methods of optimal

location of substations.

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

UNIT – III

System Analysis: Voltage drop & power loss calculations: Derivation for voltage drop & power loss in lines – Uniformly distributed loads & non-uniformly distributed loads - Three phase balanced primary lines.

UNIT – IV

Protection, Coordination & Automation: Objectives of distribution system protection schemes of parallel & Ring main feeders. Coordination of protective devices: General coordination procedure –Various types of coordinated operation of protective devic

UNIT – V

Compensation for Power Factor Improvement & Voltage Control: Capacitive compensation for power factor control – Different types of power capacitors – shunt & series capacitors – Effect of shunt capacitors (Fixed & switched) – Effect of series capacitors – Power factor correction – Capacitor allocation – Procedure to determine the best capacitor location, Voltage Control: Equipment for voltage control– Effect of AVB/AVR – Line drop compensation

Text Books:

1. "Electric Power Distribution system, Engineering" – by Turan Gonen, McGraw hill Book Company. 3rd edition (ISBN: 9781482207002).
2. Electric Power Distribution-by A. S. Pabla, Tata McGraw-Hill Publishing Company, 7th edition (ISBN: 9789389538397).

Reference Books:

1. Electrical Distribution Systems by Dale R. Patrick & Stephen W. Fardo, CRC press (ISBN: 9781439804728).
2. Electrical Power Distribution Systems by V. Kamaraju, Right Publishers (ISBN: 9781259081743).

Web Links:

1. nptel.ac.in/courses/108105067/
2. nptel.ac.in/courses/108102047/
3. nptel.ac.in/Clarify_doubts.php?subjectId=108106025

Flexible Alternating Current Transmission Systems

	L	T	P	C
Course Code:241EE025	**3**	**0**	**0**	**3**

Course Outcomes:

At the end of the Course, student will be able to:

CO1	Explain the concepts of FACTS controller & power flow control in transmission lines.
CO2	Explain the operation & control of voltage & current source converters.
CO3	Explain the different methods of compensations using shunt compensators.
CO4	Explain the different methods of compensations using series compensators.
CO5	Analyze the operation of the Unified Power Flow Controller (UPFC) & Interline power flow controller (IPFC).

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	2	3	1	-	-	-	-	-	-	-	-
CO2	3	2	1	-	-	-	-	-	-	-	-
CO3	2	3	1	-	-	-	-	-	-	-	-
CO4	2	3	1	-	-	-	-	-	-	-	-
CO5	3	1	2	-	-	-	-	-	-	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	1	-
CO2	1	-
CO3	1	-
CO4	1	-
CO5	1	-

UNIT – I

Introduction to FACTS: Power flow in an AC System – Loading capability limits – Dynamic stability considerations – Importance of controllable parameters – Basic types of FACTS controllers – Benefits from FACTS controllers – Requirements & characteristics of high-power devices – Voltage & current rating – Losses & speed of switching – Parameter trade–off devices.

UNIT – II

Voltage source converters (VSC): Voltage source converter (VSC) – Single phase full-wave bridge converter – Square wave voltage harmonics for a single–phase bridge converter – Three–phase full-wave bridge converter - Transformer connections for 12 pulse operation.
Current Source Converter (CSC): Three–phase current source converter– Comparison of current source converter with voltage source converter.

UNIT – III

Shunt Compensators: Objectives – Mid–point voltage regulation for line segmentation – End of line voltage support to prevent voltage instability – Improvement of transient stability – Power oscillation damping. Variable Impedance Type VAR Generator: Thyristor Switched/Controlled Reactor (TSR/TCR) – Thyristor Switched Capacitor (TSC) –Fixed Capacitor Thyristor Controlled Reactor (FC-TCR) - Thyristor Switched Capacitor & Thyristor Controlled Reactor (TSC–TCR) - Switching Converter type VAR generator. Principle of operation & comparison of SVC & STATCOM.

UNIT – IV

Series Compensators: Concept of series capacitive compensation – Improvement of transient stability Power oscillation damping – Functional requirements. Variable Impedance type series compensators – GTO Thyristor controlled Series Capacitor (GSC) – Thyris

UNIT – V

Combined Compensators: Schematic & basic operating principles of unified power flow controller (UPFC) & Interline power flow controller (IPFC) – Controller applications of transmission lines.

Text Books:

1 "Understanding FACTS" N.G.Hingorani & L.Guygi, IEEE Press. Indian Edition is available:– Standard Publications (ISBN: 9788186308790).

2 Flexible AC Transmission systems, Song.Y. H& Johns. A.T, IET Press (ISBN: 9788190858809).

Reference Books:

1	"Flexible ac transmission system (FACTS)" Edited by Yong Hue Song & Allan T Johns, Institution of Electrical Engineers, London (ISBN: 9788190858809).
2	Thyristor-based FACTS Controllers for Electrical Transmission Systems, by R.MohanMathur & Rajiv k.Varma, Wiley (ISBN: 9788126532247).

Web Links:

1	https://nptel.ac.in/courses/108/102/108102179/
2	https://nptel.ac.in/courses/108/107/108107157/
3	https://nptel.ac.in/courses/108/107/108107114/

HVDC Transmission

	L	T	P	C
Course Code:241EE026	**3**	**0**	**0**	**3**

Course Outcomes:

At the end of the course, student will be able to:

CO1	Explain different types of HVDC levels & basic concepts
CO2	Explain the operation of converters
CO3	Explain the control concept of reactive power control & AC/DC load flow
CO4	Explain the converter faults & protection methods.
CO5	Explain the generation & calculation of harmonic effects & design low, high pass filters.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	2	1	-	-	-	-	-	-	-	-
CO2	3	2	1	-	1	-	-	-	-	-	-
CO3	3	2	1	-	1	-	-	-	-	-	-
CO4	3	2	1	-	-	-	-	-	-	-	-
CO5	3	2	2	-	-	-	-	-	-	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	1	-
CO2	1	-
CO3	1	-
CO4	1	-
CO5	1	-

UNIT – I

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 D.C. Transmission.

