AC -5.05.2018
Item No. 4.52

UNIVERSITY OF MUMBAI

Revised syllabus (Rev- 2016) from Academic Year 2016 -17

Under

FACULTY OF TECHNOLOGY

Electrical Engineering

Third Year with Effect from **AY 2018-19**

As per **Choice Based Credit and Grading System** with effect from the AY 2016–17

Program Structure for
TE Electrical Engineering
University of Mumbai
(With Effect from 2018-19)

Scheme for Semester V

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
EEC501	Power System - II	4	-	1	4	-	1	5
EEC502	Electrical Machines - III	4	-	-	4	-	-	4
EEC503	Control System - I	4	-	-	4	-	-	4
EEC504	Power Electronics	4	-	-	4	-	-	4
EEDLO501X	Department Level Optional Course-I	3	-	1	3	-	1	4
EEL501	Business Communication and Ethics	-	4**	-	-	2	-	2
EEL502	Control System Lab	-	2	-	-	1	-	1
EEL503	Electrical Machines Lab - III	-	2	-	-	1	-	1
EEL504	Power Electronics Lab	-	2	-	-	1	-	1
Total		**19**	**10**	**2**	**19**	**5**	**2**	**26**

**** Out of four hours, 2 hours theory shall be taught to entire class and 2 hours practical in batches**

Examination Scheme for Semester V

Course Code	Course Name	Examination Scheme												Total Marks
		Theory				Term Work		Practical		Oral		Pract./Oral		
		External (UA)		Internal (CA)										
		Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	
EEC501	Power System - II	80	32	20	8	25	10	-	-	-	-	-	-	125
EEC502	Electrical Machines - III	80	32	20	8	-	-	-	-	-	-	-	-	100
EEC503	Control System - I	80	32	20	8	-	-	-	-	-	-	-	-	100
EEC504	Power Electronics	80	32	20	8	-	-	-	-	-	-	-	-	100
EEDLO 501X	Department Level Optional Course-I	80	32	20	8	25	10	-	-	-	-	-	-	125
EEL501	Business Communication and Ethics	-	-	-	-	50	20	-	-	-	-	-	-	50
EEL502	Control System Lab	-	-	-	-	25	10	-	-	25	10	-	-	50
EEL503	Electrical Machines Lab - III	-	-	-	-	25	10	-	-	-	-	25	10	50
EEL504	Power Electronics Lab	-	-	-	-	25	10	-	-	-	-	25	10	50
Total		**400**	**-**	**100**	**-**	**175**	**-**	**-**	**-**	**25**	**-**	**50**	**-**	**750**

List of Department Level Optional Courses

Course Code	Department Level Optional Course - I
EEDLO5011	Communication Engineering
EEDLO5012	Renewable Energy and Energy Storage
EEDLO5013	Utilization of Electrical Energy

Course Code	Department Level Optional Course - II
EEDLO6021	Digital Communication Engineering
EEDLO6022	Micro-grid
EEDLO6023	Advanced Power Electronics

University of Mumbai						
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**		**Credits Assigned**		
		Theory	**Tutorial**	**Theory**	**Tutorial**	**Total**
EEC501	**Power System-II (abbreviated as PS-II)**	**4**	**1**	**4**	**1**	**5**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
EEC501	Power System –II	20	20	20	80	03	25	125

Course Objectives	• To impart knowledge on transmission line operation during fault. • To study power system transients and insulation co-ordination.
Course Outcomes	Student will be able • To understand different kind of faults on transmission line. • To analyse symmetrical fault • To analyse symmetrical components and unsymmetrical faults. • To illustrate and analyse power system transients • To understand insulation co-ordination in power system. • To understand and analyse corona on transmission line.

Module	Contents	Hours
1	**Symmetrical Fault Analysis:** Introduction to synchronous machine, basic construction, operation and equivalent circuit diagram, short circuit of synchronous machine: no load and loaded machine, transient on a transmission line, selection of Circuit breaker, short circuit MVA, algorithm for SC studies, Z Bus formulation, symmetrical fault analysis using Z bus **(numerical on Z bus formulation up to 3x3 matrix).**	14
2	**Symmetrical Components:** Introduction, Symmetrical component transformation, phase shift in star-delta transformers, sequence impedances and sequence network of transmission line, synchronous machine and transformer, power invariance, construction of sequence network of a power system.	07
3	**Unsymmetrical Fault Analysis:** Types of unsymmetrical faults, Analysis of shunt type unsymmetrical faults: single line to ground (SLG) fault, line to line (L-L) fault, double line to ground (LLG) fault, bus impedance matrix method for analysis of shunt type unsymmetrical faults. Analysis of series type unsymmetrical faults: one open conductor faults, two open conductor fault.	07
4	**Power System Transients**: Review of transients in simple circuits, recovery transient due to removal of short circuit, arcing grounds, capacitance switching, current	12

