Kavayitri Bahinabai Chaudhari
NORTH MAHARASHTRA UNIVERSITY,
JALGAON (M.S.)

Third Year Bachelor of Engineering

in

Electrical

(As per NEP 2020 Guidelines)

Faculty of Science and Technology

कवयित्री बहिणाबाई चौधरी उत्तर महाराष्ट्र विद्यापीठ
अंतरी पेटवू ज्ञानज्योत
1990
'A' Grade
NAAC Re-Accredited
(4th Cycle)

SYLLABUS STRUCTURE

For Affiliated Colleges

Semester – V & VI

W.E.F. 2026 – 27

Syllabus Structure for Third Year Engineering (Semester – V, Level – 5.5) (Electrical) (w.e.f. 2026 – 27)

(As per NEP 2020 Guidelines)

Course Code	Name of the Course	Category	Teaching Scheme				Evaluation Scheme					Credits
							Theory		Practical		Total	
			Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE (CA)	ESE (UA)	ICA (CA)	ESE (UA)		
EE -501	Power System -I	PCC	3			3	40	60			100	3
EE -502	Power System -I Lab	PCC			2	2			25	25 (PR)	50	1
EE -503	Power Electronics	PCC	3			3	40	60			100	3
EE -504	Power Electronics Lab	PCC			2	2			25	25 (PR)	50	1
EE -505	High Voltage Engineering Lab	PCC	3		4	7			50	25 (OR)	75	5
EE -506	Program Elective Course – I	PEC	3			3	40	60			100	3
EE -507	Program Elective Course – I Lab	PEC			2	2			25		25	1
EE -508	Signals and Systems	MD M	2			2	40	60	25		125	2
OE -509	Open Elective – III	OE	2			2			25		25	2
			16		**10**	**26**	**160**	**240**	**175**	**75**	**650**	**21**

ISE: Internal Sessional Examination ESE: End Semester Examination ICA: Internal Continuous Assessment

CA: College Assessment UA: University Assessment

Program Elective Course – I		
Course Code		**Name of the Subject / Course**
EE -506	A	Power Generation and Economics
EE -506	B	Electrical Machine Design
EE -506	C	Special Electrical Machines

Syllabus Structure for Third Year Engineering (Semester – VI, Level – 5.5) (Electrical) (w.e.f. 2026 – 27)

(As per NEP 2020 Guidelines)

Course Code	Name of the Course	Category	Teaching Scheme				Evaluation Scheme					Credits
							Theory		Practical		Total	
			Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE (CA)	ESE (UA)	ICA (CA)	ESE (UA)		
EE -601	Control System	PCC	3			3	40	60			100	3
EE -602	Control System Lab	PCC			2	2			25	25 (PR)	50	1
EE -603	Power System-II	PCC	3			3	40	60			100	3
EE -604	Power System-II Lab	PCC			2	2			25	25 (PR)	50	1
EE -605	Program Elective Course – II Lab	PEC	3		4	7			50	25 (OR)	75	5
EE -606	Program Elective Course – III	PEC	3			3	40	60			100	3
EE -607	Program Elective Course – III Lab	PEC			2	2			25		25	1
EE -608	Wind and Solar Power Systems	MD M	2			2	40	60	25		125	2
EE -609	Electrical Installation	VSEC	1		2	3			25		25	2
			15		**12**	**27**	**160**	**240**	**175**	**75**	**650**	**21**

ISE: Internal Sessional Examination ESE: End Semester Examination ICA: Internal Continuous Assessment
CA: College Assessment UA: University Assessment

Program Elective Course – II Lab			**Program Elective Course – III**		
Course Code		**Name of the Subject / Course**	**Course Code**		**Name of the Subject / Course**
EE -605	A	Software Application Lab	EE -606	A	Microprocessor and Microcontroller
EE -605	B	Electrical Automation Lab	EE -606	B	Utilization of Electrical Energy
EE -605	C	Computer Aided Electrical Drawing Lab	EE -606	C	Illumination Engineering

EXIT COURSE FOR U. G. B. VOCATIONAL in Electrical (DURATION 8 WEEKS)

Course Code	Name of the Course	Category	Teaching Scheme				Evaluation Scheme					Credits
							Theory		Practical		Total	
			Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE (CA)	ESE (UA)	ICA (CA)	ESE (UA)		
EE -610	Internship / Apprenticeship	OJT							125			4
EE -611	Mini Project	Project							25			4
									150			8

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COURSE OUTLINE

For Affiliated Colleges

Semester – V

W.E.F. 2026 – 27

POWER SYSTEM-I (PCC)					
COURSE OUTLINE					
Course Title:	**POWER SYSTEM-I**	**Short Title:**	**PS-I**	**Course Code:**	**EE501**

Course description:
Power System-I explores the knowledge of parameter, characteristic of transmission line. The subject also explores the performance of transmission lines.

	Hours/week	**No. of weeks**	**Total hours**	**Semester credits**
Theory	03	15	45	**03**
Practical	02	15	30	**01**

Prerequisite course(s):

Basic Electrical and Electronics Engineering and Engineering Mathematics

Course objectives:

The objective of this course is to impart knowledge so that the student will:

1. Introduce Electrical Power System
2. Introduce operation of transmission network and distribution network
3. Develop an understanding of the technical and environmental aspects of power transmission
4. Develop professional skills required to design electrical power transmission system .
5. Provide fundamental knowledge required for modeling and analyzing transmission networks

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand the concepts of power system and importance of transmission line.
2. Estimate the parameters of transmission lines in power systems
3. Analyze performance of short transmission Line.
4. Analyze performance of medium transmission Line.
5. Analyze performance of long transmission Line.

COURSE CONTENT

POWER SYSTEM-I		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End Semester Exam (ESE) UA:**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE) CA:	**40 marks**

Unit–I	**No. of Lectures: 09 Hours**	**Marks: 12**

Structure of Power System, Overview of transmission & distribution system, Various levels of power transmission, Voltage levels at generation, Transmission and distribution, introduction to overhead transmission lines and underground cables, Introduction to category of load and load curve, load duration curve, load factor, demand factor, diversity factor, Plant capacity factor, plant use factor.

Resistance of line, Skin effect, Inductance of line: Flux linkages of a Conductor, Inductance of a Single phase two wire line, Inductance of composite conductor lines-Self and Mutual GMD, GMR

Unit–II	**No. of Lectures: 09Hours**	**Marks: 12**

Transmission Line Parameters-II

Inductance of Three phase overhead lines with symmetrical and unsymmetrical spacing, Effect of transposition, Bundled conductors, Proximity effect, Capacitance of a Transmission Line:

Electric field and potential difference, Capacitance of a Single phase overhead line, Capacitance of Three phase symmetrical and unsymmetrical spaced lines

Unit–III	No. of Lectures: 09 Hours	Marks: 12

Performance of Short Transmission Lines

Classification of Transmission Lines: short, medium & long transmission lines. Short Transmission Lines: Regulation and Efficiency of a Transmission Lines, Effect of power factor on Transmission Efficiency and voltage regulation of a line

Unit–IV	No. of Lectures: 09 Hours	Marks: 12

Performance of Medium Transmission Lines:

Medium Transmission Lines: End Condenser method, Nominal T and π, method, Ferranti Effect, Charging current and line losses in open circuited line, Effect of Capacitance on performance of loaded line, Generalised circuit constants (ABCD parameters)

Unit–V	No. of Lectures: 09 Hours	Marks: 12

Performance of Long Transmission Lines

Introduction, Analysis of Long Transmission Lines (Rigorous Method), Surge Impedance, Surge Impedance loading, Interpretation of the long line equations, Ferranti effect, equivalent circuit of a long line, power flow through a transmission line, methods of voltage control, compensation of transmission lines

Text Books:

1. D.P. Kothari & I. J. Nagrath, "Modern Power System Analysis" 4th edition Tata Mc Graw Hill

Reference Books:

1. W.D. Stevenson, Jr. " Elements of Power System Analysis", Mc Graw Hill.
2. C.L. Wadhwa, "Electrical Power System", New Age International.
3. Stagg and El-Abiad, "Computer Methods in Power System Analysis" TMH.
4. Hadi Sadat; "Power System Analysis", Tata McGraw Hill.
5. L. P. Singh; "Advanced Power System Analysis & Dynamics", New Age International
6. Chakraborthy, Soni, Gupta & Bhatnagar, "Power System Engineering", Dhanpat Rai & Co.
7. T.K Nagsarkar & M.S. Sukhija, "Power System Analysis" Oxford University Press, 2007.

NPTEL Links:

1. Power System Engineering by prof. Debapriya Das, IIT Kharagpur
   https://nptel.ac.in/courses/108105104
2. Power Electronics and Distributed Generation by Prof. Vinod John IIS Banglore
   https://nptel.ac.in/courses/108108034
3. Restructured Power System by Prof S.A. Khaparde and Dr. A.R. Abhyankar IIT delhi
   https://nptel.ac.in/courses/108101005
4. Power System Operation and Control by Prof. A.M.Kulkarni IIT Bombay
   https://nptel.ac.in/courses/108101040
5. Power System Generation, Transmission and Distribution by Prof. D.P. Kothari IIT Delhi
   https://nptel.ac.in/courses/108102047

<table>
<tr><th colspan="5">POWER SYSTEM-I LAB (PCC)</th></tr>
<tr><th colspan="5">LAB COURSE CONTENT</th></tr>
<tr><td colspan="2">POWER SYSTEM-I LAB</td><td colspan="2">Semester:</td><td>V</td><td>Course Code: EE502</td></tr>
<tr><td colspan="2">Teaching Scheme:</td><td colspan="4">Examination scheme</td></tr>
<tr><td>Practical:</td><td>2 hours/week</td><td colspan="3">End Semester Exam (ESE) UA: PR</td><td>25 marks</td></tr>
<tr><td></td><td></td><td colspan="3">Internal Continuous Assessment (ICA) CA:</td><td>25 marks</td></tr>
<tr><td colspan="2">End Semester Exam (ESE) Pattern:</td><td colspan="4">(Practical) PR</td></tr>
<tr><td colspan="6">Concerned faculty member should suitably frame SEVEN laboratory assignments from the following list.
1. Measurement of ABCD parameters of medium transmission line.
2. Measurement of ABCD parameters of Long transmission line.
3. To validate Ferranti effect on an unloaded transmission line.
4. Estimation of surge impedance loading of the transmission line.
5. Analysis of the effect of VAR compensation on the profile of receiving end voltage using capacitor bank.
6. Determination of reactive power required for zero regulation at different loads.
7. Analysis of voltage improvement of reactive power control using Tap changing transformer.
8. To determine the performance of the short transmission line by calculating its efficiency and regulation.
9. To determine the performance of the medium transmission line by calculating its efficiency and regulation.
10. To determine the performance of the long transmission line by calculating its efficiency and regulation.
11. Visit to HV/EHV substation or power generating substation.</td></tr>
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2. C.L. Wadhwa, “Electrical Power System”, New Age International.
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</table>

POWER ELECTRONICS (PCC)

COURSE OUTLINE

Course Title:	POWER ELECTRONICS	Short Title: PE	Course Code:EE503

Course description:

Technology has improved by lips and bounds making the power devices more closely to an ideal switch. Power electronics has already found an important place in modern technology and has revolutionized control of power and energy. The greater efficiency and control features of power electronics are becoming attractive for applications in motion control by replacing the earlier electro-mechanical and electronic systems. Applications in power transmission include high-voltage dc (HVDC) converter stations, flexible ac transmission system (FACTS), and static-var compensators. In power distribution these include dc-to-ac conversion, dynamic filters, frequency conversion, and Custom Power System.

	Hours/week	No. of weeks	Total hours	Semester credits
Theory	03	15	45	**03**
Practical	02	15	30	**01**

Prerequisite course(s):

Basic Electrical & Electronics Engineering, Analog and Digital Electronics.

Course objectives:

The objective of this course is to impart knowledge so that the student will:

1. Describe power semiconductor devices in thyristor family.
2. Present triggering methods, commutation methods etc. of thyristor.
3. Classify controlled rectifiers and dual converters.
4. Demonstrate dc-dc converters and their control techniques.
5. To understand the different configurations of inverters, coppers and cycloconverters.

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand the behavior and fundamentals of semiconductor devices operated as power switches, protection and reliability of the switches.
2. Analysis of the triggering and commutation techniques for devices and how to overcome on difficult issues of devices using special devices.
3. Able to design of single-phase and three-phase thyristor converters and describe the role of power electronics as an enabling technology in various applications.
4. Learn the basic concepts of operation of dc-to-dc converters and dc-to-ac inverters and be able to analyze basic converter topologies for various applications such as energy conservation, renewable energy, transportation etc.
5. Illustrate the basic concepts of operation of ac voltage controllers and cyclo-converters

COURSE CONTENT

POWER ELECTRONICS		Semester:	V
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):	**40 marks**

Unit–I	No. of Lectures: 09 Hours	Marks: 12

Thyristors: Static characteristics, turn-on methods, switching characteristics, (Turn-on and Turn-off), gate characteristics, two transistor models, ratings, protection: design of snubber circuits, di/dt, dv/dt; series and parallel operation of thyristor, string efficiency;
Thyristor family: Operating Characteristics of LASCR, Diac, Triac.

Unit–II	No. of Lectures: 09 Hours	Marks: 12

Firing circuits for thyristor: General layout, R firing circuit, RC firing circuit, UJT: basic structure, V-I characteristics

Commutation Techniques: Forced and Natural, Classification of Forced Commutation: Class A, Class B, Class C, Class D, Class E, and Class F.

Power switching devices: Introduction, Basic Structure, ON-OFF Control and Operational characteristics and Applications: Gate turn-off thyristor (GTO), Insulated Gate Bipolar Transistor (IGBT), MOSFET

Unit–III	No. of Lectures: 09 Hours	Marks: 12

Controlled Rectifiers: Single-phase full wave rectifier: mid-point converter (M-2), bridge converters (B2), with resistive and inductive load, single-phase semi-converter, with resistive and inductive load. Three phase fully converters (B-6), three-phase semi-converters with resistive and inductive load. Effect of source impedance on performance of converters.

Dual Converters: Principle of operation, ideal and practical, without and with circulating current.

Unit–IV	No. of Lectures: 09 Hours	Marks: 12

Choppers: Principle of operation, control strategies, step-down chopper, step-up chopper, types of chopper circuits: type A, type B, type C, type D, type E, thyristor chopper circuits: voltage-commutated chopper, current- commutated chopper, multi-phase choppers.

Inverters: Single-phase voltage source inverters: half-bridge and full-bridge (with Resistive and Inductive load), Mc Murry inverter, Modified three phase bridge inverters (180-Degree conduction mode Voltage source inverters)**,** Series inverter, Single Phase Parallel inverter, Introduction to PWM techniques.

Unit–V	No. of Lectures: 09 Hours	Marks: 12

AC voltage controller: Types, integral cycle control, single-phase voltage controller: half and full wave with resistive and inductive load, three phase AC voltage controller.

Cyclo converters: Principle, single-phase/single-phase, three-phase/single-phase, three-phase/three-phase, reduction of output harmonics

Text Books:

1. Dr. P. S. Bimbhra, “Power Electronic” Khanna Publishers, 3rd edition, 2012.
2. Muhammad H. Rashid, “Power electronics: circuits, devices, and applications”, Pearson Education India, Third Edition, 2012
3. M. D. Singh ,K. B. Khanchandani, “Power Electronics” Tata McGraw Hill Second edition 2007

Reference Books:

1. M. Ramamoorty, “An Introduction to Thyristors and their Applications”, East-West Press (Pvt.) Ltd., Second Edition, 2011.
2. V. R. Moorthy, “Power Electronics Devices Circuit and Industrial Applications”, Oxford University Press, First Edition, 2015.
3. L. Umanand, “Power Electronics: Essentials and Applications”, Wiley India, 2009.
4. R. W. Erickson and D. Maksimovic, “Fundamentals of Power Electronics”, Springer Science & Business Media, 2007
5. Philip T. Krein, “Elements of Power Electronics”, Oxford University Press, International Second Edition, 2016.
6. P. C. Sen, “Modern Power Electronics”, S. Chand and company, 2005.

NPTEL Links:

1. Fundamental of Power Electronics by Prof. L Umananad, IISc, Banglore
   nptel.ac.in/courses/108101126
2. Power Electronic by Prof B G Fernandes, Prof. Kishore Chatterjee, IITB
   nptel.ac.in/courses/108101038

POWER ELECTRONICS LAB (PCC)				
LAB COURSE CONTENT				
POWER ELECTRONICS LAB		**Semester:**	**V**	**Course Code: EE504**
Teaching Scheme:		**Examination scheme**		
Practical:	**2 hours/week**	**End Semester Exam (ESE) UA: PR**		**25 marks**
		Internal Continuous Assessment (ICA) CA:		**25 marks**
End Semester Exam (ESE) Pattern:		**(Practical) PR**		

Concerned faculty member should suitably frame SEVEN laboratory assignments from the following list.

1. To study of R and RC firing circuits.
2. To study of UJT firing circuits.
3. To study of characteristics of SCR and MOSFET.
4. To study of characteristics of IGBT and GTO.
5. To study forced commutation methods for SCRs.
6. To study operation of fully controlled converter with various types of loads.
7. To study operation of half controlled converter with various types of loads.
8. To study SCR parallel inverter, control circuit.
9. To study operation of SCR series inverter along controlled rectifiers.
10. To study operation of Step-down chopper.
11. To study operation of Step-up chopper with firing circuit.
12. To study the single-phase AC Voltage Controller.
13. To study the single-phase cycloconverter using simulation software
14. Study of three Phase invertors suing simulation software

Text Books

1. Dr. P. S. Bimbhra, “Power Electronic” Khanna Publishers, 3rd edition, 2012.
2. Muhammad H. Rashid, “Power electronics: circuits, devices, and applications”, Pearson Education India, Third Edition, 2012
3. M. D. Singh ,K. B. Khanchandani, “Power Electronics” Tata McGraw Hill Second edition 2007

Reference Books:

1. M. Ramamoorty, “An Introduction to Thyristors and their Applications”, East-West Press (Pvt.) Ltd., Second Edition, 2011.
2. V. R. Moorthy, “Power Electronics Devices Circuit and Industrial Applications”, Oxford University Press, First Edition, 2015.
3. L. Umanand, “Power Electronics: Essentials and Applications”, Wiley India, 2009.
4. R. W. Erickson and D. Maksimovic, “Fundamentals of Power Electronics”, Springer Science & Business Media, 2007

Guidelines for ICA:

Students must submit ICA in the form of journal. Each assignment should be well documented. Faculty in Charge will assess the assignments continuously and grade or mark of each assignment on completion date declared for each assignment.

Guide lines for ESE:PR

ESE will be based on the laboratory assignments submitted by the students in the form of journal. In ESE the student may be asked to perform any one practical. Evaluation will be based on paper work and performance in the practical.

HIGH VOLTAGE ENGINEERING LAB (PCC)					
COURSE OUTLINE					
Course Title:	**HIGH VOLTAGE ENGINEERING LAB**	**Short Title:**	**HVL**	**Course Code:**	**EE 505**

Course description: This course provides an introduction to power generation by using conventional sources. This course covers the working, selection of site, different elements of various conventional power plants. This course also provides an introduction to the economics consideration of the power plants.

	Hours/week	**No. of**	**Total hours**	**Semester credits**
Theory	3	15	45	**05**
Practical	4	15	60	

Prerequisite course(s):

Power System-I, Power System-II

Course objectives:

The objective of this course is to impart knowledge so that the student will:

1. Understand the various processes of breakdown in solid, liquid and gaseous dielectric materials.
2. Understand and apply various methods of generation and measurement of DC, AC, impulse voltage and current.
3. Enable students to understand the charge formation and separation phenomena in clouds, the causes of overvoltage and lightning phenomena,
4. Develop the ability among learners to execute testing on various high-voltage equipment as per standards.
5. Understand design, layout, safety precautions, earthing , and shielding of HV laboratory.

Course outcomes:

After successful completion of this course the student will be able to:

1. Identify, describe and analyze the breakdown theories of gaseous, solid and liquid materials.
2. Analyze the occurrence of over voltage and to provide remedial solutions.
3. Describe and use of various methods of generation of high AC, DC, impulse voltage and current.
4. Demonstrate the methods of measurement of high AC, DC, impulse voltage and current, tests on high voltage equipment and devices.
5. Study design of high voltage laboratory with all safety measures.

COURSE CONTENT

HIGH VOLTAGE ENGINEERING LAB		**Semester:**	**V**
Teaching Scheme:		**Examination scheme:**	
Lectures:	**3hour/week**	**End Semester Exam (ESE) UA: OR**	**25 marks**
Practical:	**4 hour/week**	**Internal Continuous Assessment (ICA) CA:**	**50 marks**
End Semester Exam (ESE) Pattern:		**(Oral) OR**	

Unit–I	**No. of Lectures: 09 Hours**	

Conduction and Breakdown in Air and Other Gaseous Dielectrics:

Gases as insulating media, Collision Processes, Ionization process in gas, Townsend's Theory, current growth equation in presence of primary and secondary ionization processes,

Townsend's criterion for breakdown in electronegative gases, Limitation of Townsend's theory, Panchen's law, Breakdown in non-uniform fields and corona discharges. Streamer mechanism of breakdown, Post-breakdown phenomenon and application. Practical considerations in using gas for insulation purposes. (Numerical on Townsend's theory and Paschen's law)

Unit–II	No. of Lectures: 09 Hours	

Breakdown in Liquid and Solid Dielectrics:

Liquid Dielectrics, Conduction and breakdown in pure liquids, Conduction and breakdown in commercial liquids: Suspended Particle Theory, Cavitations and bubble Theory. Solid dielectrics used in practice, Intrinsic, Electro-mechanical and Thermal breakdown, Breakdown of solid dielectrics in practice, due to chemical, electrochemical deterioration, treeing, tracking, Internal discharges. Breakdown of composite insulation, Application of insulating materials in electrical power apparatus, electronic equipment's.

Unit–III	No. of Lectures: 09 Hours	

Generation & Measurement of High Voltage and Currents:

Generation of high voltage and currents: Generation of high DC voltages by rectifier, Voltage doublers and multiplier circuits. Electrostatic machines, Generation of high AC voltage – Cascading of transformers, series and parallel Resonance transformer (system), Tesla coil. Generation of impulse voltages and currents-Impulse voltage definition, wave front and wave tail time, Multistage impulse generator, Modified Marx circuit, Tripping and control of conventional impulse generators, Introduction to Generation of high impulse current, (Design of Marx Generators circuits- numerical can be taken). Generation of switching surges. (Numerical based on impulse generation, high DC voltage generation, optimum number of stages)

Unit–IV	No. of Lectures: 09 Hours	

Measurement of High Voltages and Currents:

High ohmic series resistance with micro-ammeter., HVAC and impulse voltage- Resistance and capacitance voltage dividers, Sphere gap for measurement of High DC, AC and impulse voltages, Capacitance Voltage Transformer Measurement of High DC, AC and impulse

Unit–V	No. of Lectures: 09 Hours	

High Voltage Testing of Electrical Power Apparatus and H V Laboratories Layouts:

Non-destructive testing of dielectric materials, DC resistivity measurement, Dielectric and loss factor measurement, Partial discharge measurement. Testing of insulators and bushing, Power capacitors and cables testing, testing of surge diverters. High Voltage laboratory– design, planning and layout. - Size and dimensions of the equipment and their layout, Classification of HV laboratory, Earthing and Shielding of H.V. laboratories, its importance.

LAB COURSE CONTENT

Concerned faculty member should suitably frame **SEVEN** laboratory assignments from the following list.

1. Study of 100 kV high voltage testing set.
2. Determination of insulating break-down strength of solid, liquid and gaseous dielectric media.
3. Study of corona discharge.
4. Double voltage double frequency withstand test on transformer.
5. Calibration of sphere gap.
6. Study of Impulse Voltage Generator.
7. Parametric Analysis of Impulse Voltage Waveform.
8. Study of Impulse Current Generator.
9. Parametric Analysis of Impulse Current Waveform.
10. Critical Flashover of a Sphere Gap using IVG.
11. Functioning of Voltage Doubler.
12. 3-Stage Cockroft Walton Voltage Multiplier.

Text Books:

1. C. L. Wadhwa, “High Voltage Engineering”, New Age International Publishers Ltd
2. M. S. Naidu, V. Kamaraju, “High Voltage Engineering”, Tata McGraw Hill Publication

Reference Books:

1. E. Kuffel, W. S. Zaengl, J. Kuffel, “High Voltage Engineering Fundamentals”, Newnes Publication
2. Prof. D. V. Razevig Translated from Russian by Dr. M. P. Chourasia, “High Voltage Engineering”, Khanna Publishers, New Delhi.
3. Ravindra Arora, Wolf Gang Mosch, “High Voltage Insulation Engineering”, New Age International Publishers Ltd. Wiley Estern Ltd.
4. High Voltage Engineering Theory and Practice by M. Khalifa Marcel Dekker Inc. New York and Basel.
5. Subir Ray, “An Introduction to High Voltage Engineering” PHI Pvt. Ltd. New Delhi.

NPTEL Link:

1. High Voltage Engineering by Prof. Ravindra Arora, IIT, Kanpur nptel.ac.in/courses/108104048
2. High Voltage DC Transmission by Prof S N Singh, IIT, Kanpur nptel.ac.in/courses/108104013

Guidelines for ICA:

Students must submit ICA in the form of journal. Each assignment should be well documented. Faculty in Charge will assess the assignments continuously and grade or mark each assignment on completion date declared for each assignment.

Guide lines for ESE:OR

ESE will be based on the laboratory assignments submitted by the students in the form of journal. Evaluation will be based on answers given by students in oral examination

Program Elective Course-I (PEC)

POWER GENERATION AND ECONOMICS (PEC)

COURSE OUTLINE

Course Title:	POWER GENERATION AND ECONOMICS	Short Title: PGE	Course Code:EE506A

Course description:

This course provides an introduction to power generation by using conventional sources. This course covers the working, selection of site, different elements of various conventional power plants. This course also provides an introduction to the economics consideration of the power plants.

	Hours/week	No. of weeks	Total hours	Semester credits
Theory	03	15	45	**03**
Practical	02	15	30	**01**

Prerequisite course(s):

Course objectives:

The objective of this course is to impart knowledge so that the student will:

1. Introduce different methods of power generation and their economic aspects.
2. Analyze the economic operation of power plants and load distribution.
3. Study tariff structures and cost analysis in power systems.
4. Understand the role of renewable energy sources in power generation.
5. Evaluate the environmental and economic impacts of power generation.

Course outcomes:

After successful completion of this course the student will be able to:

1. Explain different power generation methods and their economics.
2. Analyze the cost structure of power generation and distribution.
3. Apply economic load dispatch techniques for optimal power generation.
4. Evaluate tariff structures and power pricing mechanisms.
5. Compare conventional and renewable energy sources based on economic and environmental factors.

COURSE CONTENT

POWER GENERATION AND ECONOMICS		Semester:	V
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):	**40 marks**

Unit–I	No. of Lectures: 09 Hours	Marks: 12

Introduction to Power Generation: Conventional Sources: Introduction, construction, operation and comparison of Hydroelectric Power Plant, Thermal Power Plant and Nuclear Power Plants

Unit–II	No. of Lectures: 09 Hours	Marks: 12

Introduction to Power Generation: Non-conventional Sources: Introduction, construction, operation and comparison of Solar, Wind, Biomass and Gas Turbine

Unit–III	No. of Lectures: 09 Hours	Marks: 12

Economics of Power Generation: Cost analysis: Fixed, variable, operating, and maintenance

costs. Interest and Depreciation. Load factor, diversity factor, demand factor, and plant capacity factor. Interconnected systems, base load & peak load plants. Load curve and load duration curve, Selection of Unit.

Unit–IV	No. of Lectures: 09 Hours	Marks: 12

Economic Load Dispatch: Effect of variable load on power system, load sharing. Input Output Characteristic, Incremental fuel cost, Economic load dispatch (ELD) with and without transmission losses. Lambda iteration method. Unit commitment.

Unit–V	No. of Lectures: 09 Hours	Marks: 12

Tariff and Energy Pricing: Tariffs, objective, factors affecting the tariff, types. Types of consumers. Types of tariff. Factors affecting tariff design. Power factor, disadvantages of low power factor, causes of low power factor, methods of power factor improvement, Location of Power factor correction equipment, Advantages of power factor improvement, economics of power factor improvement and comparison of methods of increasing power supplied, Choice of equipment.

Text Books:

1. B.R. Gupta, "Generation of Electrical Energy", Eurasia Publishing House (Pvt.) Ltd, Seventh Edition, 2017.
2. J.B. Gupta, "A Course in Electric Power", S.K. Kataria and Sons, Fourteenth Edition, 2013.