UNIT – II

Analysis of HVDC Converters:
Choice of converter configuration – analysis of Graetz – characteristics of 6 pulse & 12 pulse converters –Cases of two 3 phase converters in star–star mode – their performance.
Converter & HVDC System Control:
Principal of DC Link Control – Converters Control Characteristics – Firing angle control – Current & extinction angle control – Effect of source inductance on the system – Starting & stopping of DC link - Power Control.
UNIT – IV

Converter Fault & Protection: Converter faults – protection against over current & over voltage in converter station – surge arresters –smoothing reactors – DC breakers –Audible noise-space charge field corona effects on DC Lines-Radio interference.

UNIT – V

Harmonics & Filters: 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 ", K. R. Padiyar - New Age International (p) Limited – 4th edition, 2024.(ISBN: 978-8122437850)
2	HVDC Transmission by S.Kamakshaiah & V. Kamaraju-Tata McGraw–Hill(ISBN: 978-0071072533)

Reference Books:

1	"HVDC Transmission", J. Arrialga - Peter Peregrinus Ltd. – London. (ISBN:978-0852969410)
2	Direct Current Transmission – by E. W. Kimbark, John Wiley & Sons.(ISBN: 978-0471475804)

Web Links:

1	https://nptel.ac.in/courses/108104013
2	http://nptel.ac.in/courses/108101040/22

Utilization of Electrical Energy

	L	T	P	C
Course Code:241EE027	**3**	**0**	**0**	**3**

Course Outcomes:

At the end of the course, student will be able to:

CO1	Identify various illumination methods produced by different illuminating sources.
CO2	Identify a suitable motor for electric drives & industrial applications
CO3	Identify most appropriate heating & welding techniques for suitable applications.
CO4	Distinguish various traction systems & determine the tractive effort & specific energy consumption.
CO5	Explain the necessity & usage of different energy storage schemes for different applications & comparisons.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	2	1	-	-	-	-	-	-	-	-
CO2	3	2	1	-	-	-	-	-	-	-	-
CO3	3	2	1	-	-	-	-	-	-	-	-
CO4	3	2	1	-	-	-	-	-	-	-	-
CO5	3	2	1	-	-	-	-	-	-	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	-	1
CO2	-	1
CO3	-	2
CO4	-	1
CO5	-	1

UNIT – I

Illumination fundamentals & Methods: Illumination fundamentals Introduction - terms used in illumination–Laws of illumination–Polar curves–Integrating sphere–Lux meter Sources of light. Various Illumination Methods Discharge lamps - MV & SV lamps – Comparison between tungsten filament lamps & fluorescent tubes Basic principles of light control– Types & design of lighting & flood lighting–LED lighting - Energy conservation.

UNIT – II

Selection of Motors: Choice of Motor - Type of Electric Drives - Starting & Running Characteristics – Speed Control–Temperature Rise – Applications of Electric Drives–Types of Industrial Loads–Continuous Intermittent & Variable Loads–Load Equalization - Introduction To Energy Efficient Motors.

UNIT – III

Electric Heating & Welding: Advantages & methods of electric heating–Resistance heating induction heating & di electric heating. Electric Welding. Electric welding–Resistance & arc welding–Electric welding equipment–Comparison between AC & DC Welding.

UNIT – IV

Electric Traction: Traction & electrification– Special features of traction motor–Mechanics of train movement, Speed-time curves, tractive effort, Specific energy consumption, acceleration & retardation–Adhesive weight, coefficient of adhesion.

UNIT – V

Introduction to Energy Storage Systems: Need For Energy Storage - Types of Energy Storage-Thermal - Electrical - Magnetic & Chemical Storage Systems - Comparison of Energy Storage Technologies Applications.

Text Books:

1. Utilization of Electric Power – by Er.R.K Rajput – Lakshmi publications Third edition 2023(ISBN: 9788131808290).
2. Utilisation of Electric Power : Including Electric Drives & Electric Traction – by Suryanarayana N.V, New Age International (P) Limited - Publishers – Third edition 2024 (ISBN: 9788122405460).

Reference Books:

1. Utilization Of Electric Energy: Including Electric Drives & Electric Traction -by Tarlok singh(ISBN: 9789380027845).
2. Utilization of Electric power & Electric Traction -by J.B.Gupta S.K.Kataria & Sons (ISBN: 9789350142585).

Web Links:

1. https://nptel.ac.in/courses/108105060
2. https://onlinecourses.nptel.ac.in/noc23_ag06/preview

Restructured Power Systems

	L	T	P	C
Course Code:241EE028	**3**	**0**	**0**	**3**

Course Outcomes:

At the end of the course, student will be able to:

CO1	Illustrate the importance of power system deregulation & restructuring.
CO2	Compute available Transfer Capability
CO3	Analyse transmission congestion & Estimate loss allocation in Power System
CO4	Compute electricity pricing in deregulated environment
CO5	Analyse dem& response in smart grid systems.

Mapping of Course Outcomes with Program Outcomes:

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	2		-	-	-	-	-	-	-	-
CO2	2	3	1	-	-	-	-	-	-	-	-
CO3	2	3	2	-	-	-	-	-	-	-	-
CO4	2	3	1	-	-	-	-	-	-	-	-
CO5	2	3	2	-	-	-	-	-	-	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	1	1
CO2	2	1
CO3	2	1
CO4	2	1
CO5	2	1

UNIT – I

Introduction Philosophy of market models, Concepts in micro-economics, Centralized & de-centralized Dispatch Philosophies – Restructuring models – Independent system operator (ISO) – Power Exchange– Market operations – Market Power – St&ard cost – Transmission Pricing – Congestion Pricing – Management of Inter zonal/Intra zonal Congestion, Restructuring Issues in Indian Power Sector, Electricity Regulation Act 2003.