	chopping phenomenon. Travelling waves on transmission lines, wave equation, reflection and refraction of waves, typical cases of line terminations, attenuation, Bewely lattice diagram. Lightning phenomenon, mechanism of Lightning stroke, shape of Lightning voltage wave, over voltages due to Lightning, Lightning protection problem, significance of tower footing resistance in relation to Lightning, insulator flashover and withstand voltages, protection against surges, surge arresters, surge capacitor, surge reactor and surge absorber, Lightning arrestors and protective characteristics, dynamic voltage rise and arrester rating.	
5	**Insulation Coordination:** Volt time curve, basic approach to insulation co-ordination in power system, over voltage protection, ground wires, insulation coordination based on lightning, surge protection of rotating machines and transformers.	03
6	**Corona:** Phenomenon of corona, Disruptive critical voltage, Visual critical voltage, corona loss, factors affecting corona loss, Radio interference due to corona, practical considerations of corona loss, corona in bundled conductor lines, corona ring, corona pulses- their generation and properties in EHV lines, charge voltage (q-v) diagram and corona loss.	05

Books Recommended:

Text Books*:*

1. Wadhwa C.L. *Electrical power system*, New Age International,4th edition,2005
2. HadiSaadat, Power System Analysis, TMH publications,2002
3. D. P. Kothari, I. J. Nagrath, Modern *Power System Analysis*,McGraw Hill,3rd edition,2006
4. B.R. Gupta, *Power System Analysis And Design*, S.Chand,4th edition,2007
5. Begamudre R.D. "Extra High Voltage AC Transmission Engineering", New Age International, 2nd edition
6. Soni M.L., Bhatanagar U.S, Gupta P.V, A *course in electrical power*, DhnapatRai sons
7. Timothy J.E.Miller, "Reactive Power Control in Electric Systems" Wiley India Pvt Ltd. 2010.
8. J.B.Gupta, "Course in power system" kataria Publication

Reference Books:

1. Stevenson, *Modern power system analysis*, TMH publication
2. TuranGonen, Modern power system analysis, Wiley,1988
3. Mehta V.K., *Principle of power system*, S Chand,4th edition,2005.
4. Arthur R. Bergen, Vijay Vittal, "Power System Analysis", Pearson Publication, Second Edition.

Assessment:
Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Term work:
Term work shall consist of minimum eight tutorials and assignments (minimum 2). The distribution of marks for term work shall be as follows:

Tutorials	:15 marks
Assignments	:05 marks
Attendance (Theory and Tutorial)	:05 marks

The final certification and acceptance of term work ensures minimum passing in the term work

Theory Examination:
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3: Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4: Remaining question will be randomly selected from all the modules.

University of Mumbai						
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**		**Credits Assigned**		
		Theory	**Tutorial**	**Theory**	**Tutorial**	**Total**
EEC502	**Electrical Machines -III (abbreviated as EMC-III)**	**4**	**-**	**4**	**-**	**4**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
EEC502	Electrical Machines –III	20	20	20	80	03	-	100

Course Objectives	• To impart knowledge on performance and operation of an induction motor. • To study design aspects of an induction motor.
Course Outcomes	Student will be able • To illustrate the working principle of three phase induction motor • To analyse and evaluate performance of three phase induction motors under various operating conditions • To illustrate various speed control and starting methods of three phase induction motor. • To illustrate the working principle of single phase induction motor • To analyse the performance of single phase induction motor. • To design three phase induction motor

Module	Contents	Hours
1	**Three Phase Induction Motors:** Introduction, Construction, Principle of operation, Rotor emf & frequency, Current and Power, Power stages, phasor diagram, Analysis of Equivalent circuit, Torque-speed characteristics in braking, motoring and generating regions. Effect of voltage and frequency variations on Induction motor performance, Losses and efficiency, No load and block rotor test, Circle diagram, Applications of 3Φ IM, Relevant standards	12
2	**Three Phase Induction Motors: Speed Control and Starting:** Speed control methods including V/f method (excluding Slip power recovery scheme), Starting methods, High torque motors, Cogging and crawling.	06
3	**Single phase Induction Motor**: Introduction**,** Principle of operation, Double field revolving theory, Equivalent circuit of single phase induction motor, Determination of equivalent circuit parameters from no load and blocked rotor test.	04
4	**Types of Single phase Induction Motor & its Applications:** Staring methods, Split phase starting- Resistance spilt phase, capacitor split phase, capacitor start and run, shaded pole starting, Reluctance starting. Applications.	04
5	**Design of Three phase Induction motors:** Output equation, Choice of	12

	specific electric and magnetic loadings, Standard frames, Main dimensions, Design of stator and rotor windings, Stator and rotor slots, Design of stator core, air gap, Design of squirrel cage rotor, end rings, Design of wound rotor.	
6	**Performance Measurement of Three Phase Induction Motors:** Calculation of leakage reactance for parallel sided slot, Carter"s coefficients, Concept of B_{60}, Calculation of No load current, Short circuit current, Dispersion coefficient. Relevant standards	10

Books Recommended:

Text Books:

1. Bimbhra P.S., *Electric Machinery* , Khanna Publisher,
2. Bimbhra P.S., *Generalized Machine Theory*, Khanna Publisher,
3. V. K. Mehta, *Principles of Electrical Machines*, S Chand Publication
4. A.K. Sawhney, "*Electrical Machine Design*", Dhanpat Rai & Co
5. M.V.Deshpande, "*Design and Testing of Electrical Machines*", PHI Learning

Reference Books:

1.M.G. Say, *Performance and design of alternating current machines*, CBS Pub.
2.Ashfaq Husain, *Electric Machines*, Dhanpat Rai and co. publications
3.A.E. Fitzgerald, Kingsly, Stephen., *Electric Machinery*, Tata McGraw Hill
4.K.G. Upadhyay, "*Design of Electrical Machines* ", New age publication

Assessment:
Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Theory Examination:
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3: Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4: Remaining question will be randomly selected from all the modules.