Reference Books:

1. Olle L. Elgerd, "Electrical Energy System Theory, An Introduction", McGraw Hill, Second Edition, 2017.
2. D.P. Kothari and I.J. Nagrath, "Modern Power System Analysis", Tata McGraw Hill Education, Fourth Edition, 2011.
3. William D. Stevenson, "Elements of Power System Analysis", Tata McGraw Hill, 4th Edition, 1985.
4. Leon K. Kirchmayer, "Economic Operation of Power Systems", Wiley India Pvt. Ltd, 2009.
5. C. L. Wadhwa, "Electrical Power System Analysis", New Age International Publication, Seventh Edition, 2017.
6. Hadi Saadat, "Power System Analysis", Tata McGraw Hill, 2nd edition, 2009.
7. A. Chakrabarti, M.L. Soni, P.V. Gupta & U.S. Bhatnagar, "A Text Book on Power System Engineering", Dhanpat Rai & Co. limited, 2016.

NPTEL Links:

1. Power Generation by Prof. D P Kothari, IIT Delhi
   nptel.ac.in/courses/108102047
2. Power System Operation and Control by Prof. A M Kulkarni, IIT, Baombay
   nptel.ac.in/courses/108101040
3. Power System Engineering by prof. Debapriya Das, IIT Kharagpur
   https://nptel.ac.in/courses/108105104

Program Elective Course-I Lab (PEC)				
POWER GENERATION AND ECONOMICS LAB (PEC)				
LAB COURSE CONTENT				
POWER GENERATION AND ECONOMICS LAB		**Semester:**	**V**	**Course Code: EE507A**
Teaching Scheme:		**Examination scheme**		
Practical:	**2 hours/week**			
		Internal Continuous Assessment (ICA) CA:		**25 marks**

Concerned faculty member should suitably frame SEVEN laboratory assignments from the following list.

1. Study of different power generation sources and their cost structures.
2. Cost comparison of conventional vs. renewable energy sources.
3. Study of base load and peak load plant.
4. Calculation of load factor, diversity factor, and plant capacity factor.
5. Study of selection of unit.
6. Economic load dispatch calculation.
7. Economic load dispatch analysis using MATLAB.
8. Tariff calculation for different consumer categories.
9. Power factor improvement calculation for different categories.
10. Case study on carbon footprint assessment of a power plant.
11. Study of a small-scale renewable energy system.
12. Field visit of conventional / non-conventional power plant.

Text Books

1. B.R. Gupta, “Generation of Electrical Energy”, Eurasia Publishing House (Pvt.) Ltd, Seventh Edition, 2017.
2. J.B. Gupta, “A Course in Electric Power”, S.K. Kataria and Sons, Fourteenth Edition, 2013.

Reference Books:

1. Olle L. Elgerd, “Electrical Energy System Theory, An Introduction”, McGraw Hill, Second Edition, 2017.
2. D.P. Kothari and I.J. Nagrath, “Modern Power System Analysis”, Tata McGraw Hill Education, Fourth Edition, 2011.
3. William D. Stevenson, “Elements of Power System Analysis”, Tata McGraw Hill, 4th Edition, 1985.

Guidelines for ICA:

Students must submit ICA in the form of journal. Each assignment should be well documented. Faculty in Charge will assess the assignments continuously and grade or mark of each assignment on completion date declared for each assignment.

Program Elective Course-I (PEC)			
ELECTRICAL MACHINE DESIGN (PEC)			
COURSE OUTLINE			
Course Title:	**ELECTRICAL MACHINE DESIGN**	**Short Title: EMD**	**Course Code:EE506B**

Course description:

The course consists of general factor of machine design, material classification, temperature rise and rating of machines. It explores the design concept of transformer core, winding overall dimension performance and cooling design of transformer. The course also provides sound understanding and basic concepts of rotating machine design.

	Hours/week	No. of weeks	Total hours	Semester credits
Theory	03	15	45	**03**
Practical	02	15	30	**01**

Prerequisite course(s):

Basic Electrical and Electronic Engineering at First Year

Course objectives:

The objective of this course is to impart knowledge so that the student will:

1. Identify the electrical engineering materials characteristic for design of electrical machines.
2. Understand the temperature rise in electrical machines and impact on rating and duty of machines.
3. Ability to design an electrical machines and components to meet desired needs within realistic constraints such as economic, environmental, social, safety, manufacturability, and sustainability.
4. Analyze the performance of designed machine.
5. Perform better in professional duties in the field of design and manufacturing industries.

Course outcomes:

After successful completion of this course the student will be able to:

1. Identify the electrical engineering materials characteristic for design of electrical machines.
2. Understand the temperature rise in electrical machines and impact on rating and duty of machines.
3. Ability to design an electrical machines and components to meet desired needs within realistic constraints such as economic, environmental, social, safety, manufacturability, and sustainability.
4. Analyze the performance of designed machine.
5. Design winding for different machines

COURSE CONTENT

ELECTRICAL MACHINE DESIGN		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):	**40 marks**

Unit–I	**No. of Lectures: 09 Hours**	**Marks: 12**

Introduction- principles of design and design factors, rating, specifications, standards, brief study of magnetic, electric, insulating and other material. Theory of solid body heating, heating and cooling time curve, rating of machines, and type of duty

Unit–II	**No. of Lectures: 09 Hours**	**Marks: 12**

Design of Transformer: Design of distribution and power Transformer,-types, classifications, specifications, core construction, transformer winding, design of transformer, output equation of single phase and three phase transformer ,overall dimension, design of core, winding, estimation of leakage reactance for H.V. and L.V. winding, resistance of winding,

Unit–III	No. of Lectures: 09 Hours	Marks: 12

Performances Transformer: No Load Current of –single phase, Three phase, Magnetizing Volt-ampere, change of parameters with change of frequency, Temperature rise of transformers , transformer oil as a cooling medium, temperature rise in plain walled tanks, design of tank with tubes ,air blast cooling, forced oil circulation , thermal rating , heating time constant of transformers.

Unit–IV	No. of Lectures: 09 Hours	Marks: 12

Induction motors: Relation between rating and dimensions of rotating Machines-symbols, Main dimensions , total loading, specific loading , output equation , factor affecting size of rotating machines , choice of specific magnetic loading , choice of specific electric loading , variation of output & losses with Linear dimensions , separation of D and L- DC Machines, Induction Motors , Synchronous Machines, standard Frames.

Design of three phase Induction Motors-design output equation, choice of average flux density in air gap, choice of ampere conductors per meter, efficiency & power factor, main dimensions.

Unit–V	No. of Lectures: 09 Hours	Marks: 12

D. C. Machine Windings- types of D.C. Windings, choice and design of simplex and duplex lap and wave Windings, equalizer connections, dummy coils, concept of multiplex Windings, reason for choosing them.

A.C. Machine Windings- single and double layer, single phase ac Windings with integral and fraction slots, three phase Windings.

Text Books:

1. A. K .Sawhney, Electric Machine Design Tenth Edition, Danpat ray and sons.

Reference Books:

1. A. E .Clayton, Performance and Design Of DC Machine, Third Edition, ELBS, ISAAC Pitman Sons.
2. N. Vinogradov, Electric Machine Winder, MIR Publication.
3. Say and Taylor, D.C. Electric Machine, ELBS, Pitman Sons.
4. Feinberg,Macmillan,Modern Power Transformer Design Practices.First Edition, Feinberg, Macmillan,
5. Transformers BHEL.

NPTEL Links:

1. Electrical Machines by Prof. G B Bhuvaneshari, IIT Delhi
   nptel.ac.in/courses/108102146
2. Computer Aided Electrical Machine Design by Prof Bhim Singh, IIT Delhi
   nptel.ac.in/courses/108102372

<table>
<tr><td colspan="5">Program Elective Course-I Lab (PCC)</td></tr>
<tr><td colspan="5">ELECTRICAL MACHINE DESIGN LAB (PEC)</td></tr>
<tr><td colspan="5">LAB COURSE CONTENT</td></tr>
<tr><td colspan="2">ELECTRICAL MACHINE DESIGN LAB</td><td colspan="2">Semester: V</td><td>Course Code: EE507B</td></tr>
<tr><td colspan="2">Teaching Scheme:</td><td colspan="3">Examination scheme</td></tr>
<tr><td>Practical:</td><td>2 hours/week</td><td colspan="2"></td><td></td></tr>
<tr><td></td><td></td><td colspan="2">Internal Continuous Assessment (ICA) CA:</td><td>25 marks</td></tr>
<tr><td colspan="2"></td><td colspan="3"></td></tr>
<tr><td colspan="5">Concerned faculty member should suitably frame SEVEN laboratory assignments from the following list.
1. Determination of magnetic characteristic.
2. Dielectric test of paper insulation.
3. Design of DC Motor Starter.
4. Design of Slip Ring Induction Motor Starter.
5. Design of Single Phase Transformer.
6. Design of main dimension of DC Motor
7. Design of main dimension of AC Motor
8. Layout of Distribution Transformer Design
9. Layout of AC Machine winding
10. Layout of DC Machine winding</td></tr>
<tr><td colspan="5">Text Books:</td></tr>
<tr><td colspan="5">1. A. K .Sawhney, Electric Machine Design Tenth Edition, Danpat ray and sons.</td></tr>
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2. N. Vinogradov, Electric Machine Winder, MIR Publication.
3. Say and Taylor, D.C. Electric Machine, ELBS, Pitman Sons.
4. Feinberg,Macmillan,Modern Power Transformer Design Practices, First Edition, Feinberg, Macmillan,
5. Transformers BHEL.</td></tr>
<tr><td colspan="5">Guidelines for ICA:</td></tr>
<tr><td colspan="5">Students must submit ICA in the form of journal. Each assignment should be well documented. Faculty in Charge will assess the assignments continuously and grade or mark of each assignment on completion date declared for each assignment.</td></tr>
</table>

Program Elective Course-I (PEC)			
SPECIAL ELECTRICAL MACHINES (PEC)			
COURSE OUTLINE			
Course Title:	**SPECIAL ELECTRICAL MACHINES**	**Short Title: SEM**	**Course Code:EE506C**

Course description:

The course explore additional knowledge of electrical machines for special purpose application. The course deal in construction, working operation, characteristic and application of special machines like unexcited synchronous motor permanent magnet and brushless dc motors.

	Hours/week	**No. of weeks**	**Total hours**	**Semester credits**
Theory	03	15	45	**03**
Practical	02	15	30	**01**

Prerequisite course(s):

Electrical Machines

Course objectives:

The objective of this course is to impart knowledge so that the student will:

1. Understand the working of special machines like stepper motor, switched reluctance motor, BLDC motor & PMSM.
2. Derive torque equation and study the characteristics of special machines
3. Design the controller for special machines
4. Study the working principle of synchronous reluctance motor
5. Simulate closed loop operation of BLDC motor

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand the working of special machines like stepper motor, switched reluctance motor, BLDC motor & PMSM.
2. Derive torque equation and study the characteristics of special machines
3. Design the controller for special machines
4. Identify the applications of special machines based on torque and characteristic.
5. Simulate closed loop operation of BLDC motor

COURSE CONTENT

SPECIAL ELECTRICAL MACHINES		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):	**40 marks**

Unit–I	**No. of Lectures: 09 Hours**	**Marks: 12**

Construction, working principal, torque equation, torque speed characteristic, speed control, braking and application of Single phase synchronous motor, reluctance motor and Hysteresis motor.

Unit–II	**No. of Lectures: 09 Hours**	**Marks: 12**

Construction, working principal, torque equation, torque speed characteristic, speed control, braking and application of DC Servomotor, AC Servomotor, Two-phase AC Servomotor, Three phase Servomotor, comparison of servomotor and conventional motor.

Unit–III	**No. of Lectures: 09 Hours**	**Marks: 12**

Construction, working principal, torque equation, torque speed characteristic, speed control, braking and application of Stepper motor, variable reluctance stepper motor, permanent magnet

stepper motor, hybrid stepper motor.

Unit–IV	No. of Lectures: 09 Hours	Marks: 12

Construction, working principal, torque equation, torque speed characteristic, speed control, braking and application of Permanent magnet AC motor(PMAC) drive, Permanent magnet DC motor(PMDC), Brushless DC motor, Printed circuit board motor.

Unit–V	No. of Lectures: 09 Hours	Marks: 12

Construction, working principal, torque equation, torque speed characteristic, speed control, braking and application of Universal motor, Linear Induction motor, Traction motor

Text Books:

1. Ashfaq Husain, “Electrical Machines”, Dhanpat Rai &Co.
2. K. Venkataratnam, “Special Electrical Machines”, Universities Press, 2008.
3. T. J. E. Miller, “Brushless Permanent Magnet and Reluctance Motor Drives”, Oxford University Press.

Reference Books:

1. R. Krishnan, “Switched Reluctance Motor Drives”, CRC Press.
2. E. G. Janardanan, “Special Electrical Machines”, PHI Learning.
3. T. J. E. Miller, “Switched Reluctance Motors and Their Control,” Magna Physics Publishing.
4. R. Krishnan, “Electric Motor Drives: Modeling,” Analysis and Control, Pearson.

NPTEL Links:

1. Electrical Machines by Prof. G B Bhuvaneshari, IIT Delhi
   nptel.ac.in/courses/108102146
2. Electrical Machines By Prof Tapas Bhattacharya, IIT Kharakpur
   nptel.ac.in/courses/108105155
3. Advanced Electric Drive by Prof P S Das, IIT Kanpur
   nptel.ac.in/courses/108104011

Program Elective Course-I Lab (PEC)				
SPECIAL ELECTRICAL MACHINES LAB (PEC)				
LAB COURSE CONTENT				
SPECIAL ELECTRICAL MACHINES LAB		**Semester:**	**V**	**Course Code: EE507C**
Teaching Scheme:		**Examination scheme**		
Practical:	**2 hours/week**			
		Internal Continuous Assessment (ICA) CA:		**25 marks**

Concerned faculty member should suitably frame SEVEN laboratory assignments from the following list.

1. Study and Testing of Stepper Motor
2. Characteristics of Permanent Magnet DC (PMDC) Motor
3. Speed Control of Switched Reluctance Motor (SRM)
4. Performance Analysis of Brushless DC (BLDC) Motor
5. Operation and Testing of Linear Induction Motor
6. Synchronous Reluctance Motor (SynRM) Study
7. Testing of Single Phase Hysteresis Motor
8. Torque-Speed Characteristics of Universal Motor
9. Control of Servo Motor (AC/DC)

Text Books:

1. Ashfaq Husain, “Electrical Machines”, Dhanpat Rai &Co.
2. K. Venkataratnam, “Special Electrical Machines”, Universities Press, 2008.
3. T. J. E. Miller, “Brushless Permanent Magnet and Reluctance Motor Drives”, Oxford University Press.

Reference Books:

1. R. Krishnan, “Switched Reluctance Motor Drive”s, CRC Press.
2. E. G. Janardanan, “Special Electrical Machines”, PHI Learning.
3. T. J. E. Miller, “Switched Reluctance Motors and Their Control,” Magna Physics Publishing.
4. R. Krishnan, “Electric Motor Drives: Modeling,” Analysis and Control, Pearson.

Guidelines for ICA:

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SIGNALS AND SYSTEM (MD M)					
COURSE OUTLINE					
Course Title:	**SIGNALS AND SYSTEM**	**Short Title:**	SS	**Course Code:**	**EE - 508**

Course description:

Signals play a major role in our life and it can be represented in a number of ways. Signal processing is a method of extracting information from the signal which in turn depends on type of signal and the nature of information it carries. This course describes the various signals with the help of mathematical tools such as FT, LT and ZT. It also introduces the state space approach of system..

	Hours/week	No. of weeks	Total hours	Semester credits
Theory	02	15	30	02

Prerequisite course(s):

Engineering Mathematics

Course objectives:

The objective of this course is to impart knowledge so that the student will :

1. Introduce the students to the various signals.
2. Study and understanding of representation of signals and systems.
3. Learn and understand different Transforms for Digital Signal Processing
4. Analysis of Discrete Time signals and systems
5. Determine state model of linear system.

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand the mathematical concepts of signal representation and transformations with their analysis.
2. Development of ability for generating proper solution to signal processing problems.
3. Students will be capable of understanding Digital Signal Processing and the analysis.
4. Apply initial and final valve theorem to the circuit.
5. Determine state model of linear system.

COURSE CONTENT

SIGNALS AND SYSTEM		**Semester:**	**V**
Teaching Scheme:		**Examination scheme:**	
Lectures:	**2 hours/week**	**End semester exam (ESE) UA:**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exams (ISE) CA:	**40 marks**
		Internal Continuous Assessment (ICA) CA:	**25 marks**

Unit–I:	**No. of Lectures: 06 Hours**	**Marks: 12**

Signals: Definition, Continuous Time signal, Discrete Signal, Signal representation: Graphical, Functional, Tabular and Sequence. Basic Elementary signals and their relationships: Unit Impulse, Unit step, Unit ramp, Unit parabolic, rectangular pulse, Triangular, Signum, Sinusoidal, Real exponential, Complex exponential, Sinc and Gaussian function. **System:** Definition, Classification, static and dynamic systems, causal and non-causal systems, Linear and Non-linear systems, time variant and time invariant systems, stable and unstable systems.**Simple manipulations of discrete time signals**-shifting, folding, time scaling. Representations of systems, Linear differential equations, Impulse response of a system, Sampling theorem

Unit–II:	**No. of Lectures: 06 Hours**	**Marks: 12**

Introduction to Fourier Series: Fourier Series (FS) representation of periodic continuous-Time (CT) signals using trigonometric and exponential forms, Dirichlet conditions for the existence of Fourier Series, Gibbs phenomenon. **Fourier Transform (FT):** Fourier Transform representation of aperiodic CTsignals; Dirichlet conditions for the existence of Fourier Transform; evaluation of magnitude and Phase response;Fourier Transform of standard CT signals; properties and their significance. **Discrete Fourier Transforms (DT):**Discrete convolution, properties of convolution, circular convolution.

Unit–III:	No. of Lectures: 06 Hours	Marks: 12

Laplace Transforms Definition, Region of Convergence (ROC), LT of some important function and numerical. Initial value theorem, Final value theorem. Convolution integral. S-Plane Poles and Zeros and numerical. Application of LT only in series R-L circuit and series R-C circuit.

Unit–IV:	No. of Lectures: 06 Hours	Marks: 12

Z-Transforms: Introduction, definition, Region of convergence (ROC), properties of the ROC for the z transform and numerical. Properties of z-transform such as Linearity, Time Reversal, Time Shifting, Scaling, Differentiation, Convolution and numerical based on these properties

Unit–V:	No. of Lectures: 06 Hours	Marks: 12

State space analysis: Concept of state (State variable and state model). State model of linear system. Eigen Values of Matrix A. Solution of state equation. Properties of State Transition Matrix and numerical

Text Books:

1. I. J. Nagrath, M. Gopal, "Control system engineering" New age, 5th edition, 2008.
2. Katsuhiko Ogata, "Modern Control engineering" Pearson, 5thdition, 2011.
3. S. Salivahanan, C. Gnanpriya, " Digital Signal processing", Tata McGraw Hill, 2001

Reference Books:

1. John G. Proakis, Dimitris G. Manolakis, "Digital Signal Processing: Principles, algorithms and applications" Fourth edition, Pearson Prentice Hall.
2. A. V. Oppenheim, A.S. Willsky and I.T. Young, "Signals and Systems" Prentice Hall, 1983.
3. A. Anand Kumar, "Signals and Systems", PHI, 2nd edition, 2012.
4. Rishabh Anand, "Signals and Systems", Khanna Book Publishing Co., Delhi
5. Tarun Rawat, "Signals and Systems", Oxford University Press, 2010.
6. B.P. Lathi, " Signal Processing and Linear Systems", Oxford University Press, 2006

NPTEL Links:

1. Principle of Signals and System by Prof Aditya Jagannatham, IIT Kanpur nptel.ac.in/courses/108104100
2. Estimation of Signals and System by Prof S Mukhopadhyay, IIT Kharagpur nptel.ac.in/courses/108105059

Guidelines for ICA:

Students must submit ICA in the form of journal. Concerned faculty member should suitably frame **FIVE** assignments based on the above syllabus. Faculty in charge will assess the assignments continuously, and grade or mark each assignment on completion date declared for each assignment.

Kavayitri Bahinabai Chaudhari NORTH MAHARASHTRA UNIVERSITY, JALGAON (M.S.)

Third Year Bachelor of Engineering

in

(Common for all)

(As per NEP 2020 Guidelines)

Faculty of Science and Technology



COURSE OUTLINE FOR OPEN ELECTIVE - III

For Affiliated Colleges

Semester – V

W.E.F. 2026 – 27

Open Elective – III

A Student can opt for any one subject out of available institute wide subjects defined in the following list as Open Elective provided, he/she has not taken that particular subject in his/her Programme core, Programme elective, Multidisciplinary Minor, other Open elective and Vocational and Skill Enhancement courses etc. throughout his / her four years of UG Engineering Programme. The student must opt a subject that is compulsorily from faculty other than that of the Major discipline.

Course Code	Name of the Subject / Course	Faculty Offered by	Department Offered by
Open Elective - III (w.e.f. 2026 - 27 at Semester - V, Third Year Engineering)			
OE – 509 A	Legal Aspects of Business	Comm. & Mgmt.	Management
OE – 509 B	Modern Office Management	Comm. & Mgmt.	Commerce
OE – 509 C	Food Adulteration and Safety	Sci. & Tech.	Environment
OE – 509 D	Insurance Management	Comm. & Mgmt.	Commerce
OE – 509 E	Indian Social Problems	Humanities	Sociology
OE – 509 F	Disaster Management	Sci. & Tech.	Environment
OE – 509 G	Pharma Marketing Management	Sci. & Tech.	Pharmacy
OE – 509 H	Circular Economy	Humanities	Economics

LEGAL ASPECTS OF BUSINESS (Open Elective – III)					
COURSE OUTLINE					
Course Title:	**LEGAL ASPECTS OF BUSINESS**	**Short Title:**	LAB	**Course Code:**	OE – 509 A

Course description:

This course provides a concise overview of the legal framework governing business in India, covering contracts, sale of goods, negotiable instruments, intellectual property rights, company law, and cyber law. It equips students with basic legal knowledge and practical understanding required for lawful, ethical, and effective business decision-making in a digital environment.

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
	02	15	30	02

Prerequisite course(s):

Basics of Law, Legal Environment of Business, Mercantile Law

Course objectives:

The objective of this course is to impart knowledge so that the student will:

1. Understand the basic concepts and rules of contracts as per the Indian Contract Act.
2. Learn the legal provisions related to sale of goods and negotiable instruments.
3. Know the importance and protection of intellectual property rights with reference to the Patents Act, Copyright Act, and Trade Marks Act.
4. Understand the basic structure and working of companies according to the Companies Act.
5. Understand digital laws, cybercrimes, and data protection as guided by the Information Technology Act.

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand the basic principles and essentials of contracts under the Indian Contract Act.
2. Apply provisions of Sale of Goods and Negotiable Instruments laws in business transactions.
3. Explain the importance and protection of Intellectual Property Rights in business.
4. Understand the formation and legal framework of companies under company law.
5. Identify cyber laws, digital transactions, and data protection under the Information Technology Act.

COURSE CONTENT

LEGAL ASPECTS OF BUSINESS		Semester:	V
Teaching Scheme:		**Examination scheme**	
Lectures:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**

Unit–I:	No. of Lectures: 06 Hours	

INDIAN CONTRACT ACT, 1872

Contract: Definition and meaning-Essentials of contract
Classification of Contracts, Offer and Acceptance
Consideration: Definition, Essentials of a Valid Consideration –Capacity to contract
Free Consent: Coercion, Undue influence, Fraud, Misrepresentation and Mistake

Unit–II:	No. of Lectures: 06 Hours	

SALES OF GOODS ACT, 1930 & Negotiable Instruments Act 1881

Sale of Goods Act 1930: Sale and agreement to sell, Conditions and warranties, Transfer of ownership, rights of unpaid seller.
Negotiable Instruments Act 1881: Meaning, type of negotiable instruments; promissory note, bill of exchange, cheque. Endorsement and negotiation, Dishonour and legal remedies

Unit–III:	**No. of Lectures: 06 Hours**	

INTELLECTUAL PROPERTY RIGHTS

Intellectual Property Rights-Meaning, Need and Importance of Intellectual Property
Patents Act, 1970 (2002): Definition, Objectives, Nature, and Types of Patents,
Transfer of Patent Rights, Rights of Patentee.
Copyright Act, 1957-Concept, Objectives, Nature, Criteria for protection, Ownership, Duration, and Copy Right in Computer Programmes.
Trademark Act 1999 (Amendment Act 2010)- Concept, Registration, rights of registered proprietor, infringement and defenses.

Unit–IV:	**No. of Lectures: 06 Hours**	

COMPANIES ACT, 1956 (Amended 2013)

Meaning, Definition and characteristics and kinds of company.
Memorandum of Association - Meaning, Purpose, Contents
Doctrine of Ultra-Vires
Articles of Association - Meaning Purpose, Content. Alternation, Constructive Notice

Unit–V:	**No. of Lectures: 06 Hours**	

The Information Technology Act, 2000 (Amended 2008)

Introduction, Digital Signatures and Electronic records, Electronic governance
Cyber-crimes: hacking, phishing, identity theft, cyber fraud and remedies
Data protection, privacy and digital compliance
Important Provision of Information Technology Act 2000

Text Books:

1. Legal Aspects of Business (8th ed.). McGraw Hill Education. - Akhileshwar Pathak

Reference Books:

1. Legal Aspects of Business – David Albuquerque
2. Business Law – N.D.Kapoor
3. Mercantile Law – M. C. Kuchhal and Vivek Kuchhal

NPTEL Links:

- https://nptel.ac.in/courses/129106006
- https://onlinecourses.swayam2.ac.in/e-learning/preview/cec21_mg02
- https://onlinecourses.nptel.ac.in/noc26_mg30/preview

Guidelines for ICA:

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MODERN OFFICE MANAGEMENT (Open Elective – III)					
COURSE OUTLINE					
Course Title:	**MODERN OFFICE MANAGEMENT**	**Short Title:**	MOM	**Course Code:**	OE – 509 B

Course description:
This course introduces the concepts and practices of modern office management in a technology-driven environment. It covers office structure, layout, communication, documentation, and record management, along with digital office tools and automation. The course also focuses on office personnel management, professional behaviour, productivity skills, and emerging trends preparing students to manage contemporary offices effectively.

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
	02	15	30	02

Prerequisite course(s):
Fundamentals of Office Administration, Business Communication, Office Administration and Secretarial Practice

Course objectives:
The objective of this course is to impart knowledge so that the student will:
1. Understand basics of modern office management and emerging office trends.
2. Learn office layout, systems, and workplace environment management.
3. Develop skills in office communication, documentation, and services.
4. Understand records management, meetings, and office automation.
5. Build competencies in personnel management and productivity skills.

Course outcomes:
After successful completion of this course the student will be able to:
1. Explain concepts and modern trends of office management.
2. Apply office layout, systems, and environmental principles.
3. Demonstrate office communication, documentation, and services.
4. Analyze records management, meetings, and office automation.
5. Evaluate personnel management, productivity, and emerging trends.

COURSE CONTENT

MODERN OFFICE MANAGEMENT		Semester:	V
Teaching Scheme:		**Examination scheme**	
Lectures:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**

Unit–I:	No. of Lectures: 06 Hours	

Introduction to Modern Office Management

Modern Office: Meaning, Definition, Characteristics, Functions and Past–Present–Future
Office Management: Meaning, Elements and Office as Service & Information Centre
Office Organisation: Office Manager- Functions, Duties, Responsibilities
Modern Trends in Office: Paperless Office and Virtual Office

Unit–II:	No. of Lectures: 06 Hours	

Office Layout and Environment

Office Systems: Objectives, Flow of Work, Planning and Scheduling
Office Layout: Meaning, Objectives, Principles, Types
Office Infrastructure & Facilities Management
Office Environment: Meaning, Factors & Importance Office Safety & Remedies

Unit–III:	No. of Lectures: 06 Hours	

Office Communication, Forms and Services

Office Communication: Internal & External Communication, Digital Communication
Business Documentation: Report Writing, Documentation and Office Correspondence
Office Forms: Types, Control, Stationery- Standardisation and Issues
Mail & Communication Services: Courier, Speed Post, Fax and E-mail Services

Unit–IV:	**No. of Lectures: 6 Hours**	

Office Record Management

Records Management: Meaning, Objectives and Organisation of Record Department
Office Meetings - Meaning, Definition, Purpose, Types of meeting
Filing & Retrieval Systems: Physical and Electronic Records, Retention and Disposal
Digital Office & Automation: E-Office, Office Software Tools and Automation Systems

Unit–V:	**No. of Lectures: 06 Hours**	

Office Personnel Management and Emerging Trends

Office Personnel Management: Types, Qualities, Recruitment, and Training
Professional Behaviour: Ethics, Discipline, Leadership and Team Coordination
Productivity Skills: Time Management and Stress Management
Emerging Trends in Office: Remote Work and Green Office Practices

Text Books:

- Office Management & Control – G.R.Terry

Reference Books:

1. Office Organization and Management – S. P. Arora, Vikas Publishing House Pvt. Ltd., New Delhi.
2. Office Organisation & Management – R.K. Chopada & Ankita Chopada, Himalaya Publishing House, Mumbai.
3. Office Management – I. M. Sahai, Kitab Mahal, Allahabad.
4. Office Management – P. K. Ghosh, Sultan Chand & Sons, New Delhi.