UNIT – II

Structure of OASIS – Processing of Information – Transfer capability on OASIS – Definitions Transfer Capability Issues – ATC – Total transfer capability between two points(TTC) – transmission reliability margin(TRM) – Capacity Benefit Margin(CBM) calculations –Methodologies to calculate ATC.
Introduction to congestion management – Methods to relieve congestion, Day Ahead Market- Online power trading.

UNIT – III

Introduction – Electricity price volatility electricity price indexes – Challenges to electricity pricing - Market clearing price– Construction of forward price curves – Short–time price forecasting, Locational Marginal Price (LMP) calculation & properties, Financial Transmission Rights (FTRs), Inverse dem& curves, supply curves, market clearing price, social benefit, deadweight loss, long-run & short-run costs. Transmission Pricing
Cost components, Postage Stamp Method, Megawatt Mile Method, Contract Path Method

UNIT – IV

Introduction – Operational planning activities of ISO – The role of ISO in pool & bilateral markets- experience of deregulation in some of the developed countries & Challenges in deregulating electric markets in developing countries – Operational plan

UNIT – V

Dem& response, Potential benefits of dem& response in smart grid, enabling smart technologies for dem& response, control devices for dem& response, Monitoring & communication system. Dem& response for Electric Vehicles, Examples. Ancillary Services within Smart Grid framework: Reactive power as an ancillary service.

Text Books:

1. Operation of Restructured Power System by Kankar Bhattacharya, Math. Bollen, Jaap E. Daalder, Kluver Academic Publisher .(ISBN: 978-0792373971)
2. Restructured Power Systems: and It's Key Issues by J. Sreenivasulu, V. Sankar, Lambert Academic Publishing, 2022.(ISBN : 978-6139460441)

Reference Books:

1. Power System Deregulation by P Srinivasa Varma & V. Sankar, Lambert Academic Publishing.(ISBN : 978-6202071901)
2. "Power system Restructuring & Deregulation", Loi Lei Lai ,John Wiley & Sons Ltd., England.(ISBN: 978-0471495000)

Web Links:

1. https://archive.nptel.ac.in/courses/108/101/108101005/
2. https://www.yumpu.com/en/document/read/20681876/introduction-to-deregulation-in-power-industry-nptel
3. http://kcg.digimat.in/nptel/courses/video/108102047/L08.html

Soft Computing Techniques In Power Systems

	L	T	P	C
Course Code:241EE029	**2**	**0**	**1**	**3**

Course Outcomes:

At the end of the course, student will be able to:

- **CO1** Underst& the concept of Artificial Intelligence
- **CO2** Analyze & mathematically model Artificial Neural Network.
- **CO3** Underst& the concept of Fuzzy Systems.
- **CO4** Analyze the mathematically model & apply it for various optimization algorithms.
- **CO5** Apply various intelligent algorithms to solve practical power system problems.

Mapping of Course Outcomes with Program Outcomes:

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	2	2	3	1	2	-	-	-	-	-	-
CO2	2	2	3	1	2	-	-	-	-	-	-
CO3	2	2	3	1	2	-	-	-	-	-	-
CO4	2	2	3	1	2	-	-	-	-	-	-
CO5	2	2	3	1	2	-	-	-	-	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	2	2
CO2	2	2
CO3	2	2
CO4	2	2
CO5	2	2

UNIT – I

Introduction: Concept of artificial intelligence, Problem solving methods & searching techniques, classification of optimization techniques like conventional methods, heusrustic methods & meta- heuristic methods.

UNIT – II

Artificial Neural Networks: Fundamental concepts, basic models, Learning rules, multilayer feed-forward networks, back-propagation training algorithm, radial basis function & recurrent networks, supervised & unsupervised learning.

UNIT – III

Fuzzy control methods: Introduction to fuzzy logic controller, types of fuzzy logic controllers, basic structure of fuzzy knowledge based controllers, fuzzification & defuzzification methods, applications of fuzzy logic control.

UNIT – IV

Optimization algorithms: Search techniques, conventional & nonconventional optimization, implementation of genetic algorithm & particle swarm optimization using conventional & non conventional optimization techniques

UNIT – V

Applications in Power System: Short term & long term load forecasting, economic load dispatch scheduling, hydro thermal scheduling, optimal power flow, identification & classification of faults.

Text Books:

1. Understanding Neural Networks & Fuzzy Logic, Stamatios V. Kartalopoulos. IEEE Press.(ISBN: 9780780311282)
2. Neural Networks, Simon Haykin. Pearson Education Asia.(ISBN: 9789332570313)

Reference Books:

1. Hand book of Genetic Algorithms, L. Davis, Van Nostr& Reinhold.(ISBN: 978044200173)
2. Intelligent Control System, M. M. Gupta IEEE Press.(ISBN: 9780780310636)

Web Links:

1. https://archive.nptel.ac.in/courses/106/105/106105173/
2. https://onlinecourses.nptel.ac.in/noc24_ee32/preview

Methods & Algorithms for Intelligent Control

	L	T	P	C
Course Code:241EE030	**3**	**0**	**0**	**3**

Course Outcomes:

At the end of the course, student will be able to:

CO1	Design feedback controllers for complex dynamic systems using ANN.
CO2	Design fuzzy logic-based controller for dynamic systems.
CO3	Construct TS fuzzy models for complex dynamic systems.
CO4	Formulate hybrid controllers by combining the concepts of Genetic Algorithm & BioInspired algorithms with ANN.
CO5	Formulate hybrid controllers by combining the concepts of Genetic Algorithm & BioInspired algorithms with Fuzzy logic.

Mapping of Course Outcomes with Program Outcomes:

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	2	2	3	1	2						
CO2	2	2	3	1	2						
CO3	2	2	3	1	2						
CO4	2	2	3	1	2						
CO5	2	2	3	1	2						

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	2	2
CO2	2	2
CO3	2	2
CO4	2	2
CO5	2	2

UNIT – I

Introduction: Introduction to intelligent control, comparison study between conventional & intelligent control, intelligent supervisory control, intelligent adaptive control.