University of Mumbai						
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**		**Credits Assigned**		
		Theory	**Tutorial**	**Theory**	**Tutorial**	**Total**
EEC503	**Control System -I (abbreviated as CS-I)**	**4**	**-**	**4**	**-**	**4**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
EEC503	Control System –I	20	20	20	80	03	-	100

Course Objectives	• To impart knowledge on control system and modeling of system and its analysis.
Course Outcomes	Student will be able • To model electrical and electromechanical system using transfer function. • To Illustrate methodology for simplification of system • To model and analyse given system in state space • To analyse steady state condition of given system • To analyse the transient and stability conditions of physical system

Module	Contents	Hours
1	**Introduction to control system** Introduction, open loop and closed loop control system with examples, brief idea of multi variable control system.	02
2	**Mathematical Model of Physical System** Transfer function of electrical, mechanical (translational and rotational) and electro mechanical systems. Transfer function model of AC & DC servomotor, potentiometer & tacho-generator. Block diagram reduction technique and signal flow graph, Mason's rule, Signal flow graph of electrical network. Conversion of BDR to SFGand vice versa.	10
3	**Time domain Analysis** Time response analysis of first and second order systems, Under damped second order system with step input. System response with additional poles and zeros. Steady state error for unity feedback systems. Static error constants and system type. Concept of stability, absolute and relative stability using Routh Hurwitz criteria,	10
4	**State Variable Analysis** Introduction to state variable, General state space representation, State space representation of Electrical and Mechanical systems. Conversion between state space and transfer function. Alternative representations in state space: (Phase variable, canonical, parallel & cascade). Similarity transformations, diagonalizing a system matrix. Laplace Transform solution of state equation, stability in state space	10
5	**Root locus techniques** Definition and properties of root locus, rules for plotting root locus,	05

	stability analysis using root locus, Transient response design via gain adjustment.	
6	**Frequency Domain Analysis** Polar plots, Bode plot, stability in frequency domain, Nyquist plots. Nyquist stability criterion. Gain margin and phase margin via Nyquist diagram and Bode plots. Relationship between Closed loop transient, Closed and open loop frequency responses. Steady state error characteristics from frequency responses.	11

Books Recommended:

Text Books:

1. Control system engineering by Norman Nise 2nd to latest edition
2. Control System engineering by Nagrath and Gopal, 5th to latest edition , Wiley Eastern
3. Modern control system engineering by K. Ogata, printice Hal
4. Modern control Systems, Twelfth edition, by Richard C Dorf, Robert H Bishop, Pearson.

Reference Books:

1. Linear Control system Analysis and design with MATLAB, by J.J. Azzo, C. H. Houpis, S.N. Sheldon, Marcel Dekkar, ISBN 0824740386
2. Feedback control of Dynamic System, G.F. Franklin, Pearson higher education, ISBN 0130980412
3. Control System Engineering, Shivanagraju s. Devi L., New age International latest edition .
4. Control Systems Technology, Curtis Johnson, Heidar Malki, Pearson
5. Control Systems Engineering, S. K. Bhattacharya, Pearson.
6. Control Systems, Theory and applications, Smarajit Ghosh, Pearson

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3: Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4: Remaining question will be randomly selected from all the modules.

University of Mumbai						
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**		**Credits Assigned**		
		Theory	**Tutorial**	**Theory**	**Tutorial**	**Total**
EEC504	**Power Electronics (abbreviated as PE)**	**4**	**-**	**4**	**-**	**4**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
EEC504	Power Electronics	20	20	02	80	03	-	100

Course Objectives	• To impart knowledge about various power semiconductor devices related to its characteristics, ratings, protection and to select semiconductor devices for various applications. • To introduce different methods of power conversion such as ac to dc, dc to dc, dc to ac the underlying principles of converter operation and hence to analyze different converter circuits for power conversion. • To keep abreast with the latest technologies and research going on in different areas related to power electronics.
Course Outcomes	Student will be able to • Select and design power electronic converter topologies for a broad range of energy conversion applications. • Analyse and simulate the performance of power electronic conversion systems. • Analyse various single phase and three phase power converter circuits and understand their applications. • Apply the basic concepts of power electronics to design the circuits in the fields of AC and DC drives, power generation and transmission and energy conversion, industrial applications. • Identify and describe various auxiliary circuits and requirements in power electronics applications such as Gate driver circuit, and snubber circuits along with electrical isolation and heat sinks