NPTEL Links:

- https://onlinecourses.swayam2.ac.in/e-learning/preview/nou23_mg05
- https://onlinecourses.swayam2.ac.in/e-learning/preview/cec21_mg24
- https://onlinecourses.swayam2.ac.in/e-learning/preview/imb24_mg54

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FOOD ADULTERATION AND SAFETY (Open Elective – III)					
COURSE OUTLINE					
Course Title:	**FOOD ADULTERATION AND SAFETY**	**Short Title:**	FAS	**Course Code:**	**OE – 509 C**

Course description:
This course is designed to impart basic knowledge on identifying major types of food adulterants and contamination, food safety hazards using engineering and microbiological principles, Interpret food laws and regulatory standards relevant to engineering practice.
Also, to emphasize the roles of students in basic food safety management frameworks.

	Hours/week	**No. of weeks**	**Total hours**	**Semester credits**
Theory	02	15	30	02

Prerequisite course(s):

Course objectives:

The objective of this course is :

1. To introduce the principles of food safety, food adulteration, and regulatory standards.
2. To explain types, sources, and detection of food adulterants using scientific and engineering approaches.
3. To familiarize students with national and international food safety regulations including FSSAI, Codex, ISO and HACCP.
4. To develop understanding of food contaminants, toxicants, and risk assessment methodologies.
5. To apply quality assurance and analytical techniques relevant to food safety monitoring.

Course outcomes:

Upon successful completion of this course the student will be able to:
CO1: Explain concepts of food safety, hazards, and adulteration mechanisms.
CO2: Identify and classify food adulterants and contaminants in different food matrices.
CO3: Apply analytical and instrumental techniques for detection of adulterants.
CO4: Interpret regulatory frameworks and food safety management systems.
CO5: Analyze risk assessment models and quality control measures in food systems.

COURSE CONTENT

FOOD ADULTERATION AND SAFETY		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**

Unit–I:	**No. of Lectures: 06 Hours**

Fundamentals of Food Safety and Adulteration

- Concept and importance of food safety
- Definitions: Food safety, food quality, food security
- Types of food hazards: Biological, Chemical, Physical
- Concept of food adulteration
- Intentional and incidental adulteration
- Food contamination vs adulteration
- Food safety challenges in developing countries
- Overview of global food safety issues
- Role of regulatory bodies
- Food standards and their significance

Unit–II:	No. of Lectures: 06 Hours	
Food Adulterants and Contaminants		

- Common food adulterants in cereals, pulses, milk, fats & oils, spices
- Chemical contaminants: Pesticide residues, heavy metals, industrial chemicals
- Natural toxins: Mycotoxins, plant toxins, marine toxins
- Veterinary drug residues
- Food additives and misuse
- Packaging contaminants
- Emerging contaminants
- Health effects of adulterants
- Case studies of major food adulteration incidents.

Unit–III:	No. of Lectures: 06 Hours	
Detection and Analytical Techniques		

- Sampling methods and protocols
- Classical methods of detection
- Chromatographic techniques (HPLC, GC)
- Analytical Methods (UV-Vis, IR, NMR, Mass Spectrometry)
- Biosensors in food safety
- Molecular methods (PCR-based detection)
- Rapid detection kits
- Validation of analytical methods

Unit–IV:	No. of Lectures: 06 Hours	
Food Safety Regulations and Standards		

- Codex Alimentarius Commission
- WTO agreements (SPS & TBT)
- Food Safety and Standards Act (India)
- FSSAI regulations
- ISO 22000 and Food Safety Management Systems
- HACCP principles and implementation
- Good Manufacturing Practices (GMP)
- Good Hygienic Practices (GHP)
- Risk analysis framework
- Traceability and recall systems.

Unit–V:	No. of Lectures: 06 Hours	
Risk Assessment and Quality Assurance		

- Risk assessment framework
- Hazard identification
- Exposure assessment
- Dose-response assessment
- Risk characterization
- Quality control tools
- Statistical quality control in food industry
- Validation and verification
- Food safety auditing

- Emerging technologies in food safety monitoring.

Text Books:

- **Food Safety and Standards**
  Authors: K. Ramawat & J. Kumar
  Publisher: CRC Press / Springer
  — Primary text for syllabus topics.
- **Food Safety & Quality Assurance: Principles and Practices**
  Author: Sunetra Roday
  Publisher: Wiley
  — Excellent coverage of adulteration, contaminants, and quality assurance concepts.
- **Food Safety and Standards in India**
  Author: B. Srilakshmi
  Publisher: New Age International
  — Strong regulatory focus (FSSAI, legal frameworks, standards).

Reference Books:

- **Food Analysis**
  Authors: S. Suzanne Nielsen
  Publisher: Springer
  Detailed analytical techniques for food adulterants and contaminants.
- **Principles of Food Toxicology**
  Authors: D. R. Heldman & D. B. Lund (Ed.)
  Publisher: Springer / CRC Press
  Toxin mechanisms, chemical hazards, risk assessment.

NPTEL Links:

- **Food Safety and Quality Management**
  https://nptel.ac.in/courses/126105011
- **Food Packaging Technology**
  https://nptel.ac.in/courses/126105010
- **Food Chemistry and Technology**
  https://nptel.ac.in/courses/126105013
- **Food Processing and Preservation**
  https://nptel.ac.in/courses/126105012

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INSURANCE MANAGEMENT (Open Elective – III)					
COURSE OUTLINE					
Course Title:	**INSURANCE MANAGEMENT**	**Short Title:**	IM	**Course Code:**	**OE – 509 D**

Course description:
This course provides a fundamental understanding of insurance concepts, principles, and practices. It covers life and general insurance products, legal and regulatory frameworks, underwriting and claims management, and the role of insurance in economic development. The course equips students with essential knowledge of insurance operations and industry practices, preparing them for opportunities in the insurance and financial services sector.

	Hours/week	**No. of weeks**	**Total hours**	**Semester credits**
Theory	02	15	30	02

Prerequisite course(s):

Basic knowledge of Commerce / Economics
Fundamental understanding of Financial Systems and Banking

Course objectives:

The objective of this course is:
1. To introduce students to the basic concepts, principles, and functions of insurance.
2. To provide knowledge of life and general insurance products and their features.
3. To familiarize students with the legal and regulatory framework of insurance in India.
4. To understand the role of insurance in economic development and financial stability.
5. To develop understanding of insurance operations including underwriting and claims management.

Course outcomes:

After successful completion of this course the student will be able to:
1. Explain the fundamental principles and functions of insurance.
2. Differentiate various life and general insurance products.
3. Describe the legal and regulatory framework governing insurance in India.
4. Analyze the contribution of insurance to economic development.
5. Understand underwriting, claims settlement, and operational practices in insurance companies.

COURSE CONTENT

INSURANCE MANAGEMENT		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**

Unit–I:	**No. of Lectures: 06 Hours**	

Fundamentals of Insurance

Meaning and definition of insurance Nature, scope and functions of insurance
Evolution and importance of insurance
Principles of insurance – Utmost Good Faith, Insurable Interest, Indemnity, Subrogation, Contribution, Proximate Cause
Types of insurance

Unit–II:	**No. of Lectures: 06 Hours**	

Life and General Insurance Products

Life Insurance – Term, Whole Life, Endowment, Annuities & Pension Plans
Basic concept of premium and mortality table
General Insurance – Fire, Marine, Motor and Health Insurance

Crop, Rural and Group Insurance Maturity and Death Claims		
Unit–III:	**No. of Lectures: 06 Hours**	
Legal and Regulatory Framework of Insurance		
LIC Act, 1956 General Insurance Act, 1972 IRDA Act, 1999 and Functions of IRDA Actuaries Act, 2006 Regulatory and ethical practices in insurance		
Unit–IV:	**No. of Lectures: 06 Hours**	
Insurance and Economic Development		
Role of insurance in economic development Growth of life and general insurance in India Liberalization of insurance sector and its impact Issues, challenges and future potential of insurance industry		
Unit–V:	**No. of Lectures: 06 Hours**	
Insurance Operations and Governance		
Underwriting – Meaning and principles (Life & General Insurance) Claims Management – Life and General Insurance Insurance agents – Licensing, functions and code of conduct Consumer protection and grievance redressal mechanism		
Text Books:		
1. **Fundamentals of Insurance** – Dr. P.K. Gupta, Himalaya Publishing House		
Reference Books: 1. Insurance: Principles And Practice – M.N. Mishra & S B Mishra, S Chand Publishing 2. Principles of Insurance Management – Neelam C Gulati, Excel Books 3. **Principles and Practice of Insurance by P. Periasamy** A.K. Basu, Himalaya Publishing House		
ONLINE COURSES SWAYAM Links: https://onlinecourses.swayam2.ac.in/e-learning/preview/cec20_mg24		
Guidelines for ICA:		
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INDIAN SOCIAL PROBLEMS (Open Elective – III)					
COURSE OUTLINE					
Course Title:	**INDIAN SOCIAL PROBLEMS**	**Short Title:**	ISP	**Course Code:**	**OE-509 E**

Course description:
This course introduces students to the sociological understanding of major social problems in India. The course includes the concept, characteristics, and approaches to the study of social problems and proceeds to examine key issues such as poverty, unemployment, population growth, and urbanization. It further explores violence against women, child labour, crime, and corruption as structural challenges affecting Indian society.

	Hours/week	**No. of weeks**	**Total hours**	**Semester credits**
Theory	02	15	30	02

Prerequisite course(s):

Course objectives:
The objective of this course is to:
1. Understand the concept and approaches to social problems in the Indian context.
2. Analyze fundamental economic and demographic social issues in India.
3. Examine population growth and urbanization and their effects on society.
4. Understand gender and child-related social problems with sociological insight.
5. Identify and evaluate crime and corruption as structural social problems.

Course outcomes:
After successful completion of this course the student will be able to:
1. Explain the sociological concept and approaches to social problems.
2. Discuss poverty and unemployment with causes and consequences.
3. Analyze the issues of population growth and urbanization in India.
4. Describe violence against women and child labour with social impacts.
5. Explain crime and corruption as social problems and suggest measures.

COURSE CONTENT

INDIAN SOCIAL PROBLEMS		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**

Unit–I:	**No. of Lectures: 06 Hours**	

Social Problems: Meaning, Characteristics of Social Problems, Types of Social Problems, Approaches to the Study of Social Problems: Social Pathology Approach, Social Disorganization Approach, Value-Conflict Approach, Deviance Approach, Methods of Studying Social Problems

Unit–II:	**No. of Lectures: 06 Hours**	

Poverty: Meaning & Types, Causes of Poverty, Consequences of Poverty, Measures for Eradication
Unemployment: Meaning & Types, Causes, Consequences, Measures to Reduce Unemployment

Unit–III:	**No. of Lectures: 06 Hours**	

Population Growth: Growth of Population in India, Causes & Consequences, Population Control Measures
Urbanization: Meaning of Urbanization, Causes of Urbanization, Problems of Urbanization, Remedies for Urban Problems

Unit–IV:	**No. of Lectures: 06 Hours**	

Violence Against Women: Meaning & Forms, Causes & Consequences, Measures to Control
Child Labour & Child Abuse: Meaning & Causes, Problems of Child Labour & Abuse, Measures

to Eliminate		
Unit–V:	**No. of Lectures: 06 Hours**	
Crime and Criminals: Meaning of Crime, Types of Crime, Causes, Prevention & Control Corruption: Meaning of Corruption, Causes & Consequences, Measures to Control Corruption		
Text Books:		
1. Ahuja, Ram. *Social Problems in India*. 4th ed., Rawat Publications, 2021.		
Reference Books: 1. G. R. Madan – Indian Social Problems, Allied Publishers 2. C. N. Shankar Rao – Sociology of Indian Society, S. Chand Publications 3. Vidya Bhushan & D. R. Sachdeva – Introduction to Sociology, Kitab Mahal Publications 4. M. N. Srinivas – Social Change in Modern India, Orient Longman / Oxford University Press 5. R. Desai – Rural Sociology in India, Bombay Popular Prakashan		
NPTEL Links: 1. https://onlinecourses.swayam2.ac.in/cec25_hs92/preview 2. https://onlinecourses.nptel.ac.in/noc24_hs140/preview		
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DISASTER MANAGEMENT (Open Elective-III)					
COURSE OUTLINE					
Course Title:	**DISASTER MANAGEMENT**	**Short Title:**	**DM**	**Course Code:**	**OE – 509 F**

Course description:
The course aims to develop an understanding of disaster management concepts, disaster risk reduction, preparedness, response, and recovery, with emphasis on managing natural and man-made disasters effectively.

	Hours/week	**No. of weeks**	**Total hours**	**Semester credits**
Theory	**02**	**15**	**30**	02

Prerequisite course(s):

Course objectives:

The objective of this course is to:

1. Understand fundamental concepts of disasters, hazard, vulnerability, risk and their engineering relevance.
2. Identify and classify natural and anthropogenic disasters and their underlying causes.
3. Explain disaster management principles, phases of disaster cycle and mitigation strategies.
4. Describe institutional frameworks, stakeholders, tools, and technologies used in Disaster Management in India and globally.
5. Apply learned skills to analyze disaster case studies, ethical issues and engineering interventions for disaster risk reduction.

Course outcomes:

Upon successful completion of the course, the students will be able to:

1. Define and explain key disaster concepts, types and impacts.
2. Distinguish between natural and man-made disasters and summaries control measures.
3. Illustrate stages of disaster management cycle and preparedness planning.
4. Evaluate roles of different stakeholders and tools in managing disaster events.
5. Analyze disaster case studies and articulate ethical, legal and policy issues.

COURSE CONTENT

DISASTER MANAGEMENT		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 Marks**

Unit–I:	**No. of Lectures: 06**	

Introduction & Disasters Fundamentals

Overview of Disaster Management: Definitions: Disaster, Hazard, Risk, Vulnerability, Capacity, Historical perspective & impacts (environment, society, economy)

Understanding Disasters: Nature, causes & classification of disasters, Concept of exposure, resilience, capacity

Unit–II:	**No. of Lectures:06**	

Natural & Anthropogenic Disasters

Natural Disasters: Earthquakes, Tsunami, Volcanoes, Cyclones, Floods, Droughts, Landslides, Extreme weather events and climate change impacts.

Anthropogenic (Man-made) Disasters: Industrial accidents, fires, pollution events, Transportation failures, structural failures.

Unit–III:	**No. of Lectures: 06**	

Pandemics, Environmental Disasters & Management Principles

Pandemics and Environmental Disasters: COVID-19 case insights and environmental disaster context.

Objectives & Principles of Disaster Management: Prevention, preparedness, mitigation, response and recovery concepts.

Disaster Management Cycle: Phases, actions and key engineering considerations

Unit–IV:	**No. of Lectures: 06 Hours**	

Stakeholders & Institutional Framework

Stakeholders in Disaster Management: Government agencies, NGOs, community groups, Technological tools (Early Warning Systems, GIS, Remote Sensing).

International Cooperation & Organizational Structures: UN agencies, regional alliances and global frameworks

Disaster Management in India: Institutional framework, NDMA, policy & legal context.

Unit–V:	**No. of Lectures: 06 Hours**	

Ethical Issues & Case Studies

Ethical Issues in Disaster Management: Resource allocation, social equity and engineering ethics

Case Studies: Natural and man-made disaster case analyses, Lessons learnt, best practices.

Text Books:

1. R. Subramanian, Disaster Management, Vikas Publishing House.
2. S.C.Sharma, Disaster Management Khanna Publishing House, New Delhi.
3. G. K. Ghosh, Disaster Management, APH Publishing Corporation, New Delhi

Reference Books:

1. A. K. Singh, Disaster Management in India, New Royal Book Company, Lucknow
2. **Anu Kapur** *Vulnerable India: A Geographical Study of Disasters,* Sage Publications, New Delhi
3. **Tushar Bhattacharya,** *Disaster Science and Management*, McGraw-Hill Education (India)
4. **Jagbir Singh (Ed.),** *Disaster Management: Future Challenges and Opportunities, Disaster,* I.K. International Publishing House

Online Courses:

NIDM E-Learning Courses (National Institute of Disaster Management)
https://elearning.nidm.gov.in/local/home/index.php

SWAYAM & NPTEL MOOCs
https://archive.nptel.ac.in/courses/105/104/105104183/

iGOT Karmayogi (For Govt. Officials) https://igotkarmayogi.gov.in/#/
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PHARMA MARKETING MANAGEMENT (Open Elective – III)					
COURSE OUTLINE					
Course Title:	**PHARMA MARKETING MANAGEMENT**	**Short Title:**	PMM	**Course Code:**	OE – 509 G

Pharmaceutical Marketing Management focuses on the planning, implementation, and control of marketing strategies specific to the pharmaceutical industry, where ethical considerations, regulatory compliance, and patient safety play a critical role. It involves understanding healthcare markets, consumer and physician behavior, product life-cycle management, pricing strategies, distribution channels, and promotional activities such as medical detailing, digital marketing, and relationship management with healthcare professionals. The discipline integrates market research, brand management, and strategic decision-making to ensure effective product positioning while complying with national and international regulations. In an increasingly competitive and technology-driven environment, pharmaceutical marketing management emphasizes value-based marketing, patient-centric approaches, and sustainable growth.

	Hours/week	**No. of weeks**	**Total hours**	**Semester credits**
Theory	02	15	30	02

Course objectives:

The objective of this course is :

1. To study the scope of marketing.
2. To study the quantitative and qualitative aspects of pharmaceutical market.
3. To study the products decision in product life cycle, product portfolios, packaging and labelling decisions.
4. To study the promotion of products.
5. To study marketing channels and management of logistics.

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand and explain core marketing concepts and their application in the pharmaceutical industry.
2. Understand quantitative and qualitative aspects of pharmaceutical market.
3. Understand the product cycle, product portfolios.
4. Assess promotional tools including personal selling, advertising, digital marketing, and ethical promotion practices.
5. Understand the marketing channels and management of logistics.

COURSE CONTENT

PHARMA MARKETING MANAGEMENT		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**

Unit–I:	**No. of Lectures: 6 Hours**	

Marketing:

Definition, general concepts and scope of marketing; Distinction between marketing & selling; Marketing environment; Industry and competitive analysis; Analyzing consumer buying behavior; industrial buying behavior.

Pharmaceutical Market:

Quantitative and qualitative aspects; size and composition of the market; demographic descriptions and socio-psychological characteristics of the consumer; market segmentation

& targeting. Consumer profile; Motivation and prescribing habits of the physician; patients' choice of physician and retail pharmacist. Analyzing the Market; Role of market research.

Unit–II:	No. of Lectures: 6 Hours	

Product Decision:

Classification, product line and product mix decisions, product life cycle, product portfolio analysis; product positioning; New product decisions; Product branding, packaging and labeling decisions, Product management in pharmaceutical industry.

Unit–III:	No. of Lectures: 6 Hours	

Promotion:

Methods, determinants of promotional mix, promotional budget; An overview of personal selling, advertising, direct mail, journals, sampling, retailing, medical exhibition, public relations, online promotional techniques for OTC Products.

Unit–IV:	No. of Lectures: 6 Hours	

Pharmaceutical Marketing Channels

Designing channel, channel members, selecting the appropriate channel, conflict in channels, physical distribution management: Strategic importance, tasks in physical distribution management.

Management of Logistics:

Supply Chain, Cold Chain, Applications of IT & management information systems for efficient marketing, controlling expiry and returned goods.

Unit–V:	No. of Lectures: 6 Hours	

Pricing:

Meaning, importance, objectives, determinants of price; pricing methods and strategies, issues in price management in pharmaceutical industry. An overview of DPCO (Drug Price Control Order) and NPPA (National Pharmaceutical Pricing Authority).

Emerging concepts in marketing:

Vertical & Horizontal Marketing; Rural Marketing; Consumerism; Industrial Marketing; Global Marketing.

AI in Pharma Marketing:

Introduction to AI in Pharma Marketing: Role of AI in modern pharmaceutical marketing, Benefits, limitations, and future scope of AI in pharma, AI-driven market research and forecasting

Text Books:

1. Arun Kumar and N Menakshi: Marketing Management, Vikas Publishing, India.
2. Ramaswamy, U.S & Nanakamari, S: Marketing Management: Global Perspective, Indian Context, Macmilan India, New Delhi.

Reference Books:

1. Philip Kotler and Kevin Lane Keller: Marketing Management, Prentice Hall of India New Delhi

NPTEL Links:

1. https://youtu.be/iOZxUvq1JNE
2. https://nptel.ac.in/courses/110104068

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CIRCULAR ECONOMY (Open Elective – III)					
COURSE OUTLINE					
Course Title:	**CIRCULAR ECONOMY**	**Short Title:**	**CE**	**Course Code:**	**OE-509 H**

Course description:
This course introduces the concept of Circular Economy, its principles, and its relevance in sustainable development. Students will learn about linear economy limitations, circular economy frameworks, business models, and its implementation in India.

	Hours/week	No. of weeks	Total hours	Semester credits
Theory	02	15	30	02

Prerequisite course(s):

Basic understanding of **Linear Economy and environmental sustainability concepts**.

Course objectives:

The objective of this course is:

1. To understand the basics of Circular Economy and its significance.
2. To familiarize students with circular economy frameworks, business models, and case studies.
3. To compare linear and circular economies, and understand traditional circular practices.
4. To understand the prospect of circular economy in India.
5. To analyze the role of government and benefits of circular economy.

Course outcomes:

After successful completion of this course the student will be able to:

1. Describe the principles and benefits of Circular Economy.
2. Apply circular economy frameworks and business models.
3. Compare and contrast linear and circular economies.
4. Identify opportunities for circular economy in India.
5. Understand the role of government and benefits of circular economy for various stakeholders.

COURSE CONTENT

CIRCULAR ECONOMY		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**

Unit–I:	**No. of Lectures: 06 Hours**	

Linear Economy and Circular Economy Basics

Linear Economy - Our Crumbling Planet: Law of Obsolescence, Disadvantages of Linear Economy,

Circular Economy: Think Ahead - Our Last Chance:- Elements of a Circular Economy, Why do we need to switch to a circular economy?

Unit–II:	**No. of Lectures: 06 Hours**	

Circular Economy Frameworks and Business Models

Fundamental Characteristics of Circular Economy - A Resource Multiplier: Innovation, Collaboration, Value optimization, Design out Waste, Renewable Energy, Closed and tighter loops, Business Models in a Circular Economy- Circular supply chain, Product as a service, Collaborations and sharing, Recovery and recycling, Product life extension, McKinsey Center for Business and Environment - the ReSOLVE framework

Unit–III:	**No. of Lectures: 06 Hours**	

Linear Vs. Circular Economy and Traditional Practices

Linear Vs Circular Economy: Differential that whither the Planet and Us? - Material value preservation, Eco-effectiveness from eco-efficiency, Shift from Raw material to residual flows, Linear VS Circular economy, SWOT analysis of Circular Economy,

Circular Economy - Old wine in new bottle: - Yoga – a circular alternate to gyms, Ayurveda – An old circular alternate to modern medicine, Earthen Pots – An old circular practice, Sun Drying – A circular alternate to laundry dryers

Unit–IV:	**No. of Lectures: 06 Hours**	

Circular Economy in India

India and Circularity - Showcasing Sustainable Future - Circularity in India, Prospect of Circular Economy in India, Role of Indian businesses, Invest in circular economy opportunities

Unit–V:	**No. of Lectures: 06 Hours**	

Circular Economy Implementation and Benefits

Role of Government -Set direction and show commitment, Enabling regulatory frameworks, Platforms for multi-stakeholder collaboration, Support circular models through public procurement and infrastructure

Benefits of Circular Economy for India- Benefits for businesses and the Economy, Benefits for the environment, Benefits for citizens

Text Books:

Reference Books:

Circular Economy: (Re)Emerging Movement by Shalini Goyal Bhalla

NPTEL Links: SWAYAM

https://onlinecourses.swayam2.ac.in/e-learning/preview/aic21_ge19

Guidelines for ICA:

Students must submit ICA in the form of journal. Concerned faculty member should suitably frame **FIVE** assignments based on the above syllabus. Faculty in charge will assess the assignments continuously, and grade or mark each assignment on completion date declared for each assignment.

Kavayitri Bahinabai Chaudhari

NORTH MAHARASHTRA UNIVERSITY, JALGAON (M.S.)

Third Year Bachelor of Engineering in Electrical

(As per NEP 2020 Guidelines)

Faculty of Science and Technology



COURSE OUTLINE

For Affiliated Colleges

Semester –VI

W.E.F. 2026 – 27

CONTROL SYSTEM (PCC)

COURSE OUTLINE

Course Title:	CONTROL SYSTEM	Short Title: CS	Course Code:	EE601

Course description:

The study of Control System Engineering is essential for the students of Electrical, Electronics, Mechanical, Aerospace & Chemical Engineering. It has applications ranges from Electrical Power System to process Control System. The course explores the knowledge of basic control systems, control system components, mathematical modeling, and time response & frequency response analysis. The course also deals in concept of design & its preliminary consideration.

	Hours/week	No. of weeks	Total hours	Semester credits
Theory	03	15	45	**03**
Practical	02	15	30	**01**

Prerequisite course(s):

Engineering Mathematics, Basic Electrical & Electronics Engineering

Course objectives:

The objective of this course is to impart knowledge so that the student will:

1. Learn the type of System, dynamics of physical systems, classification of control system, analysis and design objective.
2. Learn how to represent system by transfer function and block diagram reduction method and Mason's gain formula.
3. Learn time response analysis and demonstrate their knowledge to frequency response.
4. Learn stability analysis of system using Root locus, bode plot, polar plot, and Nyquist plot.
5. Learn the design problem and preliminary considerations lead, lag and lead-lag networks, design of closed loop systems using compensation techniques in time domain and frequency domain.

Course outcomes:

After successful completion of this course the student will be able to:

1. Analyze open loop and closed-loop control systems for stability and steady-state performance
2. Design a closed-loop control system to satisfy dynamic performance specifications using frequency response, root-locus, and state-space techniques, as well as steady state error specifications
3. Compute stability of linear systems using the Routh array test and use this to generate control design constraints
4. Compute gain and phase margins from Bode diagrams and Nyquist plots and understand their implications in terms of robust stability
5. Design Lead-Lag compensators based on frequency data for an open-loop linear system

COURSE CONTENT

CONTROL SYSTEM		Semester:	VI
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):UA**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):CA	**40 marks**

Unit–I	No. of Lectures: 09 Hours	Marks: 12

Fundamentals of Control System: Open loop & closed control; servomechanism, Physical system. Transfer functions, Block diagram algebra, Signal flow graph, Mason's gain formula, Reduction of parameter variation and effects of disturbance by using negative feedback

Unit–II	No. of Lectures: 09 Hours	Marks: 12

Time Response analysis: Standard test signals, time response of first and second order systems, time response specifications, steady state errors and error constants Design specifications of second order systems: Derivative error, derivative output, integral error and PID compensations, design considerations for higher order systems, performance indices.

Unit–III	No. of Lectures: 09 Hours	Marks: 12

Control System Components: Constructional and working concept of ac servomotor, synchronous and stepper motor, Stability and Algebraic Criteria: concept of stability and necessary conditions, Routh Hurwitz criteria and limitations, Root Locus Technique: The root locus concepts, construction of root loci

Unit–IV	No. of Lectures: 09 Hours	Marks: 12

Frequency response Analysis: Frequency response, correlation between time and frequency responses, polar and inverse polar plots, Bode plots Stability in Frequency Domain: Nyquist stability criterion, assessment of relative stability: gain margin and phase margin, constant M&N circles.

Unit–V	No. of Lectures: 09 Hours	Marks: 12

Introduction to Design: The design problem and preliminary considerations lead, lag and lead-lag networks, design of closed loop systems using compensation techniques in time domain and frequency domain. State variable technique: State variable technique, conversion of state variable model to transfer function model and vice-versa, diagonalization, Controllability and observability and their testing.