UNIT – II

Neural network based control: Introduction to Neural Network, theory of neural network for classification & function approximation, supervised & unsupervised learning rules, RBF neural network, Support vector machines, intelligent control using Neural Network, Approximation capabilities by feed-forward & recurrent neural network, Neuro-control

based on back propagation algorithm, system identification with neural network.

UNIT – III

Fuzzy logic control: Introduction to fuzzy set theory & logic, application of fuzzy logic in control system, fuzzy quantization of knowledge, fuzzy controller design, Fuzzy T-S modelling for dynamic system & stability using Lyapunov theory.

UNIT – IV

Genetic algorithm & control: Basic theory & operations of Genetic algorithm, GA based control system, optimization problem using GA related to control & other engineering problems.

UNIT – V

Bio-inspired evolutionary algorithms: Bio-inspired evolutionary algorithms – like Particle swamp optimization (PSO), simulated annealing, Fire-fly optimization, bacterial foraging etc – only the concepts & case studies related control problems.

Text Books:

1	Intelligent Control: Power Electronic Systems (Monographs in Electrical and Electronic Engineering, Dote, Yasuhiko - Hoft, Richard G.(ISBN: 9780198564669) IEEE Pres.
2	Genetic Algorithms in Search, Optimization, and Machine Learning, Goldberg, Pearson Education.(ISBN : 978-0201157673)

Reference Books:

1	Fuzzy logic (intelligence control & information), J. Yen & R. Langari, Pearson, first edition.(ISBN: 978-0135258170)
2	Methods & Applications of Intelligent Control, Spyros G. Tzafestas.

Web Links:

1	https://archive.nptel.ac.in/courses/108/104/108104049/
2	https://archive.nptel.ac.in/courses/106/106/106106126/

Advanced Control Systems

	L	T	P	C
Course Code: 241EE031	**3**	0	0	**3**

Course Outcomes:
At the end of the Course, Student will be able to:

CO 1: To familiarize the state space representation in controllable, observable, diagonal & Jordan canonical forms

CO 2: Introduce the concept of controllability & observability tests through canonical forms & design of state feedback controller by pole placement technique & State Observer design.

CO 3: Analysis of a nonlinear system using a describing function approach

CO 4: Illustrate Lypanov'sstability analysis method for linear & non-linear continuous time autonomous systems.

CO 5: Formulation of Euler Lagrange equation for the optimization of typical functional & solutions.

Mapping of course outcomes with program outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	1				2					
CO2	2	3	1								
CO3	2	1	3			1					
CO4	2	3	1			1					
CO5	2	3	1								

Mapping of course outcomes with program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	1	1
CO2	1	1
CO3	1	1
CO4	1	-
CO5	1	1

UNIT-I: State Space Analysis

State Space Representation – Canonical forms – Controllable canonical form – Observable canonical form - Jordan Canonical Form - Solution of state equation – State transition matrix

UNIT-II: Controllability - Observability & Design of Pole Placement

Tests for controllability & observability for continuous time systems – Time varying case – Minimum energy control – Time invariant case – Principle of duality - Effect of state feedback on controllability & observability – Design of state feedback control through pole placement.

UNIT-III: Nonlinear Systems

Introduction to nonlinear systems - Types of nonlinearities. Introduction to phase plane analysis -Singular points; Describing function - basic concepts - Describing functions of non- linearity's.

UNIT-IV: Stability analysis by Lyapunov Method

Stability in the sense of Lyapunov – Lyapunov's stability & Lyapunov's instability theorems – Direct method of Lyapunov for the linear & nonlinear continuous time autonomous systems.

UNIT-V: Calculus of Variations

Minimization of functional of single function – Constrained minimization – Minimum principle –Control variable inequality constraints – Control & state variable inequality constraints –Euler lagrangine equation

Text Books:

1. Modern Control Engineering – by K. Ogata - Prentice Hall of India - 3rd edition (ISBN :9789332550162).
2. Automatic Control Systems by B.C. Kuo - Prentice Hall Publication (ISBN: 9780471134763).

Reference Books:

1. Modern Control System Theory – by M. Gopal - New Age International Publishers (ISBN: 9780470274248).
2. Control Systems Engineering by I.J. Nagarath&M.Gopal - New Age International (P) Ltd(ISBN: 9788195175581).
3. Digital Control & State Variable Methods – by M. Gopal - Tata Mc Graw–Hill Companies (ISBN: 9781259083174).

Web Links:

1. https://www.slideshare.net/ntpc-project-korbasuper-themal-power-plant
2. https://www.euronuclear.org/1-information/energy-uses.htm
3. https://www.slideshare.net/9anku/electrical-distribution-system

Concept of Smart Grid Technology

	L	T	P	C
Course Code:241EE032	**2**	**0**	**0**	**2**

Course Outcomes:

At the end of the course, student will be able to:

- **CO1** Explain the concepts of smart grid & its issues in interconnection.
- **CO2** Explain various smart grid technologies & its usage in smart applications.
- **CO3** Describe the concepts of smart substations.
- **CO4** Analyze micro grids & distributed generation systems.
- **CO5** Describe the different technologies in smart grid.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	2	3	1								
CO2	2	3	1								
CO3	2	3	1								
CO4	2	3	1								
CO5	2	3	1								

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	1	1
CO2	1	1
CO3	1	1
CO4	1	1
CO5	1	1

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

Information & Communication Technology for Smart Grid: Advanced Metering Infrastructure (AMI) - Home Area Network (HAN) - Neighborhood Area Network (NAN) - Wide Area Network (WAN).

UNIT – III

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 - Net Metering.

UNIT – IV

Smart Grid Technologies: Part 2: Smart Substations - Substation Automation - Feeder Automation. Geographic Information System (GIS) - Intelligent Electronic Devices (IED) & their application for monitoring & protection.

UNIT – V

Micro grids & 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.