Module	Contents	Hours
1	**Thyristors:** Basic operation of silicon controlled rectifier, two transistor analogy, Static and Dynamic characteristics, Gate characteristics, Firing circuits, Commutation circuits, Protection circuit of SCR, Basic operation and characteristic of Triac, GTO, Diac.	04
2	**Power semiconductor devices:** Basic operation and characteristics of power diodes, power BJTs, power MOSFETs, IGBTs, Silicon Carbide (SiC)and GaN devices, Safe Operation Area (SOA) for each devices. Comparison of devices, selection of devices for various applications, conduction and switching losses; Gate Drive Circuitry for Power Converters and snubber circuits, heat sinks.	12
3	**Controlled Rectifiers:** Single phase half wave rectifiers, full wave rectifiers (mid-point and bridge configuration) for R and R-L load,	08

	freewheel diode, harmonic analysis of input current and input power factor for single phase fully controlled rectifier, effect of source inductance (concept only), single phase dual converter, Three phase semi converter and full converter with R load, Applications, Numerical for calculation of output voltage, single phase PWM rectifier, basic working principle and applications.	
4	**Inverter:** Principle of operation, Performance parameters, Single phase voltage source bridge Inverters, Three phase VSI (120° and 180° conduction mode), control of inverter output voltage , PWM techniques-Single PWM, Multiple PWM, Sinusoidal PWM, Introduction to Space vector modulation, Current source inverters, comparison of VSI and CSI, Applications.	06
5	**DC to DC Converter**: Basic principle of dc to dc conversion, switching mode regulators – Buck, Boost, Buck-Boost, Cuk regulators, bidirectional dc to dc converters, all with resistive load and only CCM mode, Applications: Power Factor Correction Circuits, LED lamp driver, Numerical included.	08
6	**AC voltage controllers:** On-Off and phase control, Single phase AC voltage controllers with R and RL loads. **Cyclo converters, Matrix converter:** Basic working principle.	10

Books Recommended:

Text Books:

1. "Power Electronics" M.H.Rashid, Prentice-Hall of India
2. "Power Electronics", Ned Mohan, Undeland, Robbins, John Wiley Publication
3. "Power Electronics", P.C Sen, Tata McGrawhill
4. "Power Electronics: Devices, Circuits and Matlab Simulations" by Alok Jain, Penram International
5. "Power Electronics", V.R Moorthi, Oxford University press
6. "Thyristors & their applications", Ramamurthy
7. "Power Electronics", M.D Singh and Khanchandani, Tata McGrawhill
8. " Silicon Carbide Power Devices" B. Jayant Baliga

Reference Books:

1. "Power Electronics", Landers, McGraw Hill
2. "Power Electronics", P.S Bhimbra, Khanna Publishers
3. "Elements of power electronics" Philip T Krein, Oxford University Press
4. "Power Electronics for Technology", Ashfaq Ahmed, Pearson
5. "Power Electronics", Joseph Vithayathil, Tata McGrawhill
6. "Silicon Carbide, Volume 2: Power Devices and Sensors," Peter Friedrichs , Tsunenobu Kimoto, Lothar Ley and Gerhard Pensl , Wiley Publications
7. "Power Electronics Converters and Regulators," Dokić, Branko L. and Blanuša, Branko

Website Reference:

1. http://nptel.iitm.ac.in: 'Power Electronics' web-course

Assessment:
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Theory Examination:
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3: Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4: Remaining question will be randomly selected from all the modules.

University of Mumbai						
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**		**Credits Assigned**		
		Theory	**Tutorial**	**Theory**	**Tutorial**	**Total**
EEDLO 5011	**Communication Engineering (abbreviated as CE)**	**3**	**1**	**3**	**1**	**4**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
EEDLO 5011	Communication Engineering	20	20	20	80	03	25	125

Course Objectives	• To impart knowledge on various modulation techniques in communication engineering. • To study different sampling techniques used in communication engineering.
Course Outcomes	Student will be able • To understand basic communication system and its components. • To illustrate and analyse amplitude modulation and demodulation techniques. • To illustrate and analyse phase modulation and demodulation techniques. • To illustrate and analyse frequency modulation and demodulation techniques. • To illustrate and analyse pulse modulation and demodulation techniques. • To understand and analyse radio receivers and sampling techniques.

Module	Contents	Hours
1	**Basics of Communication System** Types of signals, Block diagram, electromagnetic spectrum, signal bandwidth and power, types of communication channels, types of noise, signal to noise ratio, noise figure, and noise temperature	04
2	**Amplitude Modulation and Demodulation** Basic concept, signal representation, need for modulation, Spectrum, waveforms, modulation index, bandwidth, voltage distribution, and power calculation **DSBFC**: Principles, modulating circuits, low level and high level transmitters **DSB suppressed carrier**:- Multiplier modulator, nonlinear modulator, and switching Modulator, **Single Side Band (SSB):-**Principle, filter method, phase shift method and third method, independent sideband (ISB) and Vestigial Side Band (VSB) principles and transmitters **Amplitude demodulation:** Diode detector, practical diode detector, and square law Detector.	08
3	**Angle Modulation and Demodulation** **Frequency Modulation (FM):** Basic concept, mathematical analysis,	08