Text Books:

1. I. J. Nagrath & M. Gopal, “Control System Engineering”, New age International.
2. K. Ogata, “Modern Control Engineering”, Prentice Hall of India, 1990
3. B.C. Kuo & Farid Golnaraghi, “Automatic Control System” Wiley India Ltd, 8th edition.
D. Roy Choudhary, “Modern Control Engineering”, Prentice Hall of India

Reference Books:

1. Norman S. Mise, Control System Engineering, Wiley Publishing Co.
2. Ajit K Mandal, “Introduction to Control Engineering” New Age International.
3. R. T. Stefani, B. Shahian, C. J. Savant and G.H. Hostetter, “Design of Feedback Control Systems” Oxford University Press, 2002.
4. Samarjit Ghosh, “Control Systems theory and Applications”, Pearson Education
5. J. P. Navani&SonalSapra, “Control System”, S. Chand Publishing.
6. Ambikapathy, “Control Systems”, Khanna Book Publishing Co. (P) Ltd., DelhI

NPTEL Links:

1. Control Engineering by Prof. Ramkirhana Pasumarthy and Prof. Mousumi Mukherjee, IIT Madras nptel.ac.in/courses/108106098
2. Control Engineering by Prof. M G Gopal, IIT Delhi nptel.ac.in/courses/108102043
3. Control Engineering by S D Agashe IIT Bombay nptel.ac.in/courses/108101037

CONTROL SYSTEM LAB (PCC)					
LAB COURSE CONTENT					
CONTROL SYSTEM LAB		**Semester:**	**VI**	**Course Code:**	**EE602**
Teaching Scheme:		**Examination scheme**			
Practical:	**2 hours/week**	**End Semester Exam (ESE) UA: PR**			**25 marks**
		Internal Continuous Assessment (ICA) CA:			**25 marks**
End Semester Exam (ESE) Pattern:		**(Practical) PR**			

Concerned faculty member should suitably frame **SEVEN** laboratory assignments from the following list.

1. To determine speed-torque characteristics of an ac servomotor.
2. To study potentiometer as an error detector.
3. To study DC position control system
4. To determine time response of second order control system
5. To determine speed-torque characteristics of dc servomotor.
6. To study PID Controller.
7. To study synchro-transmitter and receiver and obtain output V/S input characteristics.
8. To Study Stepper Motor.
9. To determine time domain response of a second order system for step input and obtains performance parameters by using software
10. To determine time domain response of a second order system for step input and obtains performance parameters by using software
11. To convert transfer function of a system into state space form and vice-versa, by using software.
12. To plot root locus diagram of an open loop transfer function and determine range of gain “k” for stability by using software.
13. To plot a Bode diagram of an open loop transfer function by using software
14. To draw a Nyquist plot of an open loop transfer functions and examine the stability of the closed loop system by using software

Text Books

1. I. J. Nagrath, M. Gopal, “Control System Engineering”, New age International.
2. D. Roy Choudhary, “Modern Control Engineering”, Prentice Hall of India.

Reference Books:

1. Norman S. Mise, Control System Engineering, Wiley Publishing Co.
2. Ajit K Mandal, “Introduction to Control Engineering” New Age International.
3. R. T. Stefani, B. Shahian, C. J. Savant and G.H. Hostetter, “Design of Feedback Control Systems” Oxford University Press, 2002.
4. Samarjit Ghosh, “Control Systems theory and Applications”, Pearson Education

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Guide lines for ESE:PR

ESE will be based on the laboratory assignments submitted by the students in the form of journal. In ESE the student may be asked to perform any one practical. Evaluation will be based on paper work and performance in the practical.

POWER SYSTEM-II (PCC)

COURSE OUTLINE

Course Title:	POWER SYSTEM-II	Short Title: PS-II	Course	EE603

Course description:

Power System-II explores the knowledge of symmetrical and unsymmetrical fault analysis. The subject emphasis on representation of power system components and load flow analysis.

	Hours/week	No. of weeks	Total hours	Semester credits
Theory	03	15	45	**03**
Practical	02	15	30	**01**

Prerequisite course(s):

Power System-I, Electrical Machines. Electrical Circuit Analysis

Course objectives:

The objective of this course is to impart knowledge so that the student will:

1. Able to discuss constituents of power system, power system components representation.
2. Able to analyze the power system in terms of symmetrical faults.
3. Able to compute symmetrical components and design sequence network of a power system
4. Able to analyze the power system in terms of unsymmetrical faults
5. Able to compute power flow analysis.

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand the representation of synchronous machine, transmission line and power transformer to evaluate the performance of power system.
2. Analyze the power system to calculate the effects of symmetrical faults on power system.
3. Analyze the power system in terms of symmetrical components and sequence networks of synchronous machines, transmission line and transformer.
4. Analyze the power system to calculate the effects of unsymmetrical faults.
5. Determine the power flow for a given system.

POWER SYSTEM-II

POWER SYSTEM-II		Semester:	VI
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):UA**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):CA	**40 marks**

Unit–I	No. of Lectures: 09 Hours	Marks: 12

Representation of power system component

Introduction: Constituents of power system and role, necessity of power system analysis, Real, reactive, complex power and its direction. Representation of power system: Single phase representation of balance three phase network, one line diagram, impedance diagram (reactance diagram), per unit system, representation of synchronous machine and power transformer.

Unit–II	No. of Lectures: 09 Hours	Marks: 12

Symmetrical Fault Analysis

Introduction, Transient on a transmission line, three phase short circuit of an Synchronous machine on no load, short circuit current and reactance of synchronous machine on no load, Short circuit of a loaded synchronous machines, Analysis of symmetrical faults in power system networks, Fault MVA and fault current (steady state), , consideration of pre-fault load current, selection of circuit breaker, Current limiting reactors, location of reactors

Unit–III	No. of Lectures: 09 Hours	Marks: 12

Symmetrical Components

Symmetrical components of 3 phase system, the phase operator, power invariance, phase shift in star delta transformers, physical significance of sequence components, sequence impedance and sequence network, sequence impedance of transmission lines, sequence impedance and network of synchronous machines, sequence impedance and network of transformers, sequence impedance and network of load, formation of sequence network of power system

Unit–IV	No. of Lectures: 09 Hours	Marks: 12

Unsymmetrical Fault Analysis

Shunt type and series type faults, symmetrical component analysis of unsymmetrical faults, Single line to ground fault (LG) on an unloaded generator , line to line fault (LL) on an unloaded generator, double line to ground fault(LLG)on an unloaded generator, unsymmetrical fault on power systems, Single line to ground fault (LG)on a power system, line to line fault (LL)on a power system , double line to ground fault(LLG)on a power system, Faults analysis of unsymmetrical faults, series or open conductor faults

Unit–V	No. of Lectures: 09 Hours	Marks: 12

Load flow analysis

Introduction, bus classifications, bus admittance matrix, Self admittance and mutual admittance, formation of Y bus using step by step method, formation of Y bus using singular transformation, Primitive network, network variables in bus frame reference, bus incidence matrix, Representation of transformer, Approximate load flow study, iterative computation of Non linear algebraic equations- Gauss and Gauss Seidel iterative technique, Gauss Seidel method for power flow study, Newton Raphson method for power flow study

Text Books:

1.D.P. Kothari & I. J. Nagrath, “Modern Power System Analysis” 4th edition Tata Mc. Graw Hill

Reference Books:

1. W.D. Stevenson, Jr. “ Elements of Power System Analysis”, Mc Graw Hill.
2. C.L. Wadhwa, “Electrical Power System”, New Age International.
3. Stagg and El-Abiad, “Computer Methods in Power System Analysis” TMH.
4. Hadi Sadat; “Power System Analysis”, Tata McGraw Hill.
5. L. P. Singh; “Advanced Power System Analysis & Dynamics”, New Age International
6. Chakraborthy, Soni, Gupta & Bhatnagar, “Power System Engineering”, Dhanpat Rai & Co.
7. T.K Nagsarkar & M.S. Sukhija, “Power System Analysis” Oxford University Press, 2007.

NPTEL Links:

1. Power System Engineering by prof. Debapriya Das, IIT Kharagpur
   https://nptel.ac.in/courses/108105104
2. Power Electronics and Distributed Generation by Prof. Vinod John IIS Banglore
   https://nptel.ac.in/courses/108108034
3. Restructured Power System by Prof S.A. Khaparde and Dr. A.R. Abhyankar IIT delhi
   https://nptel.ac.in/courses/108101005
4. Power System Operation and Control by Prof. A.M.Kulkarni IIT Bombay
   https://nptel.ac.in/courses/108101040
5. Power System Generation, Transmission and Distribution by Prof. D.P. Kothari IIT Delhi
   https://nptel.ac.in/courses/108102047

POWER SYSTEM-II LAB (PCC)					
LAB COURSE CONTENT					
POWER SYSTEM-II		**Semester:**	**VI**	**Course Code:**	**EE 604**
Teaching Scheme:		**Examination scheme**			
Practical:	**2 hours/week**	**End Semester Exam (ESE) UA: PR**			**25 marks**
		Internal Continuous Assessment (ICA) CA:			**25 marks**
End Semester Exam (ESE) Pattern:		**(Practical) PR**			

Concerned faculty member should suitably frame **SEVEN** laboratory assignments from the following list.

1. Static measurement of sub-transient reactance of a salient-pole alternator.
2. Measurement of negative sequence reactance of a synchronous machine.
3. Measurement of zero sequence reactance of a synchronous machine.
4. To perform short circuit analysis for LLL fault.
5. Determination of steady state power limit of a transmission line.
6. Unsymmetrical fault analysis for LG, fault on A.C / D.C network analyzer
7. Unsymmetrical fault analysis for LL fault on A.C / D.C network analyzer
8. Unsymmetrical fault analysis for LLG fault on A.C / D.C network analyzer
9. Formulation and calculation of Y- bus matrix of a system using software.
10. Computer aided solution of power flow problem by Gauss Seidal method.
11. Computer aided solution of power flow problem by Newton-Raphson method.
12. Visit to HV/EHV substation or power generating substation

Text Books:

1. D.P. Kothari & I. J. Nagrath, "Modern Power System Analysis" 4th edition Tata Mc. Graw Hill

Reference Books:

1. W.D. Stevenson, Jr. " Elements of Power System Analysis", Mc Graw Hill.
2. C.L. Wadhwa, "Electrical Power System", New Age International.
3. Stagg and El-Abiad, "Computer Methods in Power System Analysis" TMH.
4. Hadi Sadat; "Power System Analysis", Tata McGraw Hill.
5. L. P. Singh; "Advanced Power System Analysis & Dynamics", New Age International
6. Chakraborthy, Soni, Gupta & Bhatnagar, "Power System Engineering", Dhanpat Rai & Co.
7. T.K Nagsarkar & M.S. Sukhija, "Power System Analysis" Oxford University Press, 2007.

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Guide lines for ESE: PR

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Program Elective Course –II (PEC)

SOFTWARE APPLICATION LAB (PEC)

COURSE OUTLINE

Course Title:	**SOFTWARE APPLICATION LAB**	**Short Title: SA**	**Course**	**EE605 A**

Course description:

The objective of this course is to introduce the students to the fundamental concepts of MATLAB and enable them to apply these concepts for solving real world problems. This course includes the basic structure and statements required for simple mathematical problems in MATLAB. This course provides the basic concepts of plot and other useful tools required to solve the problems.

	Hours/week	**No. of weeks**	**Total hours**	**Semester credits**
Theory	03	15	45	**05**
Practical	04	15	60	

Prerequisite course(s):

Basic sciences, mathematics and subjects of Electrical Engineering, C and C++

Course objectives:

The objective of this course is to impart knowledge so that the student will:

1. To familiarize the student in introducing and exploring MATLAB/Simulink.
2. To enable the student on how to approach for solving Engineering problems using simulation tools.
3. To prepare the students to use MATLAB/Simulink in their project works
4. To provide a foundation in use of this softwares for real time applications.
5. To use the MATLAB/Simulink for solving complex engineering problems.

Course outcomes:

After successful completion of this course the student will be able to:

1. Implement small and medium programs of varying complexity using the most commonly used features of the language.
2. Employ good programming style, standards and practices during program development.
3. Solve the different numerical techniques and perform Matrix operations
4. Understand and use of MATLAB/Simulink for solving simple electrical engineering problems.
5. Use modern engineering tools in MATLAB/Simulink which are useful for analyzing and designing of electrical power system

SOFTWARE APPLICATION LAB

SOFTWARE APPLICATION LAB		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End Semester Exam (ESE) UA:**	**25 marks**
		OR	
		Internal Continuous Assessment (ICA) CA:	**50 marks**
Practical:	**4 hours/week**		

Unit–I	**No. of Lectures: 09 Hours**	

Introduction to MATLAB/Simulink

Standard MATLAB windows, Operations with variables: naming, checking existence, clearing and operations, Arrays: columns and rows: creation and indexing, size & length, multiplication, division, power and operations.

Unit–II	**No. of Lectures: 09 Hours**	

Writing script

Writing script files: logical variables and operators , flow control and loop operators

Writing functions: input/output arguments, function visibility, path and MATLAB Startup Simple graphics : 2D and 3D plots and figures and subplots

Unit–III	No. of Lectures: 09 Hours	

Data and data flow in MATLAB

Data types: Matrix, string, cell and structure, creating, accessing elements and manipulating of data of different types. File Input-Output: MATLAB files, text files, binary files, mixed text-binary files.

Unit–IV	No. of Lectures: 09 Hours	

Introduction to Simulink

Simulation steps, Types of mathematical model, developing a model, Simulink solution of differential equation, solvers, Assigning variables, Observing variable during simulation. Storing or saving data, linking script file with model file, Data import/export, Creating and masking subsystems

Unit–V	No. of Lectures: 09 Hours	

Applications of MATLAB/Simulink

Simulation of R-L-C series circuit, Finding laplace transform and inverse laplace transform using MATLAB, Step response using MATLAB, Root locus and Bode plot, Simulation of Single phase half wave and full wave rectifiers, battery charger, Effect of source inductances, Simulation of controlled converters and AC voltage controller.

LAB COURSE CONTENT

Concerned faculty member should suitably frame **SEVEN** laboratory assignments from the following list.

1. A. Simple Arithmetic Calculation: Perform simple arithmetic calculations:
   a. Addition, subtraction, multiplication, division and exponentiation.
   b. Assign values to variables.
   c. Suppress screen output.
   d. Control the appearance of floating point numbers on the screen.
2. Create: Simple sine plot, line plot, an exponentially decaying sine plot, space curve, log scale plot, Overlay plot and Fancy plots.
3. Write a program to find transient response in RC and RL circuit.
4. Write a program to plot voltage and current in inductive and capacitive circuit
5. Build a simple circuit with Power System blocks and connect it to other Simulink Blocks
6. Create an electrical subsystem, simulate transients, and discretize simple circuits
7. Single phase fully controlled converter using R and RL load using MATLAB /Simulink.
8. Single phase AC voltage regulator using MATLAB / SIMULINK
9. Step response without and with derivative control
10. Obtain the step and ramp response of the control system.

Text Books:

1. Dr. Shailendra Jain, “Modeling & Simulation using MATLAB-Simulink”, Wiley India, 2013.
2. Rudra Pratap, “Getting Started With Matlab: A Quick Introduction For Scientists And Engineers” Oxford University Press, 2011.

Reference Books:

1. Using MATLAB Graphics, Version 10, The Math Works, Inc., 2012.
2. MATLAB Release Notes for Release 12, The Math Works, Inc., 2012.
3. Sivanandam S.N., Sumathi S., Deepa S. N., “Introduction to Fuzzy Logic using MATLAB”, Springer-Verlag Berlin Heidelberg, 1st edition, 2007.
4. S. Sivanandam, S. Sumathi, “Introduction to Neural Networks Using MATLAB”, McGraw Hill Education, 1st Edition, 2017.

NPTEL Links: 1. NPTEL Course by Prof. Niket Kaisare Matlab Programming for Numerical Computation - Course 2. NPTEL Course by Prof. Dipakkimar Giri. nptel.ac.in/courses/101104545
Guidelines for ICA:
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Guide lines for ESE: OR
ESE will be based on the laboratory assignments submitted by the students in the form of journal. Evaluation will be based on answers given by students in oral examination

Program Elective Course –II (PEC)				
ELECTRICAL AUTOMATION LAB (PEC)				
COURSE OUTLINE				
Course Title:	**ELECTRICAL AUTOMATION LAB**	**Short Title: EA Lab**	**Course**	**EE605 B**

Course description:

This course provides a fundamental understanding of **Programmable Logic Controllers (PLC)** and **Supervisory Control and Data Acquisition (SCADA)** systems used in modern industrial automation. The course introduces students to the architecture, operation, and programming of PLCs, along with the principles of SCADA-based monitoring and control.

	Hours/week	**No. of weeks**	**Total hours**	**Semester credits**
Theory	03	15	45	**05**
Practical	04	15	60	

Prerequisite course(s):

Course objectives:

The objective of this course is to impart knowledge so that the student will:

1. Understand the fundamentals and architecture of PLCs used in industrial automation.
2. Learn PLC programming techniques using ladder logic and other IEC standard languages.
3. Analyze PLC hardware components, I/O modules, memory, and scan cycles.
4. Understand the concept, architecture, and components of SCADA systems.
5. Learn data acquisition, monitoring, and supervisory control using SCADA.

Course outcomes:

After successful completion of this course the student will be able to:

1. Explain the working principles, architecture, and components of PLC systems**.**
2. Develop PLC programs using ladder logic for industrial control applications such as motor control, sequencing, and interlocking
3. Analyze and implement timers, counters, analog I/O, and PID control using PLCs.
4. Use Ladder Logic Function and advance function for PLC programming
5. Describe the architecture, components, and operation of SCADA systems

ELECTRICAL AUTOMATION LAB

ELECTRICAL AUTOMATION LAB		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End Semester Exam (ESE) UA: OR**	**25 marks**
		Internal Continuous Assessment (ICA) CA:	**50 marks**
Practical:	**4 hours/week**		

Unit–I	**No. of Lectures: 09 Hours**	

Introduction to Automation: Need for industrial automation, Conventional control vs automated control, Introduction to PLC and SCADA, Applications of PLC & SCADA in industry

Unit–II	**No. of Lectures: 09 Hours**	

Basics of Programmable Logic Controller (PLC): Definition and advantages of PLC, PLC hardware architecture, CPU, power supply, Input and output modules, Digital inputs and digital outputs, PLC scan cycle

Unit–III	**No. of Lectures: 09 Hours**	

PLC Programming and Application: Introduction to ladder logic, Basic ladder elements (NO & NC contacts,) Coils, Simple ladder programs, Timers and counters (basic), interlocking and sequencing, Motor ON/OFF control, Start–stop control circuit, Simple conveyor or lamp control

Unit–IV	**No. of Lectures: 09 Hours**	

Introduction to SCADA: Definition and purpose of SCADA, Basic SCADA architecture, Components of SCADA system, PLC / RTU, HMI, Communication network

Unit–V	**No. of Lectures: 09 Hours**	

SCADA Operation Basics: Introduction to HMI screens, Tags and data points, Basic graphic displays, Real-time monitoring, Alarm and event basics, Trend display (basic concept)

LAB COURSE CONTENT

Concerned faculty member should suitably frame **SEVEN** laboratory assignments from the following list.

1. **Familiarization with PLC:** Identification of PLC hardware components, PLC rack, CPU, power supply, I/O modules, PLC wiring basics (input switches, output lamps)
2. **Basic Ladder Logic Programs:** Creating a simple ladder program, Downloading and running program in PLC, Online monitoring of ladder logic
3. **Digital I/O Experiments :**ON/OFF control of lamp using push button, Toggle (latching) operation, Set–Reset logic
4. **Motor Control Using PLC:** Start–Stop control of single-phase / three-phase motor, Forward motor control using PLC, Interlocking using PLC logic
5. **Timer Applications:** ON-delay timer operation, OFF-delay timer operation, Timer-based lamp or motor control
6. **Counter Applications:** Up counter operation, Down counter operation, Object counting using counter logic
7. **Sequential Control:** Sequential operation of outputs, Traffic light control using PLC, Simple process sequence control
8. **Introduction to SCADA Software:** Familiarization with SCADA software environment, Creating a new SCADA project, Understanding runtime and development modes
9. **SCADA Tag Configuration:** Creating internal and external tags, Linking PLC tags with SCADA tags, Data types and addressing basics
10. **Alarm Configuration:** Creating simple alarms, Setting alarm limits, Alarm acknowledgement and logging

Text Books:

1. Curtis Johnson, “Process Control Instrumentation Technology”, Pearson Education.
2. Madhuchhanda Mitra, Samarjit Sen Gupta, “Programmable Logic controllers and Industrial Automation”, Penram International Publishing India Pvt. Ltd.

Reference Books:

1. Stuart A. Boyer, “SCADA Supervisory Control and Data Acquisition”, ISA Publication.
2. John W. Webb, Ronold A Reis,“ Programmable Logic Controllers, Principles and Applications”, Prentice Hall of India Pvt. Ltd.
3. Kilian, “Modern control technology: components & systems”, Delmar.
4. Bela G Liptak “Process Software and Digital Networks”, CRC Press
5. Pollack. Herman, W & Robinson., T. “Computer Numerical Control”, Prentice Hall.

NPTEL Links:

1. Industrial Automation and Control by Prof. S. Mukhopadhyay, IIT Kharagpur.

https://nptel.ac.in/courses/108105088
Guidelines for ICA:
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Guide lines for ESE: OR
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Program Elective Course –II (PEC)

Computer Aided Electrical Drawing LAB (PEC)

COURSE OUTLINE

Course Title:	**Computer Aided Electrical Drawing LAB**	**Short Title: CAED**	**Course**	**EE605 C**

Course description:

This course introduces the fundamentals of computer-aided drafting with specific emphasis on electrical drawings. Topics include basic drawing commands, electrical symbols and standards, wiring diagrams, panel layouts, schematic diagrams, and documentation techniques. Hands-on practice using drawing tools helps students translate electrical concepts into precise technical drawings while following industry standards and safety codes.

	Hours/week	**No. of weeks**	**Total hours**	**Semester credits**
Theory	03	15	45	**05**
Practical	04	15	60	

Prerequisite course(s):

Electrical Workshop

Course objectives:

The objective of this course is to impart knowledge so that the student will:

1. Understand the fundamentals of electrical drawing standards and symbols
2. Gain proficiency in drawing tools for electrical drafting
3. Prepare electrical layouts, wiring, and schematic diagrams
4. Develop skills to read, interpret, and modify electrical drawings
5. Apply computer-aided techniques in real-time electrical engineering applications

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand basic concepts of computer-aided drafting and electrical drawing standards.
2. Use drawing software tools to create and modify electrical drawings.
3. Draw standard electrical symbols, wiring diagrams, and schematic diagrams
4. Prepare electrical layouts for residential and commercial buildings
5. Create panel diagrams and basic industrial electrical drawings

Computer Aided Electrical Drawing LAB

Computer Aided Electrical Drawing LAB		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End Semester Exam (ESE) UA: OR**	**25 marks**
		Internal Continuous Assessment (ICA) CA:	**50 marks**
Practical:	**4 hours/week**		

Unit–I	**No. of Lectures: 09 Hours**

Introduction to Computer Aided Drafting : Introduction to computer aided drawing tools and its applications in electrical engineering Overview of drawing tools and interface, coordinate system, drawing limits. Basic drawing and editing commands. Screen layout, menus, toolbars, and command line, Basic drawing commands (Line, Circle, Arc, Rectangle, Poly line).

Unit–II	**No. of Lectures: 09 Hours**

Electrical Drawing Standards and Symbols: Importance of standards in electrical drawings Electrical symbols as per IS / IEC standards Line types, layers, dimensioning, and text styles Drawing setup for electrical projects. Electrical drawings must follow **standard rules** to ensure Uniformity, Easy interpretation, Safety, International understanding.

Unit–III	No. of Lectures: 09 Hours	
Basic Electrical Drawings : Single-line and schematic diagrams. Wiring diagrams for simple electrical circuits Lighting and power circuit drawings Earthing and protective device symbols. Basic electrical drawings show **simple electrical circuits and installations** using standard symbols. They help in Understanding circuit operation, Correct wiring and installation, Maintenance and troubleshooting.		
Unit–IV	**No. of Lectures: 09 Hours**	
Residential and Commercial Electrical Lay outs: Electrical layout of residential buildings Placement of lights, fans, switches, sockets, Load distribution and circuit planning, Preparation of electrical layout drawings using drawing. An electrical layout is a plan showing the position of electrical points, wiring routes, and accessories in a building, Safe electrical installation, Proper load distribution.		
Unit–V	**No. of Lectures: 09 Hours**	
Panel and Industrial Electrical Drawings : Introduction to electrical panels, Panel layout and wiring diagrams, Motor control and basic industrial circuit drawings, Preparation of panel drawings using drawing tools. Panel and industrial electrical drawings are used to represent control panels, power panels, and industrial electrical system, Correct installation and wiring, Operation and maintenance of industrial equipment.		

LAB COURSE CONTENT

Concerned faculty member should suitably frame **SEVEN** laboratory assignments from the following list.

1. Practice of basic drawing commands: Line, Circle, Arc, Rectangle, Poly line.
2. Practice of editing commands: Move, Copy, Rotate, Mirror, Trim, Extend.
3. Drawing of standard electrical symbols as per IS / IEC standards
4. Creation and use of layers, colors, and line types for electrical drawings
5. Text, dimensioning, and annotation of electrical drawings.
6. Creation of blocks and attributes for electrical symbols.
7. Drawing of electrical cable layout with component identification.
8. Drawing of electrical Earthing layout with component identification.
9. Drawing of electrical motor control layout with component identification.
10. Drawing of electrical panel layout with component identification.
11. Preparation of Bill of Materials (BOM) from electrical drawings.
12. Mini project: Preparation of a complete electrical drawing set using computer aided drawing tools

Text Books:

1.Sham Tickoo, "Computer Aided Electrical Drawing**"** BPB Publications)

Reference Books:

1. M. Yogesh, B.S. Nagaraja, "Computer Aided Electrical Drawing" ,PHI Learning Publication.

NPTEL Link

1. Computer Aided Design by Prof Anoop Chawla, Prof. Madhusudan Rao,IITD nptel.ac.in/courses/112102101

Guidelines for ICA:

Students must submit ICA in the form of journal. Each assignment should be well documented. Faculty in Charge will assess the assignments continuously and grade or mark each assignment on completion date declared for each assignment.

Guide lines for ESE: OR

ESE will be based on the laboratory assignments submitted by the students in the form of journal. Evaluation will be based on answers given by students in oral examination

Program Elective –III (PEC)

MICROPROCESSOR AND MICROCONTROLLER (PEC)

COURSE OUTLINE

Course Title:	**MICROPROCESSOR AND MICROCONTROLLER**	**Short Title: MPMC**	**Course**	**EE606 A**

Course description:

This course provides knowledge about basic feature of microprocessor and microcontroller and theirs application in measurements of electrical parameters.

	Hours/week	**No. of weeks**	**Total hours**	**Semester credits**
Theory	03	15	45	**03**
Practical	02	15	30	**01**

Prerequisite course(s):

Basic analog and digital electronics

Course objectives:

The objective of this course is to impart knowledge so that the student will:

1. Student will be conversant with the basic function and operation of microprocessor.
2. Programming is a process of problem solving and communication in language of mnemonics.
3. Understand the application of microprocessor for the measurements of Electrical parameter.
4. Explain the microcontroller architecture & describe the features of a typical microcontroller.
5. Use the 8051 addressing modes and instruction set and apply this knowledge to develop programs in assembly language

Course outcomes:

After successful completion of this course the student will be able to:

1. Apply basic electronic subject and software algorithm application for understanding Architectures assemble language of microprocessor.
2. Develop assembly language source code for applications that use I/O ports, timer and single/multiple interrupts.
3. Develop assemble language programming and interfacing peripherals for wide application in electrical engineering
4. Describe the architecture and features of the microcontroller.
5. Illustrate addressing modes and execute programs in assembly language for the microcontroller

MICROPROCESSOR AND MICROCONTROLLER

MICROPROCESSOR AND MICROCONTROLLER		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):UA**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):CA	**40 marks**

Unit–I	**No. of Lectures: 09 Hours**	**Marks: 12**

8085 Microprocessor:

Organization, architecture, functional pin diagram, Generation of control signal, Addressing modes, Instruction format, Stack, subroutine, types of subroutine, I/O Mapped I/O and memory mapped I/O, interrupt - interrupt structure.

Unit–II	**No. of Lectures: 09 Hours**	**Marks: 12**

Assembly language Programming:

Classification of instructions, complete instruction set, assembly language programming include arithmetic and logical, conditional, branch control, stack, subroutine timer and counter.

Unit–III	**No. of Lectures: 09 Hours**	**Marks: 12**

Interfacing memory and Peripherals:
Types of memory - ROM, RAM: static & dynamic, PROM, EPROM, EEPROM, memory organization, Interfacing 4KX8 EPROM – 4KX8 RAM -Interfacing I/O ports to 8085-Hand shake signals.
Study of common IO peripheral devices, their architecture, control words and control register & different modes of operation 8255 PPI

Unit–IV	No. of Lectures: 09 Hours	Marks: 12

8051 Microcontroller
Introduction to concept of microcontroller, Intel 8051 Functional block diagram, Functions of pins of 8051, Memory organization of 8051, PSW and Flag Bits, Stack and Stack pointer. Overview of special function registers, Data transfer instructions and arithmetic and logical instructions and programs in assembly language

Unit–V	No. of Lectures: 09 Hours	Marks: 12

Interfacing and Microcontroller Application :
Light Emitting Diode (LEDs), Push Buttons, Relays and Latch Connection, Keyboard interfacing, 7-Segment displays interfacing, LCD interfacing, ADC and DAC interfacing, interfacing of stepper motors,
Industrial applications of Microcontrollers: Measurement application, Automation and Control applications

Text Books:

1. R. S. Gaonkar. “Microprocessor Architecture, Programming, & Applications with 8085”, Penram International Publication (India) Pvt. Ltd., Third edition, 6th Edition, 2013.
2. B. Ram, “Fundamentals of Microprocessors & Microcontrollers” Dhanpat Rai Publication, 2014.
3. Triebel, Walter A Singh, Avtar , “The 8088 and 8086 Microprocessors” Pearson Publication, New Delhi 2015.