Text Books:

1. Integration of Green & Renewable Energy in Electric Power Systems - by Ali Keyhani – Mohammad, N. Marwali - Min Dai Wiley (ISBN: 9780470187760).
2. The Smart Grid: Enabling Energy Efficiency & Demand Response - by Clark W.Gellings – Fairmont Press (ISBN: 9781439815748).

Reference Books:

1. The Advanced Smart Grid: Edge Power Driving Sustainability by andres Carvallo - John Cooper - Artech House Publishers (ISBN: 9781608071272).
2. Smart Grid: Technology & Applications - by Janaka B. Ekanayake - Nick Jenkins -Kithsiri Liyanage - Jianzhong Wu - Akihiko Yokoyama - Wiley publishers (ISBN: 9780470974094).

Web Links:

1. https://nptel.ac.in/courses/108104052/
2. https://nptel.ac.in/downloads/108101040/
3. https://nptel.ac.in/courses/108101040/

Energy Audit, Conservation & Management

	L	T	P	C
Course Code:241EE033	**3**	**0**	**0**	**3**

Course Outcomes:

At the end of the course, student will be able to:

CO1	Explain energy efficiency, conservation, & various technologies.
CO2	Design energy efficient lighting systems.
CO3	Calculate power factor of systems & propose suitable compensation techniques.
CO4	Explain energy conservation in HVAC systems.
CO5	Calculate life cycle costing analysis & return on investment on energy efficient technologies. Calculate the Time value of Money.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	2	3	2	-	-	-	-	-	-	-	-
CO2	3	1	2	-	-	-	-	-	-	-	-
CO3	2	3	1	-	-	-	-	-	-	-	-
CO4	2	3	1	-	-	-	-	-	-	-	-
CO5	3	2	1	-	-	-	-	-	-	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	2	-
CO2	2	-
CO3	2	-
CO4	2	-
CO5	2	-

UNIT – I

Basic Principles of Energy Audit:
Energy audit- definitions - concept - types of audit - energy index - cost index - pie charts - Sankey diagrams & 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 & functions - language - Questionnaire – check list for top management.

UNIT – III

Energy Efficient Motors & 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 & practice - lighting control - lighting energy audit.

UNIT – IV

Power Factor Improvement & 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 - d

UNIT – V

Economic Aspects & 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 (ISBN: 9788131207383).
2. Energy management hand book by W.C. Turner - John wiley & sons (ISBN: 9781420088700).

Reference Books:

1. Energy efficient electric motors by John. C. andreas - Marcel Dekker Inc Ltd-2nd edition (ISBN: 9781489914675).
2. Energy management by Paul o' Callaghan - Mc-graw Hill Book company-1st edition (ISBN: 9780077076788).

Web Links:

1. https://nptel.ac.in/courses/108106022/
2. https://nptel.ac.in/courses/112105221/
3. https://onlinecourses.nptel.ac.in/noc17_mm17/preview

Electric Energy Storage Systems

	L	T	P	C
Course Code:241EE036	**3**	**0**	**0**	**3**

Course Outcomes:

At the end of the course, student will be able to:

- **CO1** Analyze the characteristics of electrical energy storage technologies.
- **CO2** Analyze the needs for electrical energy storage.
- **CO3** Analyze the needs for electrical energy storage.
- **CO4** Underst& the various types of electrical energy storage systems.
- **CO5** Identify various real time applications of energy storage systems.

Mapping of Course Outcomes with Program Outcomes:

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	2	3	1								
CO2	3	2	1								
CO3	2	1	3								
CO4	3	1	1								
CO5	3	2	2								

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	2	
CO2	2	
CO3	2	
CO4	2	
CO5	2	

UNIT – I

Electrical Energy Storage (EES) Technologies: Characteristics of electricity, Electricity & the roles of EES, High generation cost during peak-dem& periods, Need for continuous & flexible supply, Long distance between generation & consumption, Congestion in power grids, Transmission by cable.

UNIT – II

Needs for Electrical Energy Storage: Emerging needs for EES, More renewable energy, less fossil fuel, Smart Grid uses, The roles of electrical energy storage technologies, The roles from the viewpoint of a utility, The roles from the viewpoint of consumers, The roles from the viewpoint of generators of renewable energy.

UNIT – III

Features of Energy Storage Systems: Classification of EES systems , Mechanical storage systems, Pumped hydro storage (PHS), Compressed air energy storage (CAES), Flywheel energy storage (FES), Electrochemical storage systems, Secondary batteries, Flow batteries, Chemical energy storage, Hydrogen (H2),Synthetic natural gas (SNG)

UNIT – IV

Types of Electrical Energy Storage systems: Electrical storage systems, Double-layer capacitors (DLC), Superconducting magnetic energy storage (SMES), Thermal storage systems, St&ards for EES, Technical comparison of EES technologies.

UNIT – V

Applications: Present status of applications, Utility use (conventional power generation, grid operation & service), Consumer use (uninterruptable power supply for large consumers), New trends in applications, Renewable energy generation, Smart Grid, Smart Micro grid, Smart House, Electric vehicles, Management & control hierarchy of storage systems, Internal configuration of battery storage systems, External connection of EES systems, Aggregating EES systems & distributed generation (Virtual Power Plant), Battery SCADA aggregation of many dispersed batteries.

Text Books:

1	"Energy Storage Benefits & Market Analysis", James M. Eyer, Joseph J. Iannucci & Garth P. Corey , Sandia National Laboratories.
2	The Electrical Energy Storage by IEC Market Strategy Board.

Reference Books:

1	"Jim Eyer, Garth Corey", Energy Storage for the Electricity Grid: Benefits & Market Potential Assessment Guide, Report, S&ia National Laboratories.
2	Energy Storage by Mullick & Garg

Web Links:

1	https://nptel.ac.in/courses/112/105/112105221/
2	https://nptel.ac.in/courses/112/107/112107283/
3	https://nptel.ac.in/content/storage2/courses/108103009

Digital Control Systems

		L	T	P	C
Course Code:	241EE038	**3**	0	0	**3**

Course Outcomes:
At the end of the Course, Student will be able to:

CO 1: To understand the concepts of digital control systems & assemble various components associated with it. Advantages compared to the analog type.
CO 2: The theory of z–transformations & application for the mathematical analysis of digital control systems
CO 3: To represent the discrete–time systems in state–space model & evaluation of state transition matrix, the design of state feedback control by "the pole placement method.", design of state observers
CO 4: To examine the stability of the system using different tests & study the conventional method of analyzing digital control systems in the w–plane.
CO 5: Design of state feedback controller through pole placement.