	frequency spectrum of FM wave, sensitivity, phase deviation and modulation index, frequency deviation and percent modulated waves, bandwidth requirement of angle modulated waves, deviation ratio, narrow band FM, and wide band FM. Varactor diode modulator, FET reactance modulator. Direct FM transmitter, indirect FM Transmitter, noise triangle in FM, pre-emphasis and de-emphasis. **Phase Modulation (PM): P**rinciple and working of transistor direct PM modulator, relationship and comparison between FM and PM. **FM demodulation:** Balance slope detector, Foster-Seely discriminator, ratio detector, comparison between FM demodulators, comparison between AM, FM and PM. Applications of FM and PM	
4	**Radio Receivers** TRF, Super-heterodyne receiver, receiver parameters, and choice of IF. AM receiver circuits and analysis, simple AGC, delayed AGC, forward AGC, and communication receiver, FM receiver circuits, comparison with AM receiver	06
5	**Pulse Modulation and Demodulation** PAM, PWM, PPM waveform generation and detection, principle, generation and detection of delta modulation and adaptive delta modulation. Applications of pulse communication	06
6	**Sampling Techniques** Theorem for low pass and band pass signals, proof with spectrum, Nyquist criteria, sampling techniques, aliasing error and aperture effect	04

Books Recommended:

Text Books:

1. Tomasi W. , "Advanced Electronics Communication systems", PGI, 4th Edition1998
2. Taub & Schiling, "Principles of Communication Systems", McGraw Hill, 2nd Ed. 1987
3. John C. proakis, "Digital Communication", McGraw Hill International, 1995
4. Haykin S, John Wiley & Sons, "Digital Communication", 3rd Ed. 1995

Reference Books:

1. Lathi B.P., "Modern Digital and Analog Communication System, Oxford University Press, 3rd Edition 1998
2. Dennis Roddy and John Coolen, "Electronic Communications", Prentice Hall of India, 3rd Ed. 1992

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Term work:

Term work shall consist of minimum eight tutorials and assignments (minimum 2). The distribution of marks for term work shall be as follows:

Tutorials :15 marks
Assignments :05 marks
Attendance (Theory and Tutorial) :05 marks

The final certification and acceptance of term work ensures minimum passing in the term work

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3: Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4: Remaining question will be randomly selected from all the modules.

University of Mumbai						
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**		**Credits Assigned**		
		Theory	**Tutorial**	**Theory**	**Tutorial**	**Total**
EEDLO 5012	**Renewable Energy and Energy Storage (abbreviated as REES)**	**3**	**1**	**3**	**1**	**4**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
EEDLO 5012	Renewable Energy and Energy Storage	20	20	20	80	03	25	125

Course Objectives	• To introduce the new paradigm of power generation in the form of renewable energy and the various means used for power processing and optimization. • To relate and study the various energy storage technology and their significance in the context of renewable energy based applications.
Course Outcomes	Student will be able to • Identify and describe the issues related to use of fossil fuels and to recognize means of mitigation through adaption of renewable energy (RE). • Identify and analyze the process of power generation through solar thermal and solar photovoltaic technologies. • Identify and describe the various components and types of Wind Energy system Fuel cell technology, tidal, wave, and biomass systems. • Identify and describe the importance of various forms of energy storage (ES) in new power generation scenario based on renewable energy. • Analyze, formulate and propose the power sharing mechanisms and to evaluate the fault scenarios in hybrid RE and ES sources. • Recognize the need to adapt and engage in operations RE/ES related activities for sustainable future.

Module	Contents	Hours
1	**Introduction-** World's and India's production and reserves of commercial energy sources, energy alternatives, review of conventional and non conventional energy sources. Statistic of net potential and current generation status of different energy alternatives. Distributed generation, Future trends in power generation and distribution.	03
2	**Solar Energy- Solar Thermal applications-**Review of solar thermal applications-solar thermal conversion devices and storage applications. **Solar Photovoltaic-** solar cell: characteristics, losses, model of a solar cell , emerging solar cell technologies; Solar PV modules, mismatch in module , hot spots, bypass diode; PV module: I-V and power curve, effect of variation in temperature and solar radiations; MPPT, types, different algorithms for electrical MPPT. distributed MPPT, MPPT converters. Types of PV systems: standalone, grid connected systems; BOS of PV	12

	system**,** Battery charge controllers, Power Conditioning Unit, Solar PV Micro-inverters Solar Plant design: mounting of PV panels supporting structures, Calculation and Design methodology of standalone PV system and grid connected system Review of regulatory standards for solar PV installations, net-metering.	
3	**Wind Energy** Review of wind energy system and its components, types of wind turbines, characteristics; Power generation and control in wind energy systems, performance calculations of wind energy systems. Topologies of WES, WES with rectifier / inverter system, Power Converters for Doubly Fed Induction Generators (DFIG) in Wind Turbines.	04
4	**Fuel Cell**- Review of fuel cells and their principle of operation, Review of types of fuel cell and their performance comparison. Topologies of fuel cell power systems, applications.	03
5	**Other Sources**- Review of other nonconventional sources, their features and applications; Biomass, Tidal, Ocean Thermal Electric Conversion, geothermal, and Micro-hydro.	04
6	**Energy Storage** Forms of energy storage, importance of storage system in new power generation scenario; Types, characteristics and performance evaluation of: batteries, ultra-capacitors, flywheels, SME, pumped hydro storage system; Applications of Energy storage in distributed generation, smart grid systems, Electric and Hybrid electric vehicles. Hybrid power system based on renewable energy and energy storage.	10