Reference Books:

1. N. Senthil Kumar, M. Saravanan, S. Jeevananathan, “Microprocessors & Microcontrollers” Oxford University Press, 2nd Edition, 2016.
2. Leventhal, “8085 Assembly Languages Programming” Tata McGraw Hill.
3. Muhammad Ali Mazidi, Janice GillispieMazidi and Rolin D. McKinlay, “The 8051 Microcontroller and Embedded Systems Using Assembly and C”, Second Edition.
4. Kenneth J. Ayala “The 8051 Micro Controller: Architecture, Programming”, Penram International, Mumbai

NPTEL Links:

1. Microprocessors & Microcontrollers by Prof. Santanu Chattopadhyay, IIT Kharagpur
   nptel.ac.in/courses/108105102
2. Microprocessor by Prof Pramod Agarwal, IIT Roorkee
   nptel.ac.in/courses/108107029

Program Elective Course-III					
MICROPROCESSOR AND MICROCONTROLLER LAB (PEC)					
LAB COURSE CONTENT					
MICROPROCESSOR AND MICROCONTROLLER LAB		**Semester:**	**VI**	**Course Code: MPMC Lab**	**EE 607A**
Teaching Scheme:		**Examination scheme**			
Practical:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**			**25 marks**

Concerned faculty member should suitably frame **SEVEN** laboratory assignments from the following list.

1. Study of architecture and instruction of 8085 along with opcodes
2. Microprocessor 8085 assembly language programs based on data transfer instruction.
3. Microprocessor 8085 assembly language programs based on arithmetic instruction e.
4. Microprocessor 8085 assembly language programs based on logical instruction.
5. Microcontroller 8051 assembly language programs based on arithmetic and logical instructions.
6. Microcontroller 8051 assembly language programs based on data transfer instruction.
7. Generation of delay using Timers of 8051 in mode 0, 1 and 2
8. LED and Push button Interfacing
9. PWM Control of DC Motors
10. Keyboard Interfacing
11. Interfacing 7-segment display
12. LCD interfacing
13. ADC and DAC Interfacing

Text Books:

1. R. S. Gaonkar. “Microprocessor Architecture, Programming, & Applications with 8085”, Penram International Publication (India) Pvt. Ltd., Third edition, 6th Edition, 2013.
2. B. Ram, “Fundamentals of Microprocessors & Microcontrollers” Dhanpat Rai Publication, 2014.

Reference Books:

1. N. Senthil Kumar, M. Saravanan, S. Jeevananathan, “Microprocessors & Microcontrollers” Oxford University Press, 2nd Edition, 2016.
2. Leventhal, “8085 Assembly Languages Programming” Tata McGraw Hill.
3. Muhammad Ali Mazidi, Janice GillispieMazidi and Rolin D. McKinlay, “The 8051 Microcontroller and Embedded Systems Using Assembly and C”, Second Edition.
4. Kenneth J. Ayala “The 8051 Micro Controller: Architecture, Programming”, Penram International, Mumbai.

Guidelines for ICA:

Students must submit ICA in the form of journal. Each assignment should be well documented. Faculty in Charge will assess the assignments continuously and grade or mark each assignment on completion date declared for each assignment.

Program Elective –III (PEC)				
UTILIZATION OF ELECTRICAL ENERGY (PEC)				
COURSE OUTLINE				
Course Title:	**UTILIZATION OF ELECTRICAL ENERGY**	**Short Title: UEE**	**Course**	**EE606 B**

Course description:

The subject explores the knowledge of different industrial derives, load characteristic, factor effecting on selection of derives depend upon their electrical , mechanical characteristic and service duty. The subject also provides the knowledge of electric traction, ideal requirement of traction motor, operation and control. The subject provides brief knowledge of heat, ventilation and air conditioning system also.

	Hours/week	No. of weeks	Total hours	Semester credits
Theory	03	15	45	**03**
Practical	02	15	30	**01**

Prerequisite course(s):

Knowledge Electrical Machines .

Course objectives:

The objective of this course is to impart knowledge so that the student will:

1. Select proper motor for given load characteristic.
2. Selection of motor based on load characteristic, electrical, mechanical characteristic and service duty.
3. Provides the knowledge of electric traction, ideal requirement of traction motor, operation and control.
4. Provides brief knowledge of heat, ventilation and air conditioning system also.
5. Evaluate the illumination level for various industrial layout.

Course outcomes:

After successful completion of this course the student will be able to:

1. Apply the knowledge of electrical engineering subjects in different application of industries like manufacturing, maintenance, operation and safety.
2. Understand the characteristic of load and selection of derive in industrial sectors.
3. Conduct practical and analyze data for proper selection of derive in realistic constrain of load requirement.
4. Understand the impact of electrical characteristic of motor in electric traction system.
5. Design different types of lighting scheme designs for indoor lighting and indoor purpose.

UTILIZATION OF ELECTRICAL ENERGY			
UTILIZATION OF ELECTRICAL ENERGY		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):UA**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):CA	**40 marks**

Unit–I	**No. of Lectures: 09 Hours**	**Marks: 12**

Electric Drives: - Type of drives, Nature of load, Section motors, electrical, mechanical , service capacity and rating and Types of Enclosures. Electrical Characteristic: Starting, Operating and running, speed control and braking characteristics of DC motor , three phase induction motor and single phase induction motor

Unit–II	**No. of Lectures: 09 Hours**	**Marks: 12**

Types of Duties :-Type of duty: Continuous, intermittent and short time rating , temperature

rise and rating calculations for these duties mechanical features , features of load diagram construction, load equalization & use of flywheel.

Unit–III	No. of Lectures: 09 Hours	Marks: 12

Traction Systems :- Requirements of ideal traction system, Systems of track electrification and their comparison, speed time curve, factors affecting on schedule speed, Tractive effort, Factors affecting in energy consumption and specific energy consumption.

Unit–IV	No. of Lectures: 09 Hours	Marks: 12

Traction Motors:- General features of traction motors, Control of traction motor: starting, speed control and braking of traction motor , Energy returned during regenerative braking ,overhead equipment control gear

Unit–V	No. of Lectures: 09 Hours	Marks: 12

Design of Interior Lighting : Definitions of maintenance factor, Uniformity ratio, Direct ratio, Coefficients of utilization and factors affecting it, Illumination required for various work planes, Space to mounting height ratio, Types of fixtures and relative terms used for interior illumination, Calculation of wattage of each lamp and no of lamps needed, Layout of lamp luminaries, Calculation of space to mounting height ratio, Indian standard recommendation and standard practices for illumination levels in various areas, Special feature for entrance, staircase, Corridor lighting and industrial building.

Text Books:

1. Gupta J. B., “Utilization of Electric Power & Electric Traction” S. K. Kataria & Sons.
2. Partab H. P., ‘Art & Science of Utilization of Electrical Engineering’ Dhanpat Rai Publications.

Reference Books:

1. O.E.Taylor , “Utilization of Electrical Energy”, Longman
2. V. V. L. Rao, “Utilization of Electrical Energy”, TMH
3. S. K. Pillai, “A Course in Electrical Energy”, TMH
4. H. Partab, “Art & Science of Utilization of Electrical Energy

NPTEL Links:

1. Industrial Drives by Prof K R Rajagopal, IIT Delhi
   nptel.ac.in/courses/108102046
2. Fundamental of Electric Drives by Prof Shyama Prasad Das, IIT Kanpur
   nptel.ac.in/courses/108104140
3. Advanced Electric Drive by Prof P S Das, IIT Kanpur
   nptel.ac.in/courses/108104011
4. Illumination Engineering by Prof N K Kishor, IIT Khargpur
   nptel.ac.in/courses/108105060

Program Elective Course-III (PEC)					
UTILIZATION OF ELECTRICAL ENERGY LAB (PEC)					
LAB COURSE CONTENT					
UTILIZATION OF ELECTRICAL ENERGY LAB		**Semester:**	**VI**	**Course Code: UEE lab**	**EE 607B**
Teaching Scheme:		**Examination scheme**			
Practical:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**			**25 marks**

Concerned faculty member should suitably frame **SEVEN** laboratory assignments from the following list.

1. Performance characteristics of DC Series motor by load test.
2. Performance characteristics of DC Series motor by Field Test.
3. Performance characteristics of DC Shunt motor by direct load test.
4. Performance characteristics of single phase induction motor by direct load test.
5. Performance characteristics of three phase induction motor by direct load test.
6. Speed control of DC series motor.
7. Speed control of three-phase slip ring induction motor by rotor resistance method
8. Rheostatic braking of DC shunt motor.
9. Study of Air conditioning system.
10. Study of induction heating &Welding.
11. Study of different types of enclosures
12. Illumination design of commercial or educational institute building.
13. Measurement illumination of different light source and comparison at same high and surrounding.

Text Books:

1. Gupta J. B., “Utilization of Electric Power & Electric Traction” S. K. Kataria & Sons.
2. Partab H. P., ‘Art & Science of Utilization of Electrical Engineering’ Dhanpat Rai Publications

Reference Books:

1. O.E.Taylor , “Utilization of Electrical Energy”, Longman
2. V. V. L. Rao, “Utilization of Electrical Energy”, TMH
3. S. K. Pillai, “A Course in Electrical Energy”, TMH
4. H. Partab, “Art & Science of Utilization of Electrical Energy

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Program Elective –III (PEC)				
ILLUMINATION ENGINEERING (PEC)				
COURSE OUTLINE				
Course Title:	**ILLUMINATION ENGINEERING**	**Short Title: IE**	**Course:**	**EE606 C**

Course description:

The explores the knowledge of types of illumination , lighting systems, lighting Scheme , measurement of might , laws of illumination , design of Interior Lighting, Indian standard recommendation and standard practices for illumination levels in various areas, design of outdoor lighting and special features of aesthetic lighting

	Hours/week	**No. of weeks**	**Total hours**	**Semester credits**
Theory	03	15	45	**03**
Practical	02	15	30	**01**

Prerequisite course(s):

Basic Electrical and Electronic Engineering at First Year

Course objectives:

The objective of this course is to impart knowledge so that the student will:

1. Provide an introduction to the fundamentals of illumination engineering and architectural lighting design.
2. Impart lighting fundamentals, measurement, and technology and their application in the analysis and design of architectural lighting systems.
3. Understand the factors to be consider while designing indoor and out door illumination schemes.
4. Evaluate the illumination level for various industrial layout.
5. Design lighting scheme for special purpose

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand concept of lighting system for various purposes
2. Identify the criteria for the selection of lamps for systems for an indoor or outdoor space .
3. Design different types of lighting scheme designs for indoor lighting and indoor purpose.
4. Measure illumination level for proper selection of light source and mounting arrangement
5. Design special lighting scheme to meet the specified needs with appropriate consideration in monument Sports and aviation lighting.

ILLUMINATION ENGINEERING			
ILLUMINATION ENGINEERING		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):UA**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):CA	**40 marks**

Unit–I	**No. of Lectures: 09 Hours**	**Marks: 12**

Introduction of Light: Radiation, colour and eye vision. Types of illumination, Day lighting, Supplementary artificial lighting and total lighting, Quality of good lighting, Factors affecting the lighting-shadow, glare, reflection, Colour rendering and stroboscopic effect, Methods of artificial lighting, Lighting systems-direct, indirect, semi direct, semi indirect, Lighting scheme, General and localized

Unit–II	**No. of Lectures: 09 Hours**	**Marks: 12**

Light Source and measurement light: Incandescent, electric discharge, fluorescent and LED light, Luminaries and control circuits. Definition of luminous flux, Luminous intensity, Lumen, Candle power, Illumination, M.H.C.P, M.S.C.P, M.H.S.C.P, Lamp efficiency, Brightness or luminance, Laws of illumination, Inverse square law and Lambert's Cosine law, Illumination at horizontal and vertical plane from point source, Concept of polar curve, Calculation of luminance and illumination in case of linear source, round source and flat source

Unit–III	No. of Lectures: 09 Hours	Marks: 12

Design of Interior Lighting : Definitions of maintenance factor, Uniformity ratio, Direct ratio, Coefficients of utilization and factors affecting it, Illumination required for various work planes, Space to mounting height ratio, Types of fixtures and relative terms used for interior illumination, Calculation of wattage of each lamp and no of lamps needed, Layout of lamp luminaries, Calculation of space to mounting height ratio, Indian standard recommendation and standard practices for illumination levels in various areas, Special feature for entrance, staircase, Corridor lighting and industrial building.

Unit–IV	No. of Lectures: 09 Hours	Marks: 12

Design of Outdoor Lighting : Street Lighting : Types of street and their level of illumination required, Terms related to street and street lighting, Types of fixtures used and their suitable application, Various arrangements in street lighting, Requirements of good street lighting, Selection of lamp and luminaries, Calculation of their wattage, Number and arrangement, Calculation of space to mounting height ratio, Calculation of illumination level available on road .Flood Lighting Types of fixtures and their suitable applications, Selection of lamp and projector, Calculation of their wattage and number and their arrangement, Calculation of space to mounting height ratio.

Unit–V	No. of Lectures: 09 Hours	Marks: 12

Special Features of Aesthetic Lighting: Monument and statue lighting, Sports lighting, Auditorium lighting and aviation and transport lighting. Lighting for displays and signaling- neon sign, LED LCD displays and lighting for surveillance.

Text Books:

1. Gupta J. B., "Utilization of Electric Power & Electric Traction" S. K. Kataria & Sons.
2. Partab H. P., 'Art & Science of Utilization of Electrical Engineering' Dhanpat Rai Publications.

Reference Books:

1. Jack L. Lindsey, "Applied Illumination Engineering" , PHI, 1991
2. John Matthews, "Introduction to the Design and Analysis of Building Electrical Systems", Springer, 1993
3. M.A. Cayless, "Lamps and Lighting" , Routledge, 1996
4. O.E.Taylor , "Utilization of Electrical Energy", Longman
5. H. S. Mamak, "Book on Lighting", Publisher International lighting Academy
6. Joseph B. Murdoch, "Illumination Engineering from Edison's Lamp to Lasers" Publisher - York, PA : Visions Communications

NPTEL Links:

1. Illumination Engineering by Prof N K Kishor, IIT Khargpur
   nptel.ac.in/courses/108105060

Program Elective Course-III (PEC)					
ILLUMINATION ENGINEERING LAB (PEC)					
LAB COURSE CONTENT					
ILLUMINATION ENGINEERING LAB		**Semester:**	**VI**	**Course Code: IE Lab**	**EE 607C**
Teaching Scheme:		**Examination scheme**			
Practical:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**			**25 marks**

Concerned faculty member should suitably frame **SEVEN** laboratory assignments from the following list.

1. Study of different light source and working operation.
2. Measurement illumination of different light source and comparison at same high and surrounding.
3. Study of Colour Rendering index of different type of lamps.
4. Illumination design of domestic layout.
5. Illumination design of commercial or educational institute building.
6. Illumination design of street light.
7. Illumination of outdoor sports area.
8. Case study of illumination audit
9. Measurement power factor of lighting load and power factor improvement.
10. Study of lighting fixture based application

Text Books:

1. Gupta J. B., "Utilization of Electric Power & Electric Traction" S. K. Kataria & Sons.
2. Partab H. P., 'Art & Science of Utilization of Electrical Engineering' Dhanpat Rai Publications.

Reference Books:

1. Jack L. Lindsey, "Applied Illumination Engineering" , PHI, 1991
2. John Matthews, "Introduction to the Design and Analysis of Building Electrical Systems", Springer, 1993
3. M.A. Cayless, "Lamps and Lighting" , Routledge, 1996
4. O.E.Taylor , "Utilization of Electrical Energy", Longman
5. H. S. Mamak, "Book on Lighting", Publisher International lighting Academy

Guidelines for ICA:

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WIND AND SOLAR POWER SYSTEMS (MD M)					
COURSE OUTLINE					
Course Title:	**WIND AND SOLAR POWER SYSTEMS**	**Short Title:**	WSPS	**Course Code:**	**EE608**

Course description: The syllabus for wind and solar power system typically covers the fundamental concepts, technologies, and applications related to the generation of electrical power at or near the point of use, rather than at centralized power plants. It focuses on the integration of renewable energy sources, small-scale power generation systems, and their role in enhancing grid stability and reliability

	Hours/week	**No. of weeks**	**Total hours**	**Semester credits**
Theory	02	15	30	**02**

Prerequisite course(s):

Electrical Power System-I

Course objectives:

The objective of this course is to impart knowledge so that the student will:

1. Understand renewable energy resources with a focus on wind and solar energy.
2. Understand the design and functioning of solar PV and wind energy systems.
3. Study grid integration and power electronics used in renewable energy systems.
4. Analyze performance, control, and economic aspects of wind and solar systems.
5. Compare different type of energy storage for power system

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand the principles of solar and wind energy conversion.
2. Design basic PV and wind energy systems.
3. Analyze the performance and efficiency of renewable energy systems.
4. Evaluate the integration of wind and solar systems with the grid.
5. Understand techno-economic aspects of wind and solar energy.

COURSE CONTENT

WIND AND SOLAR POWER SYSTEMS		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**2 hours/week**	**End Semester Exam (ESE) UA:**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE) CA:	**40 marks**
		Internal Continuous Assessment (ICA) CA:	**25 marks**

Unit–I	**No. of Lectures: 06 Hours**	**Marks: 12**

Distributed Power Generation: Concept and advantages of distributed power generation, distributed power generation system energy sources, function of power electronics interface, Solar energy for distributed power generation, Wind energy for distributed power generation,.

Unit–II	**No. of Lectures: 06 Hours**	**Marks: 12**

Solar Energy : Solar radiation: types, measurement, and estimation, Solar geometry and angles, Solar photovoltaic (PV) principles and characteristics, Types of solar cells: mono-crystalline, polycrystalline, thin-film, PV module construction and rating, I-V characteristics of PV cells, MPPT (Maximum Power Point Tracking) techniques, Balance of system: batteries, inverters, controller, Standalone and grid-connected PV systems

Unit–III	**No. of Lectures: 06 Hours**	**Marks: 12**

Wind Energy: Wind energy fundamentals, Wind characteristics and speed measurement, Types of wind turbines (HAWT, VAWT), Power output from wind turbines, Wind turbine components: rotor, gearbox, generator, yaw, pitch system, Wind site selection and wind farm layout, Aerodynamics of wind turbines, Power coefficient and tip speed ratio		
Unit–IV	**No. of Lectures: 06 Hours**	**Marks: 12**
Grid Integration : Wind electric generators: synchronous and induction machines, Control strategies: pitch and stall control, Wind power conversion systems (WECS), Power electronics for wind energy systems, Grid integration of wind and solar systems, Power quality issues, Hybrid renewable energy systems (solar-wind), Economics and cost analysis		
Unit–V	**No. of Lectures: 06 Hours**	**Marks: 12**
Energy Storage System : Introduction to Electrochemical battery, battery capacity, Battery Parameters and Comparisons, Battery Pack Discharge Curves and Aging, Battery Models, SOC, SOD, SOH, DOD, Battery technologies used in, Lead acid battery, Nickel based battery, Lithium battery, Grephene battery and comparison of Battery types., Overview of key Fuel cell technologies, fuel cell types, electrode materials, safety issues, life cycle analysis.		

Text Books:

1. Dr. B R Gupta, "Generation of Electrical Energy", S Chand Publication
2. B.H. Khan**,** Non-Conventional Energy Resources*,* McGraw Hill
3. Chetan Singh Solanki**,** Solar Photovoltaics: Fundamentals, Technologies and Applications*,* PHI

Reference Books:

1. G.D. Rai**,** Non-Conventional Energy Sources*,* Khanna Publishers
2. Mukund R. Patel**,** Wind and Solar Power Systems, CRC Press
3. Chetan Singh Solanki, Solar Photovoltaics: Fundamentals, Technologies and Applications, PHI
4. S.P. Sukhatme, Solar Energy: Principles of Thermal Collection and Storage, TMH
5. Tiwari & Ghosal**,** Renewable Energy Resources*,* Narosa Publishing House

NPTEL Links:

1. Electric Vehicle and Renewable Energy by Prof Ashok Jhunjhunwala, IIT Madras nptel.ac.in/courses/108106182
2. Smart Grid by Prof N P Padhy and Prof Premalata Jena, IIT Roorkee nptel.ac.in/courses/108107113

Guidelines for ICA:

Students must submit ICA in the form of journal. Concerned faculty member should suitably frame **FIVE** assignments based on the above syllabus. Faculty in charge will assess the assignments continuously, and grade or mark each assignment on completion date declared for each assignment.

ELECTRICAL INSTALLATION (VSEC)					
ELECTRICAL INSTALLATION (PCC)					
COURSE OUTLINE					
Course Title:	**ELECTRICAL INSTALLATION**	**Short Title:**	**EI**	**Course Code:**	**EE 609**

Course description: The course explores the knowledge of electrical installation in domestic, commercial and industrial sectors. The course provide the procedure in calculation of load, estimation of bill of material and preparing technical specification and quantity. The course also provide safety guideline during electrical installation.

	Hours/week	**No. of**	**Total hours**	**Semester credits**
Theory	1	15	15	**02**
Practical	2	15	30	

Prerequisite course(s):

Maintenance of Electrical Installation

Course objectives:

The objective of this course is to impart knowledge so that the student will:

1. Understand the size and rating of different electrical appliances.
2. Select various wire, cable based on size of installation and application.
3. Estimate load , cable and wiring size for different electrical installation.
4. Use the safety precaution measure in electrical installation.
5. Prepare single line diagram and bill of material for electrical installation

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand the size and rating of different electrical appliances.
2. Select various wire, cable based on size of installation and application.
3. Estimate load , cable and wiring size for different electrical installation.
4. Use the safety precaution measure in electrical installation.
5. Prepare single line diagram and bill of material for electrical installation

COURSE CONTENT

ELECTRICAL WORKSHOP		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme:**	
Lectures:	**1 hour/week**		
Practical:	**2 hour/week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**

Unit–I	**No. of Lectures: 03 Hours**	

Introduction to Electrical Installation: Types of electrical installations (residential, commercial, industrial), Standards and codes , Tools used in electrical installation, Wiring accessories and materials , Factors affecting selection of wiring system. Layout of lamp luminaries, Calculation of space to mounting height ratio. Street light and outdoor application layout and material estimation

Unit–II	**No. of Lectures: 03 Hours**	

Electrical Installation Planning: Load calculation, Selection of wires, cables, and protection devices, Preparation of single-line diagrams (SLD), Estimating and costing of electrical installation, Industrial load and installation planning, Capacity of transformer ,Power Backup and cables.

Unit–III	**No. of Lectures: 03 Hours**	
Earthing and Grounding: Need and types of earthing(Plate, Pipe, Rod), Earth resistance and methods to reduce it, Earthing of appliances and lightning arrestors, Safety measures during installatios.		
Unit–IV	**No. of Lectures: 03 Hours**	
Protection and Safety : Over-current protection (fuses, MCB, MCCB), Introduction LT and HT Circuit Breakers, Rating of switchgears, Earth leakage protection (ELCB, RCCB), Safety practices in electrical installation, First aid for electric shock		
Unit–V	**No. of Lectures: 03 Hours**	
Installation of Rooftop Solar PV: Site survey, calculation of capacity of Solar PV Rooftop plant , Specification of Solar PV Module, String of Solar PV, Specification of On-grid Inverter, Single line diagram, structure and metering.		

LAB COURSE CONTENT

Concerned faculty member should suitably frame **SEVEN** laboratory assignments from the following list.

1. Study of different wire and cable and their layout methods
2. Illumination layout for indoor application
3. Illumination layout for outdoor application
4. Preparation of single line diagram for domestic wiring and estimation.
5. Load calculation for small industry and sizing of transformer.
6. Load calculation for commercial establishment building and sizing of transformer and circuit breakers.
7. Demonstration of applications for MCB and ELCB.
8. Preparing layout of 11kV or 33kV Substation along with bill of materials.
9. Preparing layout On-Grid Rooftop Solar PV Plant along with bill of materials.
10. Visit to industrial site under installation stage.

Text Books:

1. S. L. Uppal, G. C. Garg, “Electrical Wiring, Estimating and Costing” Khanna Publishers 6 th Edition, 2012

Reference Books:

1. P. P. Gupta, “Maintenance of Electrical Equipments” Dhanpatrai and Sons
2. A. K. Sawhney. “Electrical & Electronic Measurement and Instrumentation” Dhanpant Rai & Co 18th edition, 2007.

NPTEL Link:

1. Transmission line insulators by Prof Subba Reddy B, IISc, Bangalore
   https://archive.nptel.ac.in/courses/108/108/108108116/

Guidelines for ICA:

Students must submit ICA in the form of journal. Each assignment should be well documented. Faculty in Charge will assess the assignments continuously and grade or mark each practical /assignment on completion date declared for each practical/assignment

EXIT COURSE

Internship / Apprenticeship:

Internship / Apprenticeship / OJT shall be corresponding to the programme (Major) subject. Internship / Apprenticeship / OJT shall be monitored jointly by faculty and Industry / organization mentor.

The role of a Mentor, nominated by institute, shall be to provide professional/research guidance to the student during the internship. They shall also facilitate networking with other subject matter experts/professionals, which will enhance the internship experience and learning of the students.

Internship / Apprenticeship / OJT corresponding to the programme (Major) subject in Exit course with an external organization / entity is desirable. External organization may be industries, research institutions, University research centers or CSIR laboratories. Internship / Apprenticeship / OJT shall be preferably in offline mode, however online mode may also be permitted.

Preferably the Mini Project in Exit course shall be based on Internship / Apprenticeship / OJT.

Activities under Internship / Apprenticeship / OJT include Project work, Seminar, Industrial Training (excluding credits for Advanced Courses). This can be Industrial / Govt. / NGO/MSME/ Rural Internship/ Innovation / Entrepreneurship / academic / industry research project.

After completion of Internship, students shall prepare a comprehensive report highlighting their learnings and takeaways during the internship period. The students are mandated to give a seminar based on the internship undertaken before an expert committee constituted by the concerned department and the assessment of internship shall be based on the following criteria:

1) Quality and effectiveness of presentation
2) Depth of knowledge and demonstrated skills
3) Variety and relevance of learning experience
4) Practical applications and relationships with concepts taught in the course
5) Internship Report
6) Attendance record, student diary (log), supervisor evaluation

Attendance record shall include daily attendance with IN and OUT time. It shall be signed by Industry supervisor.

Student Diary (log) shall include daily activities carried out by the student during Internship with Task assigned, Activities performed, key learnings etc. It shall be signed by Industry supervisor.

Supervisor evaluation form shall include the following with ratings in FIVE-point scale.

1) Behaviours
2) Performs in a dependable manner
3) Cooperates with co-workers and supervisors
4) Shows interest in work
5) Learns quickly
6) Shows initiative
7) Produces high quality work
8) Accepts responsibility
9) Accepts criticism
10) Demonstrates organizational skills
11) Uses technical knowledge and expertise
12) Shows good judgment
13) Demonstrates creativity/originality
14) Analyzes problems effectively
15) Is self-reliant
16) Communicates well
17) Writes effectively
18) Has a professional attitude
19) Gives a professional appearance
20) Is punctual
21) Uses time effectively

Supervisor evaluation form shall be signed by Industry supervisor.

Mini project:
The student shall carry out a Mini project based on the knowledge acquired during the degree course and/or Internship. The project may be either fully theoretical/practical or involving both theoretical and practical work to be assigned by the guide / mentor / department. The work may also be Study/Survey/Design or R&D work. The work may also be on specified task or project assigned to the students during Internship. The project may also be a sponsored project. The project shall be corresponding to the programme (Major) subject.
Upon completion of the Mini project, the student shall submit project report in the form of hard bound. Assessment for the Mini project shall also include presentation by the student. Assessment of Mini project shall be based on the following criteria:

1) Problem Identification / Project Objectives
2) Methodology / Design
3) Implementation
4) Results and Discussion
5) Conclusion
6) Report
7) Depth of Understanding
8) Presentation
9) Demonstration of the project

Kavayitri Bahinabai Chaudhari
NORTH MAHARASHTRA UNIVERSITY,
JALGAON (M.S.)