Mapping of course outcomes with program outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	1	-								
CO2	2	3	1								
CO3	2	1	3								
CO4	2	3	1								
CO5	2	3	1								

Mapping of course outcomes with program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	1	1
CO2	1	1
CO3	1	1
CO4	1	1
CO5	1	1

UNIT-I: Introduction to Signal Processing

Introduction to analog & digital control systems – Advantages of digital systems – Continuous & Discrete Time Signals – Sample & hold devices – Sampling theorem & data reconstruction – Frequency domain characteristics of zero order hold.

UNIT-II: Z–Transformations

Z–Transforms – Theorems – inverse Z–transforms – Formulation of difference equations & solving – Block diagram representation – Pulse transfer functions & finding open loop & closed loop responses.

UNIT-III: State Space Analysis & the Concepts of Controllability & Observability

State space representation of discrete time systems – Solving Discrete Time state space equations – State transition matrix & its properties – Concepts of controllability & observability

UNIT-IV: Stability Analysis

Mapping between the S–Plane & the Z–Plane – Primary strips & Complementary strips – Stability criterion – Modified Routh's stability criterion & Jury's stability - Design using frequency response in the w–plane for lag & lead compensators – Root locus technique in the z–plane

UNIT-V: State Feedback Controllers & State Observers

Design of state feedback controller through pole placement – Necessary & sufficient conditions –Ackerman's formula – Design of state observers

Text Books:

1. Discrete–Time Control systems – K. Ogata - Pearson Education/PHI - 2nd Edition.(ISBN: 978-8120327603)
2. Digital Control & State Variable Methods by M.Gopal - TMH - 4th Edition.(ISBN:978-007133327)

Reference Books:

1. Digital Control Systems - Kuo - Oxford University Press - 2nd Edition.(ISBN: 978-0195120646)
2. Digital Control & State Variable Methods – by M. Gopal - Tata Mc Graw–Hill Companies.(ISBN:978-007133327)

Web Links:

1. https://nptel.ac.in/courses/108103008
2. https://ocw.mit.edu/courses/2-171-analysis-&-design-of-digital-control-systems-fall-2006/

Alternative Energy Sources

	L	T	P	C
Course Code:241EE034	**3**	**0**	**0**	**3**

Course Outcomes:

At the end of the course, student will be able to:

CO1	Describe the environmental aspects of Renewable Energy Resources.
CO2	Describe the use of Solar Energy & the various components used in the energy production.
CO3	Underst& the conversion principles of Wind & Biomass Energy Resources.
CO4	Acquire the basic knowledge of Ocean Thermal Energy
CO5	Acquire the basic knowledge of energy conversion & Hydrogen Energy.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	3	2			2					
CO2	3	3	2			2					
CO3	3	3	2			2					
CO4	3	3	2			2					
CO5	3	3	2			2					

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	1	1
CO2	2	1
CO3	2	1
CO4	2	1
CO5	1	1

UNIT – I

Introduction: Principles of renewable energy; energy & sustainable development, worldwide renewable energy availability, renewable energy availability in India, brief descriptions on solar energy, wind energy, tidal energy, wave energy, ocean thermal energy, biomass energy, geothermal energy, oil shale

UNIT – II

Solar Energy: Fundamentals; Solar Radiation; Estimation of solar radiation on horizontal & inclined surfaces; Solar radiation Measurements- Pyrheliometers, Pyrometer, Solar Thermal systems: Flat plate collector; Solar distillation; Solar Pond electric power plant.

Photovoltaic system for electric power generation.

UNIT – III

Wind Energy: Wind velocity & power from wind; major problems associated with wind power, Basic components of wind energy conversion system (WECS); Classification of WECS- Horizontal axis- single, double & multiblade system. Vertical axis- Savonius & darrieus types.
Biomass Energy: Biomass Resources; Biomass conversion technologies-fixed dome; Urban waste to energy conversion.

UNIT – IV

Tidal Power: Tides energy suppliers & their mechanics; fundamental characteristics of tidal power, harnessing tidal energy, advantages & limitations.
Ocean Thermal Energy Conversion: Principle of working, OTEC power stations in the world, problems as

UNIT – V

Green Energy: Introduction, Fuel cells: Classification of fuel cells – H2; Operating principles, Zero energy Concepts. Benefits of hydrogen energy, hydrogen production technologies (electrolysis method only), hydrogen energy storage, applications of hydrogen energy (contemporary cases).

Text Books:

1. Non-Conventional energy resources, Khan B.H, Tata Mc-Graw hill, New Delhi, 3rd edition (ISBN: 9789352601882).
2. Non-conventional Energy Sources, G.D.Rai, Khanna Publications, New Delhi, 4th edition (ISBN: 9788174090737).

Reference Books:

1. Renewable energy resources, Twidell, J.W. & Weir, A., BSP Books Pvt.Ltd, UK, 2nd edition (ISBN: 9780415584388).
2. Renewable Energy Technologies, R.Ramesh, Uday kumar, Narosa Publishing House, New Delhi, 1st edition (ISBN:9788173190674).

Special Electrical Machines

	L	T	P	C
Course Code:241EE035	**3**	**0**	**0**	**3**

Course Outcomes:

At the end of the course, student will be able to:

- **CO1** Explain the operation & control of Stepper Motor.
- **CO2** Describe theory of operation & control of Switched Reluctance Motor.
- **CO3** Explain the operation & control of Synchronous Reluctance Motor.
- **CO4** Describe theory of operation & control of Permanent Magnet Brushless D.C. Motors
- **CO5** Explicate the theory of PMSM & LIM & its applications.