Books Recommended:

Reference Books:

1. Ali Keyhani, Mohammad N. Marwali, Min Dai "Integration of Green and Renewable Energy in Electric Power Systems", Wiley
2. Green M.A " Solar Cells": Operating Principles, technology and System Applications, Prentice Hall Inc, Englewood Cliffs N.J, U.S.A, 1982
3. James Larminie, Andrew Dicles "Fuel Cell Systems Explained," Wiley publication
4. Chetan Singh Solanki , *Solar Photo Voltaics* , PHI Learning Pvt Ltd., New Delhi,2009
5. Hashem Nehrir and Caisheng Wang, Modeling *and control of fuel cells: Distributed Generation Applications,* IEEE Press, 2009
6. J.F. Manwell and J.G. McGowan, *Wind Energy Explained, theory design and applications*, Wiley publication
7. Leo J.M.J. Blomen and Michael N. Mugerwa, "Fuel Cell System", New York, Plenum Press, 1993.
8. D. D. Hall and R. P. Grover, *Biomass Regenerable Energy,* John Wiley, New York, 1987.
9. Felix A. Farret and M. Godoy Simoes, *Integration of Alternative Sources of Energy*, 2006, John Wiley and Sons.
10. Robert Huggins, Energy Storage, Springer, 2010
11. M. Ehsani, Y. Gao, and Ali Emadi, *Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design*, Second Edition, CRC Press.

12. S. Chakraborty, M. G. Simões and W. E. Kramer, *Power Electronics for Renewable and Distributed Energy System*, Springer 2013
13. Ahmed Faheem Zobaa, *Energy storage – Technologies and Applications*, InTech Publication 2013.
14. N. Femia • G. Petrone, G. Spagnuolo and M. Vitelli, *Power Electronics and Control Techniques for Maximum Energy Harvesting in Photovoltaic Systems*, CRC Press, 2013

Website Reference:

1. http://nptel.iitm.ac.in: 'Energy Resources and Technology' web-course
2. http://nptel.iitm.ac.in: 'Non conventional Energy Systems' web-course

Other References Material

1. Heinrich Ha¨Berlin, *Photovoltaics System Design And Practice*, Wiley, 2012
2. Shin'ya Obara, *Design of Renewable Energy Systems: Microgrid and Nature Grid Methods*, Engineering Science Reference, 2014

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Term work:

Term work shall consist of minimum eight tutorials and assignments (minimum 2). The distribution of marks for term work shall be as follows:

Tutorials :15 marks
Assignments :05 marks
Attendance (Theory and Tutorial) :05 marks

The final certification and acceptance of term work ensures minimum passing in the term work

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3: Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4: Remaining question will be randomly selected from all the modules.

University of Mumbai						
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**		**Credits Assigned**		
		Theory	**Tutorial**	**Theory**	**Tutorial**	**Total**
EEDLO 5013	**Utilization of Electrical Energy (abbreviated as UEE)**	**3**	**1**	**3**	**1**	**4**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
EEDLO 5013	Utilization of Electrical Energy	20	20	20	80	03	25	125

Course Objectives	• To impart the knowledge on different types of drives used in electric traction. • To impart the basic knowledge of some domestic electric appliances.
Course Outcomes	Students will be able • To understand and analyse the power factor for improving the quality of supply. • To analyse different type of traction systems. • To understand modern tools to control electric traction motors. • To understand concept of electrical heating and welding and their application. • To understand different methods of cooling systems used in domestic electric appliances.

Module	Contents	Hours
1	**Power Factor** Power factor, disadvantages of low power factor, Causes of low power factor, methods of power factor improvement, advantages of power factor improvement and economics of power factor improvement.	04
2	**Electric Traction** Requirement of an ideal traction system. Traction system- Non electric traction system, electric traction system, diesel traction. System of Track electrification- DC system, single phase, three phase, composite system (Kando system), single phase AC to DC system. Different accessories for track electrification- overhead wire, conductor rail system, current collector- pantograph, catenary. Traction mechanics-Types of services, speed time curve, trapezoidal and quadrilateral speed time curves, power and energy output from driving axles, average and schedule speed (numerical), specific energy consumption, factors affecting specific energy consumption, dead weight, accelerating weight and adhesive weight.	12
3	**Electric Traction Motors and Controls** Desirable characteristics of traction motors, suitability of DC series motors, AC series motors, three phase induction motors and linear	10