Bachelor of Engineering – Honors
in
High Voltage and Power Systems Engineering
for Third Year Bachelor of Engineering
in
Electrical
(As per NEP 2020 Guidelines)

Faculty of Science and Technology



SYLLABUS STRUCTURE & COURSE OUTLINE
For Affiliated Colleges
Semester – V & VI
W.E.F. 2026 – 27

Honors in High Voltage and Power Systems Engineering

Syllabus Structure for Honors in High Voltage and Power Systems Engineering: Additional Credit (Semester – V) (w.e.f. 2026 – 27)
(As per NEP 2020 Guidelines)

Course Code	Name of the Course	Category	Teaching Scheme				Evaluation Scheme					Credits
							Theory		Practical		Total	
			Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE (CA)	ESE (UA)	ICA (CA)	ESE (UA)		
EE -510A	EHV Transmission System	PCC	3			3	40	60			100	3
EE -511A	EHV Transmission System Lab	PCC			2	2			25	25 (OR)	50	1

Syllabus Structure for Honors in High Voltage and Power Systems Engineering: Additional Credit (Semester – VI) (w.e.f. 2026 – 27)
(As per NEP 2020 Guidelines)

Course Code	Name of the Course	Category	Teaching Scheme				Evaluation Scheme					Credits
							Theory		Practical		Total	
			Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE (CA)	ESE (UA)	ICA (CA)	ESE (UA)		
EE -612A	Digital Protection of Power System	PCC	3			3	40	60			100	3
EE -613A	Digital Protection of Power System Lab	PCC			2	2			25	25 (OR)	50	1

EHV TRANSMISSION SYSTEM (Honors) (PCC)					
COURSE OUTLINE					
Course Title:	**EHV TRANSMISSION SYSTEM**	**Short Title:**	EHV	**Course Code:**	**EE510 A**

Course description:
This course provides an introduction to power generation by using conventional sources. This course covers the working, selection of site, different elements of various conventional power plants. This course also provides an introduction to the economics consideration of the power plants.

	Hours/week	**No. of weeks**	**Total hours**	**Semester credits**
Theory	03	15	45	**03**
Practical	02	15	30	**01**

Prerequisite course(s):
Power System –I and II

Course objectives:
The objective of this course is to impart knowledge so that the student will:
1. Understand the principles and challenges of EHV and UHV transmission systems.
2. Analyze corona effects, insulation coordination, and overvoltage phenomena in EHV systems.
3. Study the design and operational aspects of EHV transmission lines and substations.
4. Evaluate the role of FACTS devices in EHV transmission.
5. Gain hands-on experience in EHV testing and simulation.

Course outcomes:
After successful completion of this course the student will be able to:
1. Explain the need for EHV transmission and compare different voltage levels.
2. Analyze corona effects, radio interference, and mitigation techniques.
3. Design EHV transmission line parameters and insulation systems.
4. Evaluate overvoltage protection and insulation coordination methods.
5. Simulate EHV systems using software tools and conduct lab experiments.

COURSE CONTENT

EHV TRANSMISSION SYSTEM		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End Semester Exam (ESE) UA:**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE) CA:	**40 marks**

Unit–I	**No. of Lectures: 09 Hours**	**Marks: 12**

Introduction to EHV Transmission:
Need for EHV and UHV transmission, Voltage levels (AC & DC): 400kV, 765kV, 1100kV, HVDC Advantages and challenges. Necessity of EHV AC transmission – advantages and problems–power handling capacity and line losses- mechanical considerations.

Unit–II	**No. of Lectures: 09 Hours**	**Marks: 12**

Corona and Radio Interference
Corona phenomenon in EHV lines, Factors affecting corona loss, Power loss and audible noise (AN) – corona loss formulae.
Radio and TV interference (RI & TVI), Radio interference (RI) - corona pulses generation, properties, limits – frequency spectrum – modes of propagation – excitation function – measurement of RI, RIV and excitation functions – Examples., Mitigation techniques.

Unit–III	No. of Lectures: 09 Hours	Marks: 12
EHV Transmission Line Parameters Resistance, inductance, and capacitance calculations, Surge impedance and SIL (Surge Impedance Loading), Bundle conductors and their advantages. Numericals.		
Unit–IV	**No. of Lectures: 09 Hours**	**Marks: 12**
Insulation Coordination & Overvoltages Lightning and switching overvoltages, Insulation coordination principles, Arcing horns, surge arresters, and grounding Voltage Control- Power circle diagram and its use – voltage control using synchronous condensers – cascade connection of shunt and series compensation		
Unit–V	**No. of Lectures: 09 Hours**	**Marks: 12**
EHV Substations & Equipment Layout of EHV substations, Circuit breakers, transformers, and isolators, Gas Insulated Substations (GIS) **FACTS in EHV Transmission** Role of Flexible AC Transmission Systems (FACTS), STATCOM, SVC, and TCSC applications		
Text Books:		
1. Rakosh Das Begamudre, "ExtraHigh Voltage A.C. Transmission Engineering", New Age International (p) limited , Second Edition,2010.		
Reference Books: 1. C.L.Wadhwa, "HIGH VOLTAGE ENGINEERING ",New Age International (p) limited , Third Edition,2010. 2. Rakosh Das Begamudre, "ExtraHigh Voltage A.C. Transmission Engineering", New Age International (p) limited , Second Edition,2010. 3. A. K. Sawhney, "A Course in Electrical and Electronic Measurements & Instrumentation", Dhanpat Rai & Co. 4. Arun K. Ghosh, "Introduction to Measurements and Instrumentation", PHI Publication 5. H.S.Kalsi, "Electronic Instrumentation", Tata McGraw Hill Private Limited, Third Edition.		
NPTEL Links: 1. Measurement of High Voltage by Prof. Ravindra Arora,IIT Kanpur https://nptel.ac.in/courses/108104048 2. High Voltage Testing by by Prof Subba Reddy B, ISc Bangalore https://nptel.ac.in/courses/108108099		

EHV TRANSMISSION SYSTEM LAB (Honors) (PCC)					
LAB COURSE CONTENT					
EHV TRANSMISSION SYSTEM LAB		**Semester:**	**V**	**Course Code:**	**EE511A**
Teaching Scheme:		**Examination scheme**			
Practical:	**2 hours/week**	**End Semester Exam (ESE) UA: OR**			**25 marks**
		Internal Continuous Assessment (ICA) CA:			**25 marks**
End Semester Exam (ESE) Pattern:		**(Oral) OR**			

Concerned faculty member should suitably frame SEVEN laboratory assignments from the following list.

1. Study effect of voltage, conductor size, spacing and surface condition.
2. Observation of corona inception voltage
3. Insulation Resistance & Breakdown Testing Using HV test kits.
4. Measurement of leakage current and breakdown voltage Insulation.
5. Dielectric Strength of Insulating Materials Breakdown voltage of air, oil, and solid insulation.
6. HV Measurement Techniques- Sphere gap method.
7. String Efficiency of Insulator- Strings Effect of grading rings and guard rings
8. Measurement of Capacitance and Loss Tangent Using Schering Bridge (demonstration)
9. EHV Transmission Line Parameter Calculation Using MATLAB / PSCAD.
10. EHV Transmission Line Parameter Calculation of R, L, C, surge impedance and SIL.
11. Visit to EHV Substation 220 kV / 400 kV / 765 kV.

Text Books:

1. Rakosh Das Begamudre, "ExtraHigh Voltage A.C. Transmission Engineering", New Age International (p) limited , Second Edition,2010.

Reference Books:

1. C.L.Wadhwa, "HIGH VOLTAGE ENGINEERING ",New Age International (p) limited , Third Edition,2010.
2. Rakosh Das Begamudre, "ExtraHigh Voltage A.C. Transmission Engineering", New Age International (p) limited , Second Edition,2010.
3. H.S.Kalsi, "Electronic Instrumentation", Tata McGraw Hill Private Limited, Third Edition.

Guidelines for ICA:

Students must submit ICA in the form of journal. Each assignment should be well documented. Faculty in Charge will assess the assignments continuously and grade or mark each assignment on completion date declared for each assignment.

Guidelines for ESE:OR

ESE will be based on practical assignment submitted by the student in the form of journal. Evaluation will be based on oral

DIGITAL PROTECTION OF POWER SYSTEM (Honors) (PCC)					
COURSE OUTLINE					
Course Title:	**DIGITAL PROTECTION OF POWER SYSTEM**	**Short Title:**	**DPPS**	**Course Code:**	**EE612 A**

Course description: This course is to be prepared to serve as an introductory course for Digital Protection of Power System. It aims to give a comprehensive up-to-date presentation of the fundamentals of digital relays, concept of digital signal processing used in digital relays and various algorithms utilized in digital/numerical relays. It begins with a state-of-the-art survey of theories and methods of digital/numeric relays and phasor measurement units (PMUs) along with IEC 61850 substation and automation protocols. In continuation, it provides a theoretical summary along with examples of real-life engineering applications to a variety of technical problems such as load shedding and frequency relaying, reclosing and synchronizing, protection issues due to interconnection of distributed energy resources in the grid and digital protection of various electrical apparatus such as generator, transformer, transmission lines etc.

	Hours/week	**No. of weeks**	**Total hours**	**Semester credits**
Theory	03	15	45	**03**
Practical	02	15	30	**01**

Prerequisite course(s):

Knowledge of power System

Course objectives:

The objective of this course is to impart knowledge so that the student will:

1. Cover analytical techniques used in digital relays and application.
2. Discuss of various digital relaying schemes for line and equipment protection.
3. Understand up-to-date presentation of the fundamentals of digital relays
4. Apply the concept of digital signal processing used in digital relays and various algorithms utilized in digital/numerical relays.
5. Provides a theoretical summary along with examples of real-life engineering applications to a variety of technical problems such as load shedding and frequency relaying, reclosing and synchronizing, protection issues due to interconnection of distributed energy resources in the grid and digital protection of various electrical apparatus

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand up-to-date presentation of the fundamentals of digital relays.
2. Discuss of various digital relaying schemes for line and equipment protection.
3. Apply the concept of digital signal processing used in digital relays and various algorithms utilized in digital/numerical relays.
4. Apply load shedding and frequency digital protection
5. Understand application of artificial intelligent Cyber security in digital protection

COURSE CONTENT

DIGITAL PROTECTION OF POWER SYSTEM		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End Semester Exam (ESE) UA:**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE) CA:	**40 marks**

Unit–I	**No. of Lectures: 09 Hours**	**Marks: 12**

Introduction of digital relays: Fundamentals of digital relays; Basic layout and elements of the digital relays with visual illustration; The concept of sampling and aliasing for digital relays; Sliding window concept of digital relays		
Unit–II	**No. of Lectures: 09 Hours**	**Marks: 12**
Estimation of phasors: Estimation of phasor using Full-cycle Discrete Fourier Transform (DFT); Estimation of phasors using Half-cycle DFT and introduction of Discrete Cosine Transform; Estimation of frequency in digital relays and practical considerations for selection of various algorithms; Digital Differential Protection of Generator, Induction motors and Busbar		
Unit–III	**No. of Lectures: 09 Hours**	**Marks: 12**
Digital Differential Protection: Digital differential protection of Transformers; Digital Directional/Non-directional Overcurrent and Earth fault relays; Overcurrent relay coordination in an interconnected power system network: LINKNET structure and determination of primary/backup relay pairs; Overcurrent relay coordination in an interconnected power system network: Example; Problems faced by digital distance relays.		
Unit–IV	**No. of Lectures: 09 Hours**	**Marks: 12**
Digital Distance Protection: Computation of direction and impedance for digital distance relays; Power swing detection and blocking technique in digital distance Relays; Protection of double-circuit transmission line using digital distance relays; Protection of multi-terminal transmission line using digital distance relays; Protection of series compensated transmission line using digital distance relays: Basic components.		
Unit–V	**No. of Lectures: 09 Hours**	**Marks: 12**
Frequency Relay and Application of AI : Load shedding and Frequency relaying: Various load shedding techniques and frequency relays; Load shedding and Frequency relaying: Factors to be considered and rate of frequency decline; Islanding phenomena: Hazards and risk of islanding and methods of islanding; Loss of existing protection coordination among protective devices. Application of artificial intelligence (AI) in digital relaying; Introduction to Phasor Measurement Unit (PMU);		
Text Books:		
1. Y.G.Paithankar, S.R.Bhide. “Fundamentals of Power System Protection”, PHI Learning Private Limited ,Second Edition,2010		
Reference Books: 1. Y.G.Paithankar, S.R.Bhide. “Fundamentals of Power System Protection”, PHI Learning Private Limited ,Second Edition,2010 2. Anderson, P.M., Power System Protection, IEEE Press, New York, 1999. 3. Blackburn, J.L., Applied Protective Relaying, Westinghouse Electric Corporation, New York, 1982. 4. Bhavesh Bhalja, R. P. Maheshwari, N. G. Chothani, Protection and Switchgear, Oxford University Press, 2nd edition, New Delhi, India, 2018. 5. Oza, B. A., N. C. Nair, R. P. Mehta, et al., Power System Protection & Switchgear, Tata McGraw Hill, New Delhi, 2010. 6. Phadke, A.G. and J.S. Thorp, Computer Relaying for Power Systems, Research Study Press Ltd, John Wiley & Sons, Taunton, UK, 1988. 7. Bhavesh Bhalja and Vijay H. Makwana, ""Transmission Line Protection Using Digital Technology,"" Springer Science+Business Media Singapore Pte. Ltd; Singapore, January 2016.		
NPTEL Links: 1. Protection scheme by Prof. A K Pardhan,IIT Kanpur		

https://nptel.ac.in/courses/108105167

2. Power system protection Prof. Bhaveshkumar , IIT Roorkee .
https://nptel.ac.in/courses/108107167

3. Signal Processing for Power System Protection by Prof S A Soman , IIT Bombay
https://nptel.ac.in/courses/108101039

<table>
<tr><th colspan="6">DIGITAL PROTECTION OF POWER SYSTEM LAB (Honors) (PCC)</th></tr>
<tr><th colspan="6">LAB COURSE CONTENT</th></tr>
<tr><td colspan="2">DIGITAL PROTECTION OF POWER SYSTEM LAB</td><td>Semester:</td><td>VI</td><td>Course Code:</td><td>EE613A</td></tr>
<tr><td colspan="2">Teaching Scheme:</td><td colspan="4">Examination scheme</td></tr>
<tr><td>Practical:</td><td>2 hours/week</td><td colspan="3">End Semester Exam (ESE) UA: OR</td><td>25 marks</td></tr>
<tr><td></td><td></td><td colspan="3">Internal Continuous Assessment (ICA) CA:</td><td>25 marks</td></tr>
<tr><td colspan="2">End Semester Exam (ESE) Pattern:</td><td colspan="4">(Oral) OR</td></tr>
<tr><td colspan="6">Concerned faculty member should suitably frame SEVEN laboratory assignments from the following list.
1. Study of relaying components and control circuit developments.
2. To conduct and plot the characteristic of re-wirable fuses and MCB.
3. To conduct and plot operating characteristics of Inverse time over current relay.
4. To conduct over current & earth fault protection scheme for alternator.
5. To conduct Protection of 3 phase transformer using differential relay (Merz- Price protection scheme).
6. To conduct and study the through fault stability of differential protection scheme applied to transformer.
7. To conduct Protection of transmission line.
8. Study of MHO distance relay to plot. a) R- X diagram b) Relay voltage Vs Admittance characteristic.
9. Study of Static relay.
10. Demonstration of microprocessor base protection.</td></tr>
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</table>

Kavayitri Bahinabai Chaudhari

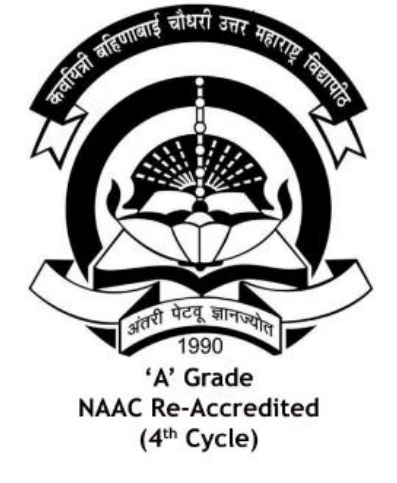
NORTH MAHARASHTRA UNIVERSITY, JALGAON

(M.S.)

Bachelor of Engineering – Honors
in
Microgrid Technologies
for Third Year Bachelor of Engineering
in
Electrical

(As per NEP 2020 Guidelines)

Faculty of Science and Technology



SYLLABUS STRUCTURE & COURSE OUTLINE
For Affiliated Colleges
Semester – V & VI
W.E.F. 2026 – 27

Honors in Microgrid Technologies

Syllabus Structure for Honors in Microgrid Technologies: Additional Credit (Semester – V) (w.e.f. 2026 – 27)

(As per NEP 2020 Guidelines)

Course Code	Name of the Course	Category	Teaching Scheme				Evaluation Scheme					Credits
							Theory		Practical		Total	
			Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE (CA)	ESE (UA)	ICA (CA)	ESE (UA)		
EE -510B	Microgrid Architectures and Converters	PCC	3			3	40	60			100	3
EE -511B	Microgrid Architectures and Converters Lab	PCC			2	2			25	25 (OR)	50	1

Syllabus Structure for Honors in Microgrid Technologies: Additional Credit (Semester – VI) (w.e.f. 2026 – 27)

(As per NEP 2020 Guidelines)

Course Code	Name of the Course	Category	Teaching Scheme				Evaluation Scheme					Credits
							Theory		Practical		Total	
			Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE (CA)	ESE (UA)	ICA (CA)	ESE (UA)		
EE -612B	Microgrid Operation and Control	PCC	3			3	40	60			100	3
EE -613B	Microgrid Operation and Control Lab	PCC			2	2			25	25 (OR)	50	1

MICROGRID ARCHITECTURES AND CONVERTERS (Honors) (PCC)			
COURSE OUTLINE			
Course Title:	**MICROGRID ARCHITECTURES AND CONVERTERS**	**Short Title: MGAC**	**Course Code:EE510B**

Course description:

The course details the fundamental concepts of microgrid and its components, types of microgrids, advantages of microgrid compared to the central conventional grid. Particularly the course describes general concepts and application, control strategies and principle of operation of DC microgrid.

	Hours/week	No. of weeks	Total hours	Semester credits
Theory	03	15	45	**03**
Practical	02	15	30	**01**

Prerequisite course(s):

Power Generation and distribution System

Course objectives:

The objective of this course is to impart knowledge so that the student will:

1. Explore the concept of microgrid fundamental and scope in power system.
2. Explore the architecture and different converters in microgrid.
3. Explore the role of renewable energy sources such as solar, wind, hydro, and biomass in distributed generation.
4. Examine the methods for integrating distributed generation systems with the main power grid.
5. Examine real-world applications and case studies where distributed power generation has been successfully implemented.

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand the principles and technologies behind distributed generation (DG) systems in view of environmental benefits of reducing carbon emissions.
2. Discuss emerging trends and the future of Microgrid in a global context.
3. Explain the architecture of microgrid.
4. Identify the different converter and its function for microgrid application.
5. Solve complex problems related to microgrid , considering technical, economic, environmental, and regulatory factors.

COURSE CONTENT

MICROGRID ARCHITECTURES AND CONVERTERS		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):UA**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):CA	**40 marks**

Unit–I	**No. of Lectures: 09 Hours**	**Marks: 12**

Overview of Microgrid, Concept of Microgrid, Microgrid and distributed generation, Microgrid vs Conventional Power System, AC and DC Microgrid with Distributed Energy Resources

Unit–II	**No. of Lectures: 09 Hours**	**Marks: 12**

Power Electronics for Microgrid, Power Electronic Converters in Microgrid Applications, Power Electronic Converters in Microgrid Applications (Power Electronic for Interfacing, Power

Electronic Converters in Microgrid Applications

Unit–III	No. of Lectures: 09 Hours	Marks: 12

Controlled Rectifiers: Single-phase full wave rectifier: mid-point converter (M-2), bridge converters (B2), with resistive and inductive load. Threephase fully converters (B-6), three-phase semi-converters with resistive and inductive load.
Principle of operation of step-down chopper, step-up chopper, types of chopper circuits: type A, type B, type C, type multi-phase choppers.

Unit–IV	No. of Lectures: 09 Hours	Marks: 12

Inverters: Single-phase voltage source inverters: half-bridge and full-bridge (with Resistive and Inductive load), Modified McMurry half-bridge inverter, three phase bridge inverters (180-Degree and 120-Degree conduction mode Voltage source inverters), Series inverter, Single Phase Parallel inverter, Introduction to PWM techniques

Unit–V	No. of Lectures: 09 Hours	Marks: 12

Modeling of converters in microgrid power system (AC /DC and DC/AC Converters Modeling), Modeling of Renewable Energy Resources (Modeling of Wind Energy System), Modeling of Renewable Energy Resources (Modeling of Photovoltaic System), Modeling of Energy Storage System

Text Books:

1. Avik Bhatacharya, “DC Microgrid”, IITR
2. S Rao & Dr. B B Parulekar, “ Energy Technology”, Khanna Publishers.
3. Dr. H S Mukunda, Understanding Clean Energy and fuels from Biomass”, Wiley India

Reference Books:

1. Thomas Ackermann, Editor, “Wind Power in Power Systems”, John Willy and sons ltd., 2005,ISBN 0- 470-85508-8.
2. Gilbert M. Masters, “Renewable and Efficient Electric Power Systems”, John Willy and sons,2004,ISBN0-471-28060-7.
3. S. P. Sukhatme, “Solar Energy”, Tata McGrew Hill, second edition, 1996,
4. ChetanSingh Solanki, "Solar Photovoltaics", fundamental, technologies and applications, PHI- second edition, 2011.

NPTEL Links:

1. Microgrid concept and architecture by Prof.Avik Bhattacharaya,IITR
   https:// nptel.ac.in/courses/108107143
2. Microgrid by Prof. N P Padhy and Premalata Jena, IITR
   https:// nptel.ac.in/courses/108107113
3. Renewable energy and Energy storage by Prof. Avik Bhattacharya, IITR
   https://nptel.ac.in/courses/108107143

<table>
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<tr><td colspan="2">Teaching Scheme:</td><td colspan="4">Examination scheme</td></tr>
<tr><td>Practical:</td><td>2 hours/week</td><td colspan="3">End Semester Exam (ESE) UA: OR</td><td>25 marks</td></tr>
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<tr><td colspan="2">End Semester Exam (ESE) Pattern:</td><td colspan="4">(Oral) OR</td></tr>
<tr><td colspan="6">Concerned faculty member should suitably frame SEVEN laboratory assignments from the following list.
1. Study and demonstration of offline invertor for solar plant
2. Study and demonstration of online invertor for solar plant
3. Study of R, RC, firing circuits.
4. Study of characteristics of SCR, MOSFET.
5. Study operation of fully controlled converter with various types of loads.
6. Study operation of half controlled converter with various types of loads.
7. Study SCR parallel inverter, control circuit.
8. Study operation of SCR series inverter along controlled rectifiers.
9. Study operation of Step-down chopper.
10. Study operation of Step-up chopper with firing circuit</td></tr>
<tr><td colspan="6">Text Books</td></tr>
<tr><td colspan="6">1. Avik Bhatacharya, “DC Microgrid”, IITR
2. S Rao & Dr. B B Parulekar, “ Energy Technology”, Khanna Publishers.
3. Dr. H S Mukunda, Understanding Clean Energy and fuels from Biomass”, Wiley India</td></tr>
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2. Gilbert M. Masters, “Renewable and Efficient Electric Power Systems”, John Willy and sons,2004,ISBN0-471-28060-7.
3. S. P. Sukhatme, “Solar Energy”, Tata McGrew Hill, second edition, 1996, ISBN 0-07-462453-9.
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<tr><td colspan="6">ESE will be based on practical assignment submitted by the student in the form of journal. Evaluation will be based on oral</td></tr>
</table>

MICROGRID OPERATION AND CONTROL (Honors) (PCC)			
COURSE OUTLINE			
Course Title:	**MICROGRID OPERATION AND CONTROL**	**Short Title: MGOC**	**Course Code:EE612B**

Course description:

The course details the fundamental concepts of microgrid and its components, types of microgrids, advantages of microgrid compared to the central conventional grid. Particularly the course describes general concepts and application, control strategies and principle of operation of DC microgrid.

	Hours/week	**No. of weeks**	**Total hours**	**Semester credits**
Theory	03	15	45	**03**
Practical	02	15	30	**01**

Prerequisite course(s):

Basic Electrical and Electronics Engineering

Course objectives:

The objective of this course is to impart knowledge so that the student will:

1. Understand mode of operation of microgrid
2. Understand the grid connected and islanding operation of microgrid
3. Identify control strategy of microgrid.
4. Understand challenges in operation of microgrid
5. Understand battery management system.

Course outcomes:

After successful completion of this course the student will be able to:

1. Classify the different architectural layout of microgrid.
2. Understand mode of operation of microgrid
3. Understand the grid connected and islanding operation of microgrid
4. Identify control strategy of microgrid.
5. Understand challenges in operation of microgrid

COURSE CONTENT

MICROGRID OPERATION AND CONTROL		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):UA**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):CA	**40 marks**

Unit–I	**No. of Lectures: 09 Hours**	**Marks: 12**

Microgrid Control Architectures, Intelligent Microgrid Operation and Control, Energy Management in Microgrid System, Control of DC Microgrid System

Unit–II	**No. of Lectures: 09 Hours**	**Marks: 12**

Operation and control of AC Microgrid, Operation and control of DC Microgrid, Operation and control of AC-DC hybrid Microgrid

Unit–III	**No. of Lectures: 09 Hours**	**Marks: 12**

Wide area Monitoring Systems, Phasor Estimation, Islanding Detection Techniques, Phasor measurement unit placement,

Unit–IV	No. of Lectures: 09 Hours	Marks: 12
, Demand side management of smart grid and microgrid , Demand Response Analysis of smart grid and microgrid , Battery Management System, Energy management		
Unit–V	**No. of Lectures: 09 Hours**	**Marks: 12**
Virtual inertia and ancillary support, Cyber security and resiliency ,Harmonic effects and its mitigation techniques		

Text Books:

1. Gilbert M. Masters, “Renewable and Efficient Electric Power Systems”, JohnWillyandsons,2004,ISBN0-471-28060-7.
2. S. P. Sukhatme, “Solar Energy”, Tata McGrew Hill, second edition, 1996, ISBN0-07-462453-9
3. S. Chowdhury, S. P. Chowdhury, PCrossley “Microgrids and Active Distribution Networks”, IET Power Electronics Series, 2012.

Reference Books:

1. Gilbert M. Masters, “Renewable and Efficient Electric Power Systems”, JohnWillyandsons,2004,ISBN0-471-28060-7.
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4. S. Chowdhury, S. P. Chowdhury, PCrossley “Microgrids and Active Distribution Networks”, IET Power Electronics Series, 2012.
5. Electric and Hybrid Vehicles: Design Fundamentals by Iqbal Hussain, CRCPress ,2003.
6. Fuel Cells and Hydrogens: From Fundamentals to Applied Research by V. Hacker, S. Mitsushima, Elsevier ,2018.

NPTEL Links:

1. Microgrid concept and architecture by Prof.Avik Bhattacharaya,IITR
   https:// nptel.ac.in/courses/108107143
2. Microgrid by Prof. N P Padhy and Premalata Jena, IITR
   https:// nptel.ac.in/courses/108107113
3. Renewable energy and Energy storage by Prof. Avik Bhattacharya, IITR
   https://nptel.ac.in/courses/108107143

MICROGRID OPERATION AND CONTROL LAB (Honors) (PCC)				
LAB COURSE CONTENT				
MICROGRID OPERATION AND CONTROL LAB		**Semester:**	**VI**	**Course Code: EE613B**
Teaching Scheme:		**Examination scheme**		
Practical:	**2 hours/week**	**End Semester Exam (ESE) UA: OR**		**25 marks**
		Internal Continuous Assessment (ICA) CA:		**25 marks**
End Semester Exam (ESE) Pattern:		**(Oral) OR**		

Concerned faculty member should suitably frame SEVEN laboratory assignments from the following list.

1. Layout of Microgrid.
2. Design of Smart Grid and Practical Smart Grid Case Study-I
3. Design of Smart Grid and Practical Smart Grid Case Study-II
4. System Analysis of AC/DC Smart Grid
5. Demonstration of grid-connected DC microgrid.
6. Demonstration of energy management in microgrid
7. Demonstration of PHIL experimentation for symmetric and asymmetric fault analysis of grid-connected DFIG wind turbine.
8. Demonstration of ancillary support from virtual synchronous generator
9. Demonstration on peak energy management using energy storage system.

Text Books:

1. Gilbert M. Masters, “Renewable and Efficient Electric Power Systems”, JohnWillyandsons,2004,ISBN0-471-28060-7.
2. S. P. Sukhatme, “Solar Energy”, Tata McGrew Hill, second edition, 1996, ISBN0-07-462453-9

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1. Gilbert M. Masters, “Renewable and Efficient Electric Power Systems”, JohnWillyandsons,2004,ISBN0-471-28060-7.
2. S. P. Sukhatme, “Solar Energy”, Tata McGrew Hill, second edition, 1996, ISBN0-07-462453-9
3. Chetan Singh Solanki, "Solar Photovoltaics", fundamental, technologies and applications, PHI second edition
4. S. Chowdhury, S. P. Chowdhury, PCrossley “Microgrids and Active Distribution Networks”, IET Power Electronics Series, 2012.
5. Electric and Hybrid Vehicles: Design Fundamentals by Iqbal Hussain, CRCPress ,2003.