Mapping of Course Outcomes with Program Outcomes:

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	2	1								
CO2	3	2	1								
CO3	3	2	1								
CO4	3	2	1								
CO5	3	2	1								

Mapping of Course Outcomes with Program Specific Outcomes:

	PSO1	PSO2
CO1		1
CO2		1
CO3		1
CO4		1
CO5		1

UNIT – I

Stepper Motors: Constructional features – Types of Stepper Motors - permanent magnet (PM) type - Hybrid type Stepper Motor - Variable Reluctance Motor (VRM) - Single stack & multiple stack VRM – Characteristics, Modes of Operation & Applications of Stepper Motor.

UNIT – II

Switched Reluctance Motors: Constructional features, Principle of operation, Torque production, Power Converters & their controllers, Methods of Rotor position sensing, Sensor less operation, Closed loop control of SRM, Characteristics.

UNIT – III

Synchronous Reluctance Motor: Construction, Working, Torque Equation, control, Advantages & Applications Synchronous Reluctance Motor

UNIT – IV

Permanent Magnet Brushless D.C. Motors: Principle of Operation, Types, EMF & torque equations, Commutation, Motor characteristics & control, Torque/speed characteristics.

UNIT – V

Permanent Magnet Synchronous Motors: Construction, Principle of Operation, EMF Equation of PMSM, Torque Equation, Comparison of Conventional & PM Synchronous Motors, Application of PMSM

Linear Induction Motors

Linear Induction Motors (LIM)- Construction– principle of operation— Development of one-sided LIM with back iron equivalent circuit of LIM-Applications

Text Books:

1. Brushless Permanent magnet & reluctance motor drives, Clarenden press, T.J.E.Miller, Oxford.
2. Special electrical Machines, K. VenkataRatnam, University press, New Delhi

Reference Books:

1. Special electrical machines, E.G. Janardhanan, PHI learning private limited.
2. Krishnan, R., “Permanent Magnet & BLDC Motor Drives”, CRC Press.

Web Links:

1. https://nptel.ac.in/courses/108102156
2. https://www.monolithicpower.com/stepper-motors-basics-types-uses
3. https://epochautomation.com/synchronous-reluctance-motor-working/

Hybrid Electric Vehicles

	L	T	P	C
Course Code: 241EE037	**3**	**0**	**0**	**3**

Course Outcomes:

At the end of the course, student will be able to:

CO 1: Analyze the architectures of HEVs with various components.
CO 2: Illustrate the concept of Electric Vehicle & Hybrid Electric Vehicles.
CO 3: Explain the Plan concept of Plug-in Electrical Vehicles.
CO 4: Analyze the power electronics converters for HEVs.
CO 5: Apply various energy storage technologies in Hybrid Vehicles.

Mapping of course outcomes with program outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	2	1	2								
CO2	2	3	3								
CO3	1	2	3	2							
CO4	2	3	3	3							
CO5	3	3	3								

CO/PSO	PSO1	PSO2
CO1	2	1
CO2	2	
CO3	2	2
CO4		2
CO5	3	

UNIT-I:

Introduction: History of hybrid vehicles, architectures of HEVs, series & parallel HEVs, complex HEVs.

UNIT-II:

Hybridization of Automobile: Fundamentals of vehicle, components of conventional vehicle & propulsion load; Drive cycles & drive terrain; Concept of electric vehicle & hybrid electric vehicle; Plug-in hybrid vehicle, constituents of PHEV, comparison of HEV & PHEV; Fuel Cell vehicles & its constituents.

UNIT-III:

Plug-in Hybrid Electric Vehicle: PHEVs & EREVs blended PHEVs, PHEV Architectures, equivalent electric range of blended PHEVs; Fuel economy of PHEVs, power management of PHEVs, end-of-life battery for electric power grid support, vehicle to grid technology, PHEV battery charging.

UNIT-IV:

Power Electronics in HEVs: Rectifiers used in HEVs, voltage ripples; Buck converter used in HEVs, non-isolated bidirectional DC-DC converter, regenerative braking, voltage source inverter, current source inverter, isolated bidirectional DCDC converter, PWM rectifier in HEVs, EV & PHEV battery chargers.

UNIT-V:

Battery & Storage Systems: Energy Storage Parameters; Lead–Acid Batteries; Ultra capacitors; Flywheels - Superconducting Magnetic Storage System; Pumped Hydroelectric Energy Storage; Compressed Air Energy Storage - Storage Heat; Energy Storage as an Economic Resource.

Text Books:

1. Advanced Electric Drive Vehicles by Ali Emadi , CRC Press.(ISBN:978-1466597693)
2. Electric & Hybrid Vehicles: Design Fundamentals by Iqbal Hussein , CRC Press.(ISBN: 978-143981175)

Reference Books:

1. Introduction to Hybrid Vehicle System Modelling & Control by Wei Liu, Wiley (ISBN:978-8126556205).
2. “Electric & Hybrid Vehicles Technologies, Modelling & Control: A Mechatronic Approach”, by Amir Khajepour, Saber Fallah& Avesta Goodarzi, John Wiley & Sons Ltd.(ISBN: 978-1118341513)

Web Links:

1. https://archive.nptel.ac.in/courses/108/103/108103009/
2. https://ndl.iitkgp.ac.in/he_document/nptel/nptel/IN__N__1_E_E__12391_I_t_H_a_E_V__14024_D_o_H_E_v__14030_14031

Power Quality

	L	T	P	C
Course Code:241EE040	**3**	**0**	**0**	**3**

Course Outcomes:

At the end of the Course, Student will be able to:

CO 1: Differentiate between different types of power quality problems.
CO 2: Explain the sources of voltage sag, voltage swell, interruptions, transients, long duration over voltages & harmonics in a power system.
CO 3: Analyze power quality terms & power quality standards.
CO 4: Explain the principle of voltage regulation & power factor improvement methods
CO 5: Demonstrate the relationship between distributed generation & power quality.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11
CO1	2	3	1								
CO2	3	2									
CO3	2	3	1	1							
CO4	3	2			2						
CO5	3	2									

Mapping of Course Outcomes with Program Specific Outcomes:

CO / PSO	PSO1	PSO 2
CO1	2	
CO2	2	
CO3	2	
CO4	2	
CO5	2	

UNIT-I

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

UNIT-II

Voltage imperfections in power systems: Power quality terms – Voltage sags – Voltage swells & interruptions – Sources of voltage sag, swell & interruptions – Nonlinear loads – IEEE standard 519-2014 & IEC standard 61000. Source of transient over voltages – Principles of over voltage protection – Devices for over voltage protection –Utility capacitor switching transients

UNIT-III

Voltage Regulation & power factor improvement: 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 – Power factor penalty – Static VAR compensations for power factor improvement.