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Kavayitri Bahinabai Chaudhari

NORTH MAHARASHTRA UNIVERSITY, JALGAON

(M.S.)

Bachelor of Engineering – Honors
in
Electrical Energy Systems
for Third Year Bachelor of Engineering
in
Electrical
(As per NEP 2020 Guidelines)

Faculty of Science and Technology



SYLLABUS STRUCTURE & COURSE OUTLINE
For Affiliated Colleges
Semester – V & VI
W.E.F. 2026 – 27

Honors in Electrical Energy Systems

Syllabus Structure for Honors in Electrical Energy Systems: Additional Credit (Semester – V) (w.e.f. 2026 – 27)

(As per NEP 2020 Guidelines)

Course Code	Name of the Course	Category	Teaching Scheme				Evaluation Scheme					Credits
							Theory		Practical		Total	
			Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE (CA)	ESE (UA)	ICA (CA)	ESE (UA)		
EE -510C	Control and Integration of Renewable Energy	PCC	3			3	40	60			100	3
EE -511C	Control and Integration of Renewable Energy Lab	PCC			2	2			25	25 (OR)	50	1

Syllabus Structure for Honors in Electrical Energy Systems: Additional Credit (Semester – VI) (w.e.f. 2026 – 27)

(As per NEP 2020 Guidelines)

Course Code	Name of the Course	Category	Teaching Scheme				Evaluation Scheme					Credits
							Theory		Practical		Total	
			Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE (CA)	ESE (UA)	ICA (CA)	ESE (UA)		
EE -612C	Electrical Energy Conservation and Auditing	PCC	3			3	40	60			100	3
EE -613C	Electrical Energy Conservation and Auditing Lab	PCC			2	2			25	25 (OR)	50	1

CONTROL AND INTEGRATION OF RENEWABLE ENERGY (Honors) (PCC)					
COURSE OUTLINE					
Course Title:	**CONTROL AND INTEGRATION OF RENEWABLE ENERGY**	**Short Title:**	CIRE	**Course Code:**	**EE510 C**

Course description: This course covers the fundamental aspects of the smart grid and its application to the existing power system. This course emphasizes on renewable energy sources integration into the present grid and microgrids, and further explores its operation, analysis, management, control, protection, and monitoring issues. The laboratory-scale demonstrations have been provided to validate a few concepts covered in this course

	Hours/week	**No. of weeks**	**Total hours**	**Semester credits**
Theory	03	15	45	**03**
Practical	02	15	30	**01**

Prerequisite course(s):

Renewable Energy Technology, Power Electronics

Course objectives:

The objective of this course is to:

1. Understand grid integration challenges such as intermittency, power quality issues, harmonics, voltage instability, and frequency deviations caused by renewable penetration.
2. Learn modeling and dynamic analysis techniques for renewable energy systems and their interaction with conventional power systems.
3. Study grid codes and standards related to renewable energy integration, including fault ride-through, reactive power support, and protection requirements.
4. Develop skills in simulation and analysis of renewable-integrated power systems using tools such as MATLAB/Simulink, PSCAD, or similar software.
5. Introduce advanced concepts such as microgrids, smart grids, energy management systems, and the role of artificial intelligence in renewable energy control.

Course outcomes:

After successful completion of this course the student will be able to:

1. Analyze the dynamic behavior of renewable-integrated power systems under varying operating and grid conditions.
2. Evaluate grid integration challenges such as voltage instability, frequency deviation, harmonics, and power quality issues caused by high renewable penetration.
3. Develop and simulate mathematical models and control algorithms (MPPT, current control, voltage control) for renewable energy systems using appropriate software tools.
4. Assess compliance of renewable energy systems with grid codes, standards, and protection requirements, including fault ride-through and reactive power support.
5. Design control and energy management strategies for renewable-based systems such as microgrids and hybrid energy systems.

COURSE CONTENT

CONTROL AND INTEGRATION OF RENEWABLE ENERGY		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End Semester Exam (ESE) :UA**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE) CA:	**40 marks**

Unit–I	No. of Lectures: 09 Hours	Marks: 12
Introduction to Energy Scenario in India, Solar and Wind enery in India: Economics of centralized generation, Decentralized Solar energy generation, Storage options for Energy		
Unit–II	**No. of Lectures: 09 Hours**	**Marks: 12**
Wide area Monitoring Systems-I Wide area Monitoring Systems-II Phasor Estimation-I Phasor Estimation-II Digital Relays for Smart Grid Protection		
Unit–III	**No. of Lectures: 09 Hours**	**Marks: 12**
Islanding Detection Techniques–I, Islanding Detection Techniques –II Islanding Detection Techniques –III Smart Grid Protection-I Smart Grid Protection-II		
Unit–IV	**No. of Lectures: 09 Hours**	**Marks: 12**
Operation and control of AC Microgrid -II Operation and control of DC Microgrid –I, Operation and control of DC Microgrid –II, Operation and control of AC-DC hybrid Microgrid –I, Operation and control of AC-DC hybrid Microgrid -II		
Unit–V	**No. of Lectures: 09 Hours**	**Marks: 12**
Hierarchical control techniques in hybrid ac-dc microgrid , Phasor measurement unit placement Cyber security and resiliency Virtual inertia and ancillary support Demand side management of smart grid Demand Response Analysis of smart grid		

Text Books:

1. Ali Keyhani Mohammad Marwali and Min Dai “Integration and Control of Renewable Energy in Electric Power System”John Wiley publishing company, 2010, 2nd Edition.

Reference Books:

1. Gilbert M. Masters, “Renewable and Efficient Electric Power Systems”, JohnWillyandsons,2004,ISBN0-471-28060-7.
2. S. P. Sukhatme, “Solar Energy”, Tata McGrew Hill, second edition, 1996, ISBN0-07-462453-9
3. ChetanSingh Solanki, "Solar Photovoltaics", fundamental, technologies and applications, PHI second edition
4. S. Chowdhury, S. P. Chowdhury, PCrossley “Microgrids and Active Distribution Networks”, IET Power Electronics Series, 2012.
5. John A. Duffie, William A. Beckman, “Solar Engineering of Thermal Processes”, WileyIntersciencePublication, 1991
6. Report on “Large Scale Grid Integration of Renewable Energy Sources - Way Forward” Central Electricity Authority, GoI, 2013.
7. Siegfried Heier, “Grid integration of wind energy conversion systems” John Willy andsons ltd, 2006
8. Bin Wu, Yongqiang Lang, Navid Zargar “,Power Conversion and Control of Wind Energy Systems”IEEE- John Wiley and Sons Ltd. Publishers, 2011,1st Edition.

NPTEL Links:

1. Smart Grid, Prof. N.P. Padhy, Prof. Premlata Jena, IIT Rookee https://nptel.ac.in/courses/108107113
2. DC Microgrid, Prof. Avik Bhattacharya, IIT Rookee nptel.ac.in/courses/108107143
3. Energy Resources and Technology, Prof. S. Banerjee, IIT Kharagpur https://nptel.ac.in/courses/108105058

CONTROL AND INTEGRATION OF RENEWABLE ENERGY LAB (Honors) (PCC)				
LAB COURSE CONTENT				
CONTROL AND INTEGRATION OF RENEWABLE ENERGY LAB		**Semester:**	**V**	**Course Code: EE511C**
Teaching Scheme:		**Examination scheme**		
Practical:	**2 hours/week**	**End Semester Exam (ESE) UA: OR**		**25 marks**
		Internal Continuous Assessment (ICA) CA:		**25 marks**
End Semester Exam (ESE) Pattern:		**(Oral) OR**		

Concerned faculty member should suitably frame SEVEN laboratory assignments from the following list.

1. Demonstration of solar power generation
2. Demonstration of wind power generation
3. Demonstration of Battery Management System
4. Solar Inverter Integration with grid.
5. Design of PV array and Measurement of string voltage.
6. Design and study of DC and AC distribution protection switch gear
7. Simulation and case study of AC Microgrid
8. Simulation and case study of DC Microgrid
9. Simulation and case study of AC-DC Hybrid microgrid
10. Demonstration of parallel inverter operation in AC microgrid
11. Demonstration of grid-connected DC microgrid
12. Design and study of DC and AC distribution protection switch gear
13. Demonstration of ancillary support from virtual synchronous generator

Text Books:

1. Ali Keyhani Mohammad Marwali and Min Dai “Integration and Control of Renewable Energy in Electric Power System”John Wiley publishing company, 2010, 2nd Edition.

Reference Books:

1. Gilbert M. Masters, “Renewable and Efficient Electric Power Systems”, JohnWillyandsons,2004,ISBN0-471-28060-7.
2. S. P. Sukhatme, “Solar Energy”, Tata McGrew Hill, second edition, 1996, ISBN0-07-462453-9
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Guidelines for ESE:OR

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ELECTRICAL ENERGY CONSERVATION AND AUDITING (Honors) (PCC)			
COURSE OUTLINE			
Course Title:	**ELECTRICAL ENERGY CONSERVATION AND AUDITING**	**Short Title: EECA**	**Course Code:EE612C**

Course description:

The course explores the knowledge of current energy Scenario, sources of primary energy and Scope of conservation in view of environment and climate change. This course provides knowledge of limited conventional energy generation, energy audit and conservation, Energy Conservation Act, energy efficient motors and other electrical gazed, scope of energy saving in domestic, industrial , agricultures sectors and demand side energy managements .Energy conservation is mandatory and answerable to next generation.

	Hours/week	No. of weeks	Total hours	Semester credits
Theory	03	15	45	**03**
Practical	02	15	30	**01**

Prerequisite course(s):

Electrical Machines and Electrical Measurement

Course objectives:

The objective of this course is to impart knowledge so that the student will:

1. Understand the need of energy audit and conservation , social and environmental cause as per Energy conservation Act .
2. Know the methodology of energy audit for industries and priority of action plan
3. Understand scope demand side management,
4. Understand energy efficient motor and energy conservation in motors, lighting, furnace and refrigeration.
5. Analyze energy performance assessment of electrical installation and financial analysis for energy audit like payback period.

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand the current energy scenario and importance of energy conservation in view of social and environmental cause.
2. Understand need of energy audit and identify methods to summarize all possible suggestion for fruitful results.
3. Analyze the energy data and electric tariff for implementation of demand side management in every sector of consumer.
4. Conduct an investigation the consumption in motive , illumination, heating and cooling system for conserving electrical energy .
5. Analyzing performance assessment of motors. Cooling system, pumps and lighting system. Students also able to recognized the importance of financial analysis .

COURSE CONTENT

ELECTRICAL ENERGY CONSERVATION AND AUDITING		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):UA**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):CA	**40 marks**

Unit–I	No. of Lectures: 09 Hours	Marks: 12
Energy Scenario and Scope of conservation: Commercial and Non-commercial energy, primary energy resources, commercial energy production, final energy consumption, energy needs of growing economy, long term energy scenario, energy pricing, energy sector reforms, energy and environment, energy security, energy conservation and its importance, energy strategy for the future, Energy Conservation Act-2001 and its features. Progress made in energy conservation in India. Scope of energy conservation in different sectors		
Unit–II	**No. of Lectures: 09 Hours**	**Marks: 12**
Energy Audit: Principles of energy audit, type and methodology of energy audit: preliminary energy audit and detailed energy audit, procedures of carrying out energy audit, energy audit implementation priority, understanding energy cost, bench marking energy performance, fuel and energy substitution, energy audit report writing, instruments used for energy audit.		
Unit–III	**No. of Lectures: 09 Hours**	**Marks: 12**
Energy Management : Concept of energy management ,review of load and utilization factors, bench marking, fuel and energy substitution , power factor improvement ,power demand monitoring. Impact of electric tariff on energy management. billing methods Concept of demand side management (DSM), scope of DSM, Load control methods, DSM planning and implementation ,load management as DSM strategy Advantages of DSM to consumers, utility and society.		
Unit–IV	**No. of Lectures: 09 Hours**	**Marks: 12**
Energy Efficiency and Conservation: Motive power: potential for saving electrical energy in motors - over sizing or under loading, improving efficiency of an existing motor, energy efficient motors, use of variable or adjustable speed drives for energy conservation. Transformer losses, energy efficient transformer and energy efficiency rating. Lighting: level of illumination for different areas. Use of right source of lamp for different applications, energy efficient lamps, energy conservation scope in lighting system Energy efficiency in air conditioning, control strategies and energy conservation opportunities		
Unit–V	**No. of Lectures: 09 Hours**	**Marks: 12**
Performance Assessment: Energy performance assessment of variable speed drives, performance terms, points for user, testing performance evolutions , format for data collection . Energy performance assessment of refrigeration and air conditioning system , performance terms, performance evolutions. Energy performance assessment of water pumps . Energy performance assessment of lighting system . Financial analysis .		
Text Books:		
1. Umesh Rathore, "Energy Management", 2nd Edition S K Kataria and Sons, 2014. 2. S. C. Tripathy, "Electrical Energy Utilization and Conservation", THM Publication		
Reference Books:		
1. Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-1, General Aspects (available online). 2. Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-3, Electrical Utilities (available online) 3. Success stories of Energy Conservation by BEE, New Delhi (www.bee-india.org) 4. B.E. Kushare, "Hand Book on Energy Efficient Motors" , International Cooper Proposition Council ,		

ELECTRICAL ENERGY CONSERVATION AND AUDITING LAB (Honors) (PCC)				
LAB COURSE CONTENT				
ELECTRICAL ENERGY CONSERVATION AND AUDITING LAB		**Semester:**	**VI**	**Course Code: EE613C**
Teaching Scheme:		**Examination scheme**		
Practical:	**2 hours/week**	**End Semester Exam (ESE) UA: OR**		**25 marks**
		Internal Continuous Assessment (ICA) CA:		**25 marks**
End Semester Exam (ESE) Pattern:		**(Oral) OR**		

Concerned faculty member should suitably frame SEVEN laboratory assignments from the following list.

1. Measurement of active power consumption of induction motor.
2. Measurement of power factor of induction motor.
3. Power factor improvement by static capacitor.
4. Study of Automatic Power factor Correction unit.
5. Measurement motor loading.
6. Measurement of illumination level.
7. Study of Colour Rendering Index of different light source.
8. Study of HT Electric Tariff
9. Energy Audit case study
10. Study of performance of pump.

Text Books

1. Umesh Rathore, “Energy Management”, 2nd Edition S K Kataria and Sons, 2014.
2. S. C. Tripathy, “Electrical Energy Utilization and Conservation”, THM Publication

Reference Books:

1. Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-1, General Aspects (available online).
2. Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-3, Electrical Utilities (available online)
3. Success stories of Energy Conservation by BEE, New Delhi (www.bee-india.org)
4. B.E. Kushare, “Hand Book on Energy Efficient Motors” , International Cooper Proposition Council ,.

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Kavayitri Bahinabai Chaudhari

NORTH MAHARASHTRA UNIVERSITY, JALGAON

(M.S.)

Bachelor of Engineering – Minor
in
Electrical and Power Engineering
for Third Year Bachelor of Engineering
offered by
Electrical

(As per NEP 2020 Guidelines)

Faculty of Science and Technology



SYLLABUS STRUCTURE & COURSE OUTLINE

For Affiliated Colleges

Semester – V & VI

W.E.F. 2026 – 27

Specialization Minor in Electrical and Power Engineering

Syllabus Structure for Specialization Minor in Electrical and Power Engineering: Additional Credit (Semester – V) (w.e.f. 2026 – 27)
(As per NEP 2020 Guidelines)

Course Code	Name of the Course	Category	Teaching Scheme				Evaluation Scheme					Credits
							Theory		Practical			
			Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE (CA)	ESE (UA)	ICA (CA)	ESE (UA)	Total	
EE -512A	Power Transmission and Distribution	PCC	3			3	40	60			100	3
EE -513A	Power Transmission and Distribution Lab	PCC			2	2			25	25 (OR)	50	1

Syllabus Structure for Specialization Minor in Electrical and Power Engineering: Additional Credit (Semester – VI) (w.e.f. 2026 – 27)
(As per NEP 2020 Guidelines)

Course Code	Name of the Course	Category	Teaching Scheme				Evaluation Scheme					Credits
							Theory		Practical			
			Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE (CA)	ESE (UA)	ICA (CA)	ESE (UA)	Total	
EE -614A	Utilization of Electrical Energy	PCC	3			3	40	60			100	3
EE -615A	Utilization of Electrical Energy Lab	PCC			2	2			25	25 (OR)	50	1

POWER TRANSMISSION AND DISTRIBUTION (Minor) (PCC)

COURSE OUTLINE

Course Title:	POWER TRANSMISSION AND DISTRIBUTION	Short Title: PTD	Course Code:EE512A

Course description:

This course provides a comprehensive understanding of the principles, components, and practices involved in electric power transmission and distribution systems. It covers the structure and operation of modern power networks, including overhead and underground transmission lines, distribution feeders, substations, and associated equipment. The course emphasizes electrical and mechanical characteristics of transmission lines, line parameters, performance analysis, voltage regulation, efficiency, and power flow under steady-state conditions.

	Hours/week	No.of weeks	Total hours	Semester credits
Theory	03	15	45	**03**
Practical	02	15	30	**01**

Prerequisite course(s):

Basic Electrical and Electronic Engineering at First Year

Course objectives:

The objective of this course is to impart knowledge so that the student will:

1. Understand the structure of electric power supply systems, from generation to utilization, with emphasis on the A.C. power supply scheme.
2. Develop understanding of the purpose, construction, and importance of conductor, line supports and insulators used in overhead lines.
3. Familiarize with various insulating materials used for underground cables and their suitability for different voltage levels.
4. Develop understanding of the requirements of a good distribution system, including voltage regulation, efficiency, reliability, and safety.
5. Provide knowledge of major equipment used in transformer sub-stations, such as transformers, circuit breakers, isolators, bus-bars, relays, and lightning arresters

Course outcomes:

After successful completion of this course the student will be able to:

1. Compare various systems of power transmission and select an appropriate system for a given application.
2. Identify and explain the main components of overhead transmission lines, including conductors, insulators, line supports, and accessories.
3. Select an appropriate type of underground cable and laying method for a given service condition and voltage level.
4. Describe the principles, components, and operation of A.C. and D.C. distribution systems**.**
5. Explain the purpose, functions, and importance of electrical sub-stations in power transmission and distribution systems

COURSECONTENT

POWER TRANSMISSION AND DISTRIBUTION		Semester:	V
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):UA**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):CA	**40 marks**

Unit–I	No.of Lectures: 09 Hours	Marks: 12
Electric Supply System- Typical A.C. Power Supply Scheme, A.C. Transmission, D.C. Transmission, Comparison of D.C. and A.C. Transmission, Advantages of High Transmission Voltages, Various System of Power transmission- Overhead System, Underground System, Comparison of various Systems of Transmission, layout of transmission lines, standard transmission voltages in India.		
Unit–II	**No.of Lectures: 09 Hours**	**Marks: 12**
Main components of Overhead Lines, Conductor Materials- Copper, Aluminium, Steel cored aluminium, Galvanised steel, Cadmium copper, Line supports – Wooden poles, Steel poles RCC poles, Steel Towers, Insulators, Types of Insulators- Pin type Insulators, Suspension type insulators, Strain Insulators, Shackle Insulators, Sag in overhead lines, Effect of Wind and Ice Loading. Mechanical factors of safety used in Transmission Line.		
Unit–III	**No.of Lectures: 09 Hours**	**Marks: 12**
Underground Cables, Construction of cables, Insulating materials for cables, Classification of Cables, Cables for 3-Phase service, Belted Cables, Screened Cables, Pressure cables, oil filled cables, Gas pressure cables, Laying of Underground cables, Direct laying, Draw-in system, Solid System,		
Unit–IV	**No.of Lectures: 09 Hours**	**Marks: 12**
Distribution System, Classification of Distribution Systems, A.C. Distribution, D.C. Distribution, Overhead versus Underground system, Connection schemes of Distribution system, Requirements of Distribution System, Design consideration in Distribution system, Types of D.C. Distributors, D.C. Distributor Calculations, A.C. Distribution Calculations		
Unit–V	**No.of Lectures: 09 Hours**	**Marks: 12**
Sub-stations, Classification of Sub-stations, Comparison between Outdoor and Indoor Sub-stations, Transformer Substation, Pole mounted Substations, Underground Sub-station, Symbols for equipment in Sub-stations, Equipment in a Transformer Sub-station, Bus-bar arrangements in Sub-stations, terminal and Through Sub-stations, Key diagram of 66/11 KV Sub-station, Key diagram of 11KV/400V Indoor Sub-station, Earthing.		

Text Books:

1. J.B. Gupta, "A Course in Electrical Power", 14th Edition, S.K. Kataria and Sons

Reference Books:

1. D.P. Kothari & I. J. Nagrath, "Modern Power System Analysis" 4th edition Tata Mc. Graw Hill
2. W.D. Stevenson, Jr. " Elements of Power System Analysis", Mc Graw Hill.
3. C.L. Wadhwa, "Electrical Power System", New Age International.

NPTEL Links:

1. Power System Engineering by prof. Debapriya Das, IIT Kharagpur
   https://nptel.ac.in/courses/108105104
2. Power Electronics and Distributed Generation by Prof. Vinod John IIS Banglore
   https://nptel.ac.in/courses/108108034
3. Restructured Power System by Prof S.A. Khaparde and Dr. A.R. Abhyankar IIT delhi
   https://nptel.ac.in/courses/108101005
4. Power System Operation and Control by Prof. A.M.Kulkarni IIT Bombay
   https://nptel.ac.in/courses/108101040
5. Power System Generation, Transmission and Distribution by Prof. D.P. Kothari IIT Delhi
   https://nptel.ac.in/courses/108102047

POWER TRANSMISSION AND DISTRIBUTION LAB (Minor) (PCC)				
LAB COURSE CONTENT				
POWER TRANSMISSION AND DISTRIBUTION LAB		**Semester:**	**V**	**Course Code: EE513A**
Teaching Scheme:		**Examination scheme**		
Practical:	**2 hours/week**	**End Semester Exam (ESE) UA: OR**		**25 marks**
		Internal Continuous Assessment (ICA) CA:		**25 marks**
End Semester Exam (ESE) Pattern:		**(Oral) OR**		

Concerned faculty member should suitably frame SEVEN laboratory assignments from the following list.

1. Conductors material and Line supports in Overhead Lines
2. Types of Insulators in Overhead Transmission Lines
3. Construction of cables, Cables for 3-Phase service, Belted Cables, Screened Cables, Pressure cables
4. Oil filled cables, Gas pressure cables, Laying of Underground cables, Direct laying, Draw-in system, Solid System
5. Single line diagram of a low tension distribution system, A.C. Primary Distribution system, A.C. Secondary Distribution System.
6. Connection schemes of Distribution System
7. Types of D.C. Distributors
8. Block diagram of typical supply system indicating the types of substation, Pole mounted Sub-station, Underground Sub-station
9. Symbols for equipment in Sub-station, Equipment in Transformer Sub-station
10. Bus-bar arrangements in Sub-stations
11. Earthing- Pipe earthing, Plate earthing
12. Typical A.C. Power Supply Scheme. Key diagram of 66/11 KV Sub-station, Key diagram of 11KV/400V Indoor Sub-station,
13. Visit to Substation

Text Books:

1. J.B. Gupta, "A Course in Electrical Power", 14th Edition, S.K. Kataria and Sons

Reference Books:

1. D.P. Kothari & I. J. Nagrath, "Modern Power System Analysis" 4th edition Tata Mc. Graw Hill
2. W.D. Stevenson, Jr. " Elements of Power System Analysis", Mc Graw Hill.
3. C.L. Wadhwa, "Electrical Power System", New Age International.

Guidelines for ICA:

Students must submit ICA in the form of journal. Each assignment should be well documented. Faculty Incharge will assess the assignments continuously and grade or mark of each assignment on completion date declared for each assignment.

Guidelines for ESE;OR

ESE will be based on practical assignment submitted by the student in the form of journal. Evaluation will be based on oral

UTILIZATION OF ELECTRICAL ENERGY (Minor) (PCC)			
COURSE OUTLINE			
CourseTitle:	**UTILIZATION OF ELECTRICAL ENERGY**	**Short Title: UEE**	**Course Code: EE614A**

Course description:

The subject explores the knowledge of different industrial derives, load characteristic, factor effecting on selection of derives depend upon their electrical , mechanical characteristic and service duty. The subject also provides the knowledge of electric traction. The course provide the basic knowledge of heating and ventilation. The explores the knowledge of types of illumination , lighting systems, lighting Scheme

	Hours/week	No.of weeks	Total hours	Semester credits
Theory	03	15	45	03
Practical	02	15	30	01

Prerequisite course(s):

Basic Electrical and Electronic Engineering at First Year

Course objectives:

The objective of this course is to impart knowledge so that the student will:

1. Understand the requirement of drives characteristic and selection methods.
2. Understand duty and rating of electric drives for different application.
3. Understand the basic of electric traction system.
4. Understand the basic operation of HVAC.
5. Understand the illumination scheme and its design.

Course outcomes:

After successful completion of this course the student will be able to:

1. Identify the drives characteristic for application of industries like manufacturing, maintenance, operation with sense safety.
2. Conduct practical and analyze data for proper selection of derive in realistic constrain of load requirement.
3. Identify the criteria for the selection of lamps, measurement of light and law of illuminations. and lighting systems for an indoor or outdoor space .
4. Undestant the basic operation of HVAC
5. Design and Evaluate different types of lighting scheme designs for indoor lighting and selection of luminary to meet the specified needs with appropriate consideration.

COURSE CONTENT

UTILIZATION OF ELECTRICAL ENERGY		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):UA**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):CA	**40 marks**

Unit–I:	**No.of Lectures: 09 Hours**	**Marks: 12**

Electric Drives: - Type of drives, Nature of load, Section motors, electrical, mechanical , service capacity and rating and Types of Enclosures. Electrical Characteristic: Starting, Operating and running, speed control and braking characteristics

Types of Duties :-Type of duty: Continuous, intermittent and short time rating , temperature rise and load equalization & use of flywheel.

Unit–II:	**No. of Lectures: 09 Hours**	**Marks: 12**

Traction Systems :- Requirements of ideal traction system, Systems of track electrification and their comparison, speed time curve, factors affecting on schedule speed, Tractive effort, Factors affecting in energy consumption.

Unit–III:	No. of Lectures: 09 Hours	Marks: 12

Heat Ventilation and Air Conditioning:-Refrigeration cycle, Type of refrigeration, air conditioning, type of air conditioning. Methods of electric heating & its advantages, resistance oven, induction heating electric welding.

Unit–IV:	No. of Lectures: 09 Hours	Marks: 12

Design of Interior Lighting : Illumination required for various work planes, Space to mounting height ratio, Layout of lamp luminaries, Calculation of space to mounting height ratio, sample calculation of total lumens and illumination level. Calculation of lamp wattage

Unit–V:	No. of Lectures: 09 Hours	Marks: 12

Design of Outdoor Lighting : Types of street and their level of illumination required, Terms related to street and street lighting, Types of fixtures used and their suitable application, , Selection of lamp and luminaries. Flood Lighting Types of fixtures and their suitable applications,

Text Books:

1. Gupta J. B., "Utilization of Electric Power & Electric Traction" S. K. Kataria & Sons.
2. Partab H. P., 'Art & Science of Utilization of Electrical Engineering' Dhanpat Rai Publications.

Reference Books:

1. O.E.Taylor , "Utilization of Electrical Energy", Longman
2. V. V. L. Rao, "Utilization of Electrical Energy", TMH
3. S. K. Pillai, "A Course in Electrical Energy", TMH
4. H. Partab, "Art & Science of Utilization of Electrical Energy

NPTEL Links:

1. Industrial Drives by Prof K R Rajagopal, IIT Delhi
   nptel.ac.in/courses/108102046
2. Fundamental of Electric Drives by Prof Shyama Prasad Das, IIT Kanpur
   nptel.ac.in/courses/108104140
3. Advanced Electric Drive by Prof P S Das, IIT Kanpur
   nptel.ac.in/courses/108104011
4. Illumination Engineering by Prof N K Kishor, IIT Khargpur
   nptel.ac.in/courses/108105060

<table>
<tr><th colspan="6">UTILIZATION OF ELECTRICAL ENERGY LAB (Minor) (PCC)</th></tr>
<tr><th colspan="6">LAB COURSE CONTENT</th></tr>
<tr><td colspan="2">UTILIZATION OF ELECTRICAL ENERGY LAB</td><td>Semester:</td><td>VI</td><td colspan="2">Course Code: EE615A</td></tr>
<tr><td colspan="2">Teaching Scheme:</td><td colspan="4">Examination scheme</td></tr>
<tr><td>Practical:</td><td>2 hours/week</td><td colspan="3">End Semester Exam (ESE) UA: OR</td><td>25 marks</td></tr>
<tr><td></td><td></td><td colspan="3">Internal Continuous Assessment (ICA) CA:</td><td>25 marks</td></tr>
<tr><td colspan="2">End Semester Exam (ESE) Pattern:</td><td colspan="4">(Oral) OR</td></tr>
<tr><td colspan="6">Concerned faculty member should suitably frame SEVEN laboratory assignments from the following list.
1. Performance characteristics of DC Shunt motor by direct load test.
2. Performance characteristics of three phase induction motor by direct load test.
3. Speed control of DC Shunt motor.
4. Speed control of three-phase slip ring induction motor by rotor resistance method
5. Electric braking of DC shunt motor.
6. Study of Air conditioning system.
7. Measurement illumination of different light source and comparison at same high and surrounding.
8. Study of Colour Rendering index of different type of lamps.
9. Illumination design of domestic layout.
10. Illumination design of small factor layout.</td></tr>
<tr><td colspan="6">1. Gupta J. B., “Utilization of Electric Power & Electric Traction” S. K. Kataria & Sons.
2. Partab H. P., ‘Art & Science of Utilization of Electrical Engineering’ Dhanpat Rai Publications.</td></tr>
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<tr><td colspan="6">Guidelines for ICA:</td></tr>
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Kavayitri Bahinabai Chaudhari

NORTH MAHARASHTRA UNIVERSITY,

JALGAON (M.S.)

Bachelor of Engineering – Minor in Electrical Machines and Drives for Third Year Bachelor of Engineering offered by Electrical

(As per NEP 2020 Guidelines)

Faculty of Science and Technology

'A' Grade
NAAC Re-Accredited
(4th Cycle)

SYLLABUS STRUCTURE & COURSE OUTLINE

For Affiliated Colleges

Semester – V & VI

W.E.F. 2026 – 27

Specialization Minor in Electrical Machines and Drives

Syllabus Structure for Specialization Minor in Electrical Machines and Drives: Additional Credit (Semester – V) (w.e.f. 2026 – 27)
(As per NEP 2020 Guidelines)

Course Code	Name of the Course	Category	Teaching Scheme				Evaluation Scheme					Credits
							Theory		Practical		Total	
			Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE (CA)	ESE (UA)	ICA (CA)	ESE (UA)		
EE -512B	AC Machines	PCC	3			3	40	60			100	3
EE -513B	AC Machines Lab	PCC			2	2			25	25 (OR)	50	1

Syllabus Structure for Specialization Minor in Electrical Machines and Drives: Additional Credit (Semester – VI) (w.e.f. 2026 – 27)
(As per NEP 2020 Guidelines)

Course Code	Name of the Course	Category	Teaching Scheme				Evaluation Scheme					Credits
							Theory		Practical		Total	
			Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE (CA)	ESE (UA)	ICA (CA)	ESE (UA)		
EE -614B	Electrical Machines Operation and Control	PCC	3			3	40	60			100	3
EE -615B	Electrical Machines Operation and Control Lab	PCC			2	2			25	25 (OR)	50	1

AC MACHINES(Minor) (PCC)			
COURSE OUTLINE			
Course Title:	**AC MACHINES**	**Short Title: ACM**	**Course Code:EE512B**

Course description:

This course is an advanced level DC Electrical Machines which will further strengthen the knowledge of the students. The course explores on understanding of construction, basic principles underlying the operation of electrical machines, performance, characteristic and of AC Machines. It also gives the platform to understand construction, working, performance and application of three phase and single phase motors.

	Hours/week	No.of weeks	Total hours	Semester credits
Theory	03	15	45	03
Practical	02	15	30	01

Prerequisite course(s):

DC Machines and Transformer

Course objectives:

The objective of this course is to impart knowledge so that the student will:

1. Understand fundamental knowledge of AC machines.
2. Develop their ability to apply the specific procedures for comprehensive treatment of rotating machines.
3. Demonstrate the characteristic of three phase AC machine for different applications.
4. Conduct test on AC Machines for evaluate performance characteristics.
5. Perform professional duties in the field of manufacturing, testing operation and control of machine.

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand fundamental principles of operation and construction for three phase and single phase ac machines.
2. Explain the characteristic of AC machines.
3. Identify type of AC Machine and application for solving engineering problem.
4. Analyze test data for qualitative and quantitative parameters to determine characteristics of AC Machine.
5. Perform professional duties in the field of manufacturing, testing operation and control of machine.

COURSE CONTENT

AC MACHINES		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):UA**	**60marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):CA	**40marks**

Unit–I	**No. of Lectures: 09 Hours**	**Marks: 12**

Three Phase Synchronous Alternator: Construction and working of three phase alternator, type of alternator, excitation system, armature winding, EMF equation voltage drop in armature winding, voltage regulation based by emf or synchronous impedance method, application of phase alternator alternator

Unit–II	**No. of Lectures: 09 Hours**	**Marks: 12**

Three Phase Induction Motor: Construction and working operation of three phase induction motor, type of 3 phase Induction motor, speed and slip relation, development of torque, torque

slip characteristic, condition for maximum torque, application of motor.

Unit–III	No. of Lectures: 09 Hours	Marks: 12

Three Phase Synchronous Motor: Construction and working of 3 phase synchronous motor, main feature of synchronous motor, starting of synchronous motor, effect of excitation and working power factor, use of damper winding and application of motor

Unit–IV	No. of Lectures: 09 Hours	Marks: 12

Single Phase Induction Motor: Construction, working , characteristic and application of Split phase induction motor, Single phase capacitor start induction motor, Single phase capacitor start capacitor run induction motor, shaded pole induction motor and universal motor

Unit–V	No. of Lectures: 09 Hours	Marks: 12

Special Motor: Construction, working , characteristic and application of Reluctance, Hysteresis, Linear induction motor. and universal motor

Text Books:

1. Ashfaq Husain, “Electrical Machines”, DhanpatRai& Co.
1. B. L. Tharaja, “Course in Electrical Technology, Volume-II,” S Chand Publication.

Reference Books:

1. P. S. Bimbhra, “Electrical Machinery”, Khanna Publishers, 2011.
2. E. Fitzgerald and C. Kingsley, "Electric Machinery”, New York, McGraw Hill Education, 2013.
3. E. Clayton and N. N. Hancock, “Performance and design of DC machines”, CBS Publishers, 2004.
4. M. G. Say, “Performance and design of AC machines”, CBS Publishers, 2002.
5. J. Nagrath and D. P. Kothari, “Electric Machines”, McGraw Hill Education, 2010.

NPTEL Links:

1. AC Machines by Prof. Tapas Kumar Bhattacharya, IITK
   https://nptel.ac.in/courses/108105155
2. AC Machines by Prof. D Kastha,IITK
   https://nptel.ac.in/courses/108105017
3. Speed Control of AC Machines by Prof. Tapas Kumar Bhattacharya, IITK
   https://nptel.ac.in/courses/108105155

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<tr><td colspan="2">Teaching Scheme:</td><td colspan="4">Examination scheme</td></tr>
<tr><td>Practical:</td><td>2 hours/week</td><td colspan="3">End Semester Exam (ESE) UA: OR</td><td>25 marks</td></tr>
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<tr><td colspan="2">End Semester Exam (ESE) Pattern:</td><td colspan="4">(Oral) OR</td></tr>
<tr><td colspan="6">Concerned faculty member should suitably frame SEVEN laboratory assignments from the following list.
1. Demonstration of excitation system for three phase alternator
2. Determination of voltage regulation of three phase alternator by direct load test.
3. Demonstration of speed slip relation for three phase induction motor.
4. Staring and reversing of three phase induction motor
5. Load test on three phase induction.
6. Demonstration of staring and synchronizing of three phase synchronous motor.
7. Characteristic of Synchronous motor at constant load variable excitation.
8. Load test on single phase induction motor.
9. Demonstration of stepper motor.
10. Demonstration of Reluctance motor.</td></tr>
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3. E. Clayton and N. N. Hancock, “Performance and design of DC machines”, CBS Publishers, 2004.
4. M. G. Say, “Performance and design of AC machines”, CBS Publishers, 2002.
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ELECTRICAL MACHINES OPERATION AND CONTROL (Minor) (PCC)

COURSE OUTLINE

Course Title:	ELECTRICAL MACHINES OPERATION AND CONTROL	Short Title: EMOC	Course Code:EE614B

Course description:

This course is an advanced level DC and AC Electrical Machines which will further strengthen the knowledge of the students. The course explores on understanding of staring, speed control and braking operation and control of AC and DC Motor.

	Hours/week	No.of weeks	Total hours	Semester credits
Theory	03	15	45	**03**
Practical	02	15	30	**01**

Prerequisite course(s):

Electrical Machines and Transformer

Course objectives:

The objective of this course is to impart knowledge so that the student will:

1. Understand the staring method precaution and requirement of electrical motors.
2. Explain the speed control of electrical motors.
3. Conduct practical to obtain required speed for specific requirement.
4. Explain different methods of electrical braking for electrical machines
5. Conduct practical to obtain required braking for specific requirement.

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand the staring method precaution and requirement of electrical motors.
2. Explain the speed control of electrical motors.
3. Conduct practical to obtain required speed for specific requirement.
4. Explain different methods of electrical braking for electrical machines
5. Conduct practical to obtain required braking and testing for specific requirement.

COURSECONTENT

ELECTRICAL MACHINES OPERATION AND CONTROL		Semester:	VI
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):UA**	**60marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):CA	**40marks**

Unit–I	No.of Lectures: 09 Hours	Marks: 12

Starting and Speed Control of DC Motor: Starters for DC motor, need of starter, basic torque equation and relation with armature current and torque, reversing of direction, speed control of dc shunt motor and series motor by armature voltage method and field control method. Calculation of torque and speed.

Unit–II	No. of Lectures: 09 Hours	Marks: 12

Electric Braking for DC Motor: Type of electrical braking, Plugging, Dynamic and Regenerative electrical braking for DC Series and Shunt Motor, four quadrant operation of drives

Unit–III	No. of Lectures: 09 Hours	Marks: 12

Starting and Speed Control of three Phase Motor: Starters for AC motor, need of starter, type of starters, reversing of motor direction, speed control of 3 phase induction motor, advantages and disadvantages of different methods, variable frequency drives.

Unit–IV	No. of Lectures: 09 Hours	Marks: 12
Electric Braking for Three Phase Induction Motor: Type of electrical braking, Plugging, Dynamic and Regenerative electrical braking for three phase induction motor, four quadrant operation of drives		
Unit–V	**No. of Lectures: 09 Hours**	**Marks: 12**
Power Electronic Control Drives: Single phase and three phase controlled converter fed separately excited DC motor drives (continuous conduction only), dual converter fed separately excited DC motor drive, rectifier control of DC series motor. Chopper control of separately excited DC motor and DC series motor. Static frequency control scheme (VSI, CSI, and cyclo – converter based) static rotor resistance and slip power recovery control schemes AC Motor.		
Text Books:		
1. Ashfaq Husain, "Electrical Machines", DhanpatRai& Co. 2. B. L. Tharaja, "Course in Electrical Technology, Volume-II," S Chand Publication.		
Reference Books:		
1. P. S. Bimbhra, "Electrical Machinery", Khanna Publishers, 2011. 2. E. Fitzgerald and C. Kingsley, "Electric Machinery", New York, McGraw Hill Education, 2013. 3. E. Clayton and N. N. Hancock, "Performance and design of DC machines", CBS Publishers, 2004. 4. M. G. Say, "Performance and design of AC machines", CBS Publishers, 2002. 5. J. Nagrath and D. P. Kothari, "Electric Machines", McGraw Hill Education, 2010.		
NPTEL Links: 1. AC Machines by Prof. Tapas Kumar Bhattacharya, IITK https://nptel.ac.in/courses/108105155 2. AC Machines by Prof. D Kastha,IITK https://nptel.ac.in/courses/108105017 3. Speed Control of AC Machines by Prof. Tapas Kumar Bhattacharya, IITK https://nptel.ac.in/courses/108105155		

<table>
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<tr><td colspan="2">ELECTRICAL MACHINES OPERATION AND CONTROL LAB</td><td colspan="2">Semester: VI</td><td colspan="2">Course Code: EE615B</td></tr>
<tr><td colspan="2">Teaching Scheme:</td><td colspan="4">Examination scheme</td></tr>
<tr><td>Practical:</td><td>2 hours/week</td><td colspan="3">End Semester Exam (ESE) UA: OR</td><td>25 marks</td></tr>
<tr><td></td><td></td><td colspan="3">Internal Continuous Assessment (ICA) CA:</td><td>25 marks</td></tr>
<tr><td colspan="2">End Semester Exam (ESE) Pattern:</td><td colspan="4">(Oral) OR</td></tr>
<tr><td colspan="6">Concerned faculty member should suitably frame SEVEN laboratory assignments from the following list.
1. Speed control of DC shunt motor by armature and field control method.
2. Speed control of DC series motor by armature and field control method.
3. Electrical braking of DC shunt motor.
4. Study and demonstration of three phase induction motor starter.
5. Speed control three phase slip ring induction motor
6. Speed control by variable frequency method.
7. Electrical braking of three phase induction motor
8. Speed control of single phase induction motor using a.c. voltage regulator.
9. Study of stepper motor drive circuit.
10. Speed control of universal motor.</td></tr>
<tr><td colspan="6">Text Books:</td></tr>
<tr><td colspan="6">1. Ashfaq Husain, “Electrical Machines”, DhanpatRai& Co.
2. B. L. Tharaja, “Course in Electrical Technology, Volume-II,” S Chand Publication.</td></tr>
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2. E. Fitzgerald and C. Kingsley, "Electric Machinery”, New York, McGraw Hill Education, 2013.
3. E. Clayton and N. N. Hancock, “Performance and design of DC machines”, CBS Publishers, 2004.
4. M. G. Say, “Performance and design of AC machines”, CBS Publishers, 2002.
5. J. Nagrath and D. P. Kothari, “Electric Machines”, McGraw Hill Education, 2010.</td></tr>
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Kavayitri Bahinabai Chaudhari

NORTH MAHARASHTRA UNIVERSITY, JALGAON

(M.S.)

Bachelor of Engineering – Minor
in
Electric Vehicles
for Third Year Bachelor of Engineering
offered by
Electrical

(As per NEP 2020 Guidelines)

Faculty of Science and Technology

'A' Grade
NAAC Re-Accredited
(4th Cycle)

SYLLABUS STRUCTURE & COURSE OUTLINE

For Affiliated Colleges

Semester – V & VI

W.E.F. 2026 – 27

Syllabus Structure for Specialization Minor in Electrics Vehicles: Additional Credit (Semester – V) (w.e.f. 2026 – 27)

(As per NEP 2020 Guidelines)

Course Code	Name of the Course	Category	Teaching Scheme				Evaluation Scheme					Credits
							Theory		Practical		Total	
			Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE (CA)	ESE (UA)	ICA (CA)	ESE (UA)		
EE -512C	Electric Vehicle Batteries and Management	PCC	3			3	40	60			100	3
EE -513C	Electric Vehicle Batteries and Management Lab	PCC			2	2			25	25 (OR)	50	1

Syllabus Structure for Specialization Minor in Electric Vehicles: Additional Credit (Semester – VI) (w.e.f. 2026 – 27)

(As per NEP 2020 Guidelines)

Course Code	Name of the Course	Category	Teaching Scheme				Evaluation Scheme					Credits
							Theory		Practical		Total	
			Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE (CA)	ESE (UA)	ICA (CA)	ESE (UA)		
EE -614C	Electric Vehicle Converter and Charger	PCC	3			3	40	60			100	3
EE -615C	Electric Vehicle Converter and Charger Lab	PCC			2	2			25	25 (OR)	50	1

ELECTRIC VEHICLE BATTERIES AND MANAGEMENT (Minor) (PCC)					
COURSE OUTLINE					
Course Title:	**ELECTRIC VEHICLE BATTERIES AND MANAGEMENT**	**Short Title:**	EVBM	**Course Code:**	**EE512C**

Course description:
An Electric Vehicle (EV) Battery Management course teaches the design, development, and operation of Battery Management Systems (BMS) for safe, efficient, and long-lasting EV batteries, covering lithium-ion chemistry, cell balancing, thermal management, SOC/SOH estimation, safety protocols, and hardware/software integration using tools like MATLAB/ Simulink..

	Hours/week	**No. of weeks**	**Total hours**	**Semester credits**
Theory	03	15	45	**03**
Practical	02	15	30	**01**

Prerequisite course(s):
Electric Machines and Drives, Power Electronics

Course objectives:
The objective of this course is to:
1. Explain EV battery technology, its components, and the role of the Battery Management System (BMS). .
2. Design battery packs (series /parallel configurations) and analyze cell datasheets for performance. .
3. Apply techniques to accurately estimate SOC, SOH, and battery aging. .
4. Understand and manage thermal aspects of battery packs for safety and longevity.
5. Diagnose battery health and perform maintenance/troubleshooting.

Course outcomes:
After successful completion of this course the student will be able to:
1. Explain EV battery technology, its components, and the role of the Battery Management System (BMS). .
2. Design battery packs (series /parallel configurations) and analyze cell datasheets for performance. .
3. Apply techniques to accurately estimate SOC, SOH, and battery aging. .
4. Understand and manage thermal aspects of battery packs for safety and longevity.
5. Diagnose battery health and perform maintenance/troubleshooting.

COURSE CONTENT

ELECTRIC VEHICLE BATTERIES AND MANAGEMENT		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End Semester Exam (ESE) :UA**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE) :CA	**40 marks**

Unit–I	**No. of Lectures: 09 Hours**	**Marks: 12**

Introduction Electric Vehicle Battery System: Introduction Selection of battery for EV, Traction battery pack design, Requirement of battery monitoring, Battery state of charge estimation methods, Battery cell equalization problem and solution, Protection interface, Energy and power estimation, Battery thermal management system,
Components of battery management system, Battery pack safety, Battery standards & tests.

Unit–II	**No. of Lectures: 09 Hours**	**Marks: 12**

Battery Management System: Introduction Selection of battery for EV, Traction battery pack design, Requirement of battery monitoring, Battery state of charge estimation methods, Battery cell equalization problem and solution, Protection interface, Energy and power estimation, Battery thermal management system,
Components of battery management system, Battery pack safety, Battery standards & tests.

Unit–III	No. of Lectures: 09 Hours	Marks: 12

Batteries and Energy Storage Systems: Energy storage technology: EV Batteries, Super capacitors,
flywheel energy storage. Batteries: Lead-acid, NiMH (Nickel-Metal Hydride), Li-Ion (Lithium-Ion), Ni-Zn (Nickel-Zinc), Ni-Cd (Nickel-Cadmium), Aluminium –Ion batteries (Al–Ion batteries),
Aluminium–air batteries (Al–air batteries)- their basic construction components, life time (cycles), efficiency, advantages and disadvantages. Comparison of various batteries.

Unit–IV	No. of Lectures: 09 Hours	Marks: 12

Smart Battery Pack Systems: Embedded battery chargers, Unregulated input power ,Wireless power (charging) System output power ,Fuel gauging, GPIO options, Safety circuit (PCM). Intrinsically safe design Authentication/encryption coding, On board charging ,High C-rate discharging Remote monitoring . Integrated power management Custom designed ruggedized molded and metal enclosures

Unit–V	No. of Lectures: 09 Hours	Marks: 12

Battery Pack Design & Integration: Cell to pack design, module assembly, busbars, housing, cooling (air/liquid).
Battery Management Systems (BMS): Function, architecture, cell balancing, monitoring. Thermal Management: Need for cooling, jacket design, temperature sensors. Battery Packaging & Safety: Structural integrity, crash safety, fire prevention.

Text Books:

1. S. Onori, L. Serrao and G. Rizzoni, “Hybrid Electric Vehicles: Energy Management Strategies”, Springer; 1st edition, 2015.
2. Mohammed Hamed Ahmed Soliman, “Advanced Battery Management Technologies for Electric Vehicles

Reference Books:

1. Iqbal Hussein, “Electric and Hybrid Vehicles: Design Fundamentals”, CRC Press, 2nd edition, Kavayitri Bahinabai Chaudhari North Maharashtra University, Jalgaon (M.S.)
2. Mehrdad Ehsani, YimiGao, Sebastian E. Gay, Ali Emadi, “Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design”, CRC Press, 1st edition, 2004.
3. James Larminie, John Lowry, “Electric Vehicle Technology Explained”, Wiley, 1st edition, 2008.
4. T. Denton, “Electric and Hybrid Vehicles”, Routledge, 1st edition, 2016. Optics – Ajoy Ghatak, McGraw Hill Publishing

NPTEL Links:

1. Electric vehicles and Renewable energy , by Prof. Ashok Jhunjhunwala, IIT Madras https://nptel.ac.in/courses/108106182
2. Fundamentals of Electric vehicles: Technology & Economics , by Prof. Ashok Jhunjhunwala, IIT Madras, https://nptel.ac.in/courses/108106170

<table>
<tr><th colspan="5">ELECTRIC VEHICLE BATTERIES AND MANAGEMENT LAB (Minor) (PCC)</th></tr>
<tr><th colspan="5">LAB COURSE CONTENT</th></tr>
<tr><td colspan="2">ELECTRIC VEHICLE BATTERIES AND MANAGEMENT LAB</td><td>Semester:</td><td>V</td><td>Course Code: EE513C</td></tr>
<tr><td colspan="2">Teaching Scheme:</td><td colspan="3">Examination scheme</td></tr>
<tr><td>Practical:</td><td>2 hours/week</td><td colspan="2">End Semester Exam (ESE) UA: OR</td><td>25 marks</td></tr>
<tr><td></td><td></td><td colspan="2">Internal Continuous Assessment (ICA) CA:</td><td>25 marks</td></tr>
<tr><td colspan="2">End Semester Exam (ESE) Pattern:</td><td colspan="3">(Oral) OR</td></tr>
<tr><td colspan="5">Concerned faculty member should suitably frame SEVEN laboratory assignments from the following list.
1. Plot charging and discharging characteristics of battery
2. Study of characteristics for Li Ion Battery
3. Study of characteristics for Fuel cell
4. Study of characteristics for Ultracapacitor
5. Visit to Electric Vehicle Battery charging station
6. Study of Battery charging circuit.
7. Study of characteristics Hybrid Energy Storage
8. To study battery management system and record associated parameters.
9. To study Tribrid system</td></tr>
<tr><td colspan="5">Text Books:</td></tr>
<tr><td colspan="5">1. Mehrdad Ehsani, YimiGao, Sebastian E. Gay, Ali Emadi, “Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design”, CRC Press, 1st edition, 2004.
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3. James Larminie, John Lowry, “Electric Vehicle Technology Explained”, Wiley, 1st edition, 2008.
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ELECTRIC VEHICLE CONVERTER AND CHARGER (Minor) (PCC)			
COURSE OUTLINE			
CourseTitle:	**ELECTRIC VEHICLE CONVERTER AND CHARGER**	**Short Title: EVCC**	**Course Code: EE614C**

Course description:

This course introduces the principles and applications of power electronic converters and charging system used in electric vehicles. It covers DC–DC converters, inverters, and on-board/off-board battery chargers with emphasis on control and efficiency Students learn about EV traction requirements, charging method , standards, and safety aspects. The course equips learners with the knowledge to analyze and design converter and charger System for modern EVs.

	Hours/week	No.of weeks	Total hours	Semester credits
Theory	03	15	45	**03**
Practical	02	15	30	**01**

Prerequisite course(s):

Power Electronics, **Electrical Machines.**

Course objectives:

1. The objective of this course is to impart knowledge so that the student will:
2. To understand power electronic converters used in EVs
3. To analyze DC–DC, AC–DC, and DC–AC converters for traction and charging
4. To study on-board and off-board EV charging systems
5. To learn standards, safety, and control techniques for EV chargers

Course outcomes:

After successful completion of this course the student will be able to:

1. Explain EV architecture and power electronic roles
2. Analyze and design DC–DC converters for EVs
3. Understand inverter operation and motor drives
4. Compare EV charging systems and charger topologies
5. Apply standards and safety principles in EV charger design

COURSE CONTENT

ELECTRIC VEHICLE CONVERTER AND CHARGER		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):UA**	**60marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):CA	**40marks**

Unit–I	**No.of Lectures: 09 Hours**	**Marks: 12**

Introduction to Electric Vehicles and Power Electronics:

Role of power electronics in EV systems , Construction, Working and Characteristics of Power semiconductor devices for EVs: Power diodes , Power MOSFETs, Insulated Gate Bipolar Transister (IGBTs), Wide Bandgap (WBG) Devices: Silicon carbide (SiC) MOSFETs, Gallium Nitride(GaN) Devices . Thermal management and efficiency considerations , Overview of EV power train components.

Unit–II	**No. of Lectures: 09 Hours**	**Marks: 12**

DC–DC Converters for Electric Vehicles:

Need for DC–DC converters in EVs, Classification: Isolated and Non-isolated converters, Buck, Boos t, Buck-Boost, Cuk, Single Ended Primary inductor converter (SEPIC),

ZETA. Bidirectional DC–DC converters, Soft-switching converters:Zero voltage switching(ZVS),ZerocurrentSwitching(ZCS) Converter Design considerations for EV applications, Control strategies for DC–DC converters, Regenerative braking and energy recovery.

Unit–III	**No. of Lectures: 09 Hours**	**Marks: 12**

Inverters and Motor Drive Converters:
Role of inverters in EV propulsion, Voltage Source Inverters (VSI) and Current Source Inverters (CSI) ,PWM techniques, Multilevel inverters for EV applications , Inverter losses and efficiency improvement, Motor drives in EVs: Classification of motors used in EVs : DC motors (series, shunt) and limitations in EVs , Induction motor , Permanent Magnet Synchronous Motor (PMSM) Brushless DC motor (BLDC), Switched Reluctance Motor (SRM), Comparison of EV motors based on efficiency, torque density, cost, control complexity, Control of traction motors.

Unit–IV	**No. of Lectures: 09 Hours**	**Marks: 12**

EV Battery Chargers:
Battery types and charging characteristics, On-board vs Off-board chargers, AC–DC converter topologies for EV chargers , Power Factor Correction (PFC) circuits , Isolated charger topologies, Fast charging vs slow charging , Charging profiles: Constant Current(CC)and Constant voltage (CV) method , Thermal and safety aspects of chargers.

Unit–V	**No. of Lectures: 09 Hours**	**Marks: 12**

Charging Standards, Control, and Protection:
EV charging levels: Level-1, Level-2, DC Fast Charging . Charging standards: Charge de Move(CHAdeMO) , Combined Charging System (CCS) , Guobiao Standard (GB/T) standard. Type-1 and Type-2 connectors . Communication protocols: CAN, PLC, ISO 15118 . Protection, safety, and EMI/EMC issues , Smart charging and Vehicle-to-Grid (V2G) concept , Future trends in EV converters and chargers.

Text Books:

1. Mehrdad Ehsani & Ali Emadi, “Modern Electric, Hybrid Electric & Fuel Cell Vehicle”, CRC Press
2. G.K. Dubey, “Fundamentals of Electric Drives”, Narosa publishing House, 2nd edition, 2002.

Reference Books:

1. M. Chilkin, “Electric Drives”, Mir Publishers, Moscow.
2. Mohammed A. El- Sharkawi, “Fundamentals of Electric Drives”, Thomson Asia, Pvt. Ltd. Singapore, 2nd edition, 2017.
3. Morden power electronics and AC drives by B.K Bose, PHI .
4. V. Subrahmanyam, “Electric Drives: Concepts and Applications”, Tata McGraw Hill, 1994.

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ELECTRIC VEHICLE CONVERTER AND CHARGER LAB (Minor) (PCC)				
LAB COURSE CONTENT				
ELECTRIC VEHICLE CONVERTER AND CHARGER LAB		**Semester:**	**VI**	**Course Code: EE615C**
Teaching Scheme:		**Examination scheme**		
Practical:	**2 hours/week**	**End Semester Exam (ESE) UA: PR**		**25 marks**
		Internal Continuous Assessment (ICA) :CA		**25 marks**
End Semester Exam (ESE) Pattern:		**(Oral) OR**		

Concerned faculty member should suitably frame SEVEN laboratory assignments from the following list.

1. To study of characteristics of SCR/MOSFET.
2. To study forced commutation methods for SCRs.
3. To study operation of fully controlled converter with various types of loads.
4. To study operation of half controlled converter with various types of loads
5. To study SCR parallel inverter, control circuit.
6. To study operation of SCR series inverter along controlled rectifiers.
7. To study operation of Step-down chopper.
8. To study operation of Step-up chopper with firing circuit
9. Design and Simulation of power devices
10. Design and Simulation of Bidirectional DC–DC Converter
11. Simulation of Single-Phase AC–DC Converter for On-Board Charger
12. Study of Fast DC Charging System

Text Books:

1. K T Chau, “Electric Vehicle Motor Drive”, IEEE Willey.
2. Mehrdad Ehsani & Ali Emadi, “Modern Electric, Hybrid Electric & Fuel Cell Vehicle”, CRC Press
3. G.K. Dubey, “Fundamentals of Electric Drives”, Narosa publishing House, 2nd edition, 2002.

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