UNIT-IV

Harmonic distortion & solutions: Voltage distortion vs. Current distortion – Harmonics vs. Transients – Harmonic indices – Sources of harmonics – Effect of harmonic distortion – Impact of capacitors, transformers, motors & meters – Point of common coupling – Passive & active filtering – Numerical problems.

UNIT-V

Distributed Generation & Power Quality: Resurgence of distributed generation – DG technologies – Interface to the utility system –Power quality issues & operating conflicts – DG on low voltage distribution networks.

Monitoring & Instrumentation: Power quality monitoring & considerations – Historical perspective of PQ measuring instruments – PQ measurement equipment – Assessment of PQ measuring data – Application of intelligent systems – PQ monitoring standards.

Text Books:

1. Electrical Power Systems Quality, Dugan R C, McGranaghan M F, Santoso S, & Beaty H W, Second Edition, McGraw–Hill, 3rd edition (ISBN: 9781259005572).

2. Electric power quality problems –M.H.J.Bollen IEEE series-Wiley India publications (ISBN: 9780780347137).

Reference Books:

1. Power System Harmonics, Arrillaga J & Watson N R, Second Edition, John Wiley & Sons (ISBN: 9788126560431).
2. Electric Power Quality Control Techniques, W. E. Kazibwe & M. H. Sendaula, Van Nostrad Reinhold, New York (ISBN: 9780442010935).
3. Power Quality by C.Shankaran, CRC Press (ISBN:9780849310409).

Web Links:

1. https://en.wikipedia.org/wiki/Electric_power_quality
2. https://www.accessengineeringlibrary.com/browse/power-quality-in-electrical-systems
3. www.p3-inc.com/images/what_is_power_quality.pdf

Electrical Safety

Course Code: 241EE043

L	T	P	C
3	0	0	3

Course Outcomes:

At the end of the Course, Student will be able to:

CO 1: Describe electrical hazards & safety equipment.
CO 2: Analyze& apply various grounding & bonding techniques
CO 3: Select appropriate safety method for low, medium equipment's & high voltage equipment.
CO 4: Participate in a safety team &Carry out proper maintenance of electrical equipment by understa&ing various St&ards.
CO 5: Analyze the safety method for high voltage equipment's.

Mapping of course outcomes with program outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	1	-	-	-	-	-	-	-	-
CO2	3	2	1	-	-	-	-	-	-	-	-
CO3	3	2	1	-	-	-	-	-	-	-	-
CO4	3	2	2	-	-	-	-	-	-	-	-
CO5	1	3	1	-	-	-	-	-	-	-	-

UNIT-I:

Hazards of Electricity & Electrical Safety Equipment: Primary & secondary hazards- arc, blast, shocks causes & effects-safety equipment flash & thermal protection, head & eye protection-rubber insulating equipment, hot sticks, insulated tools, barriers & signs, safety tags, locking devices-voltage measuring instruments- proximity & contact testers-safety electrical one line diagram-electrician's safety kit.

UNIT-II:

Grounding of Electrical Systems & Equipment: General requirements for grounding & bonding-definitions grounding of electrical equipment-bonding of electrically conducting materials & other equipment connection of grounding & bonding equipment- system grounding- purpose of system grounding-grounding electrode system- grounding conductor connection to electrodes-use of grounded circuit conductor for grounding equipment- grounding of low voltage & high voltage systems.

UNIT-III:

Safety Procedures & Methods: The six step safety methods- pre job briefings - hot-work decision tree-safe switching of power system- lockout-tag out- flash hazard calculation & approach distances-calculating the required level of arc protection-safety equipment, procedure for low, medium & high voltage systems- the one-minute safety audit

UNIT-IV:

Safety Management & Organizing Structure: Electrical safety program structure, development-company safety team- safety policy program implementation- employee electrical safety teams-safety meetings- safety audit accident prevention- first aid- rescue techniques-accident investigation.

UNIT-V:

Electrical Maintenance & Legal Safety Requirements &St&ards: Safety related case for electrical maintenance- reliability centred maintenance (RCM) - eight step maintenance program-frequency of maintenance- maintenance requirement for specific equipment & location- regulatory bodies- national electrical safety code st&ard for electrical safety in work place- occupational safety & health administration st&ards, Indian Electricity Acts related to Electrical Safety

Text Books:

1. 'Electrical Safety Handbook' by John Cadick, Mary Capelli-Schellpfeffer, Dennis Neitzel, Al Winfield, McGraw-Hill Education, 4th Edition (ISBN: 9780071745130)
2. "Electric Safety Practice & Standards", Khaled Ismail, CRC Press, Taylor & Francis (ISBN: 9781138073999).

Reference Books

1. 'Electrical Safety- a guide to the causes & prevention of electric hazards', Maxwell Adams.J, The Institution of Electric Engineers, IET (ISBN: 9780852968062).
2. 'Electrical Safety in the Workplace', Ray A. Jones, Jane G. Jones, Jones & Bartlett Learning (ISBN: 9780877655800).

Web Links:

1. http://nptel.ac.in/courses/103106071/5
2. https://www.electricalsafetyfirst.org.uk