	induction motor for traction. Control of Traction motors- Requirement, starting and speed control by using rheostat control, series parallel method, transition from series to parallel (shunt transition, bridge transition), thyristor control method, chopper control of motor in DC Traction System, PWM control of induction motor. Breaking- Requirement of breaking system, mechanical breaking, electrical breaking, rheostatic breaking, regenerative breaking. Substation- Location and distribution system, substation equipment, traction SCADA and railway signaling.	
4	**Electric Heating** Classification of electric heating methods, Resistance heating- Direct resistance heating, indirect resistance heating, application, Arc heating- Direct arc heating, indirect arc heating, applications of arc heating, Induction heating. Core type induction furnaces- Ajax Wyatt furnace, coreless induction furnace, Application of induction heating. Dielectric heating- principle, choice of frequency for dielectric heating, application of dielectric heating. Eddy current heating principle and applications.	03
5	**Electric Welding** Electric welding- welding methods, electric arc welding, resistance types welding and application, modern welding techniques. Electric arc welding- Formation and characteristics of electric arc, effect of arc length, arc blow, Electrode used in arc welding, spot welding machine.	03
6	**Other application of Electrical Energy** Terminology, Refrigeration and Air conditioning, Refrigeration cycle, Vapour compression type, vapour absorption type, Electrical circuit of a Refrigerator, Room Air conditioner window type and split type.	04

Books Recommended:

Text Books:

1. Utilization of Electric Energy by J. B. Gupta, SK Kataria & Sons.
2. Utilization of Electric Energy by R. K. Rajput, Laxmi Publications (P) Ltd.
3. Generation, Distribution and Utilization of Electric Energy by C.L.Wadhwa, Wiley Eastern Ltd.
4. I. Hussein, *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press, 2003

Reference Books:

1. Art, Science of . Utilization of Electric Energy by H. Pratap, Dhanpat Rai & Sons
2. Electric Traction by H. Pratap, Dhanpat Rai & Sons
3. Designing with light- A Lighting Handbook by Anil Valia, Lighting System
4. Generation and Utilization of Electric Energy by S. Sivanagaraju, Pearson Eduction India
5. M. Ehsani, Y. Gao,S.E.Gay and Ali Emadi, *Modern Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design,* CRC Press. 2005
6. "Lamps and lighting" by M.A.Cayless, J.R.Coaton and A.M.Marsden

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Term work:

Term work shall consist of minimum eight tutorials and assignments (minimum 2). The distribution of marks for term work shall be as follows:

Tutorials	:15 marks
Assignments	:05 marks
Attendance (Theory and Tutorial)	:05 marks

The final certification and acceptance of term work ensures minimum passing in the term work

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3: Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4: Remaining question will be randomly selected from all the modules.

University of Mumbai						
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**		**Credits Assigned**		
		Theory	**Practical**	**Theory**	**Practical**	**Total**
EEL501	**Business Communication and Ethics (abbreviated as BCE)**	**-**	**4****	**-**	**2**	**2**

Course Code	Course Name	Examination Scheme							Total
		Theory				Practical			
		Internal Assessment			End Sem. Exam	Term Work	Pract. and Oral	Oral	
		Test 1	Test 2	Avg.					
EEL501	Business Communication and Ethics	-	-	-	-	50	-	-	50

Course Objectives	• To inculcate professional and ethical attitude at the workplace • To enhance effective communication and interpersonal skills • To build multidisciplinary approach towards all life tasks • To hone analytical and logical skills for problem-solving
Course Outcomes	The students will be able to • Design a technical document using precise language, suitable vocabulary and apt style. • Develop the life skills/ interpersonal skills to progress professionally by building stronger relationships. • Demonstrate awareness of contemporary issues knowledge of professional and ethical responsibilities. • Apply the traits of a suitable candidate for a job/higher education, upon being trained in the techniques of holding a group discussion, facing interviews and writing resume/SOP. • Deliver formal presentations effectively implementing the verbal and non-verbal skills.

Module	Contents	Hours
01	**Report Writing**	05
1.1	Objectives of Report Writing	
1.2	Language and Style in a report	
1.3	Types : Informative and Interpretative (Analytical, Survey and Feasibility)and Formats of reports (Memo, Letter, Short and Long Report)	
02	**Technical Writing**	03
2.1	Technical Paper Writing (IEEE Format)	

2.2	Proposal Writing	
03	**Introduction to Interpersonal Skills**	08
3.1	Emotional Intelligence	
3.2	Leadership and Motivation	
3.3	Team Building	
3.4	Assertiveness	
3.5	Conflict Resolution and Negotiation Skills	
3.6	Time Management	
3.7	Decision Making	
04	**Meetings and Documentation**	02
4.1	Strategies for conducting effective meetings	
4.2	Notice, Agenda and Minutes of a meeting	
4.3	Business meeting etiquettes	
05	**Introduction to Corporate Ethics**	02
5.1	Professional and work ethics (responsible use of social media - Facebook, WA, Twitter etc.)	
5.2	Introduction to Intellectual Property Rights	
5.4	Ethical codes of conduct in business and corporate activities (Personal ethics, conflicting values, choosing a moral response and making ethical decisions)	
06	**Employment Skills**	06
6.1	Group Discussion	
6.2	Resume Writing	
6.3	Interview Skills	
6.4	Presentation Skills	
6.5	Statement of Purpose	

Books Recommended:

1. Fred Luthans, *"Organizational Behavior",* McGraw Hill, edition
2. Lesiker and Petit, *"Report Writing for Business",* McGraw Hill, edition
3. Huckin and Olsen, *"Technical Writing and Professional Communication",* McGraw Hill

4. Wallace and Masters, *"Personal Development for Life and Work",* Thomson Learning, 12th edition
5. Heta Murphy*, "Effective Business Communication"*, Mc Graw Hill, edition
6. Sharma R.C. and Krishna Mohan, *"Business Correspondence and Report Writing",* Tata McGraw-Hill Education
7. Ghosh, B. N., *"Managing Soft Skills for Personality Development",* Tata McGraw Hill. Lehman,
8. Dufrene, Sinha, "BCOM", Cengage Learning, 2nd edition
9. Bell, Smith, "Management Communication" Wiley India Edition, 3rd edition.
10. Dr. Alex, K., "Soft Skills", S Chand and Company
11Subramaniam, R., "Professional Ethics" Oxford University Press.
12. Robbins Stephens P., "Organizational Behavior", Pearson Education
13. https://grad.ucla.edu/asis/agep/advsopstem.pdf

Suggested List of Assignments:

1. Report Writing (Theory)
2. Technical Proposal
3. Technical Paper Writing (Paraphrasing a published IEEE Technical Paper)
4. Interpersonal Skills (Group activities and Role plays)
5. Interpersonal Skills (Documentation in the form of soft copy or hard copy)
6. Meetings and Documentation (Notice, Agenda, Minutes of Mock Meetings)
7. Corporate ethics (Case studies, Role plays)
8. Writing Resume and Statement of Purpose

Term work:

Term work shall consist of all assignments from the list. The distribution of marks for term work shall be as follows:

Book Report:	10 Marks
Assignments:	10 Marks
Project Report Presentation:	15 Marks
Group Discussion:	10 Marks
Attendance:	05 Marks

The final certification and acceptance of term work ensures the minimum passing in the term work.

University of Mumbai						
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**		**Credits Assigned**		
		Theory	**Practical**	**Theory**	**Practical**	**Total**
EEL502	**Control System Lab (abbreviated as CS Lab)**	**-**	**2**	**-**	**1**	**1**

Course Code	Course Name	Examination Scheme							Total
		Theory				Practical			
		Internal Assessment			End Sem. Exam	Term Work	Pract. and Oral	Oral	
		Test 1	Test 2	Avg.					
EEL502	Control System Lab	-	-	-	-	25	-	25	50

Course Objectives	• To study basic concepts of control system • To impart knowledge on various components of control systems.
Course Outcomes	Students will be able • To illustrate the functioning of various components of control system. • To analyse the response of physical system for various inputs. • To analyse the stability of the system using time domain and frequency domain techniques by simulation.

Syllabus: Same as that of Course EEC503 Control System – I

Suggested List of Laboratory Experiment:

(A) Laboratory Experiments

1. Study of AC Servomotor
2. Study of DC Servomotor
3. Study of potentiometer as an error detector
4. Study of Synchros as an error detector
5. Study of AC position control system
6. Study of DC position control system
7. Obtain time response of first order to step ramp and parabolic input
8. Obtain time response of second order system to step input.

(B) Simulation Based Experiments

1. Draw root locus and hence obtain steady state stability of control system
2. Draw Bode plot and hence obtain steady state stability of control system
3. Draw Nyquist plot and hence obtain steady state stability of control system

Any other experiment based on syllabus which will help students to understand topic/concept.

Term work:

Term work shall consist of minimum eight experiments. The distribution of marks shall be as follows:

Experiments Performance :10 marks
Journal :10 marks

Attendance (Theory and Practical) :05 marks

The final certification and acceptance of term work ensures the minimum passing in the term work.

Oral Examination:

Oral examination will be based on entire syllabus.

University of Mumbai						
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**		**Credits Assigned**		
		Theory	**Practical**	**Theory**	**Practical**	**Total**
EEL503	**Electrical Machines Lab - III (abbreviated as EMC Lab -III)**	**-**	**2**	**-**	**1**	**1**

Course Code	Course Name	Examination Scheme							Total
		Theory				Practical			
		Internal Assessment			End Sem. Exam	Term Work	Pract. and Oral	Oral	
		Test 1	Test 2	Avg.					
EEL503	Electrical Machines Lab –III	-	-	-	-	25	25	-	50

Course Objectives	• To impart practical knowledge of single phase and three phase induction motor.
Course Outcomes	Students will be able • To evaluate performance of single phase and three phase induction motor by carrying load test. • To analyse performance of single phase and three phase induction motor by carrying no load and blocked rotor test. • To illustrate the operation of various type of starters. • To illustrate different methods of speed control for three phase induction motor.

Syllabus: Same as that of Course EEC502 Electrical Machines - III

Suggested List of Laboratory Experiment:

1) Load Test on three phase sq. cage Induction Motor.
2) Load test on three phase slip ring induction motor.
3) No load and Blocked rotor test on three phase Induction Motor.
4) Performance analysis of three phase Induction Motor using Circle diagram.
5) Load Test on single phase Induction Motor.
6) No load and Blocked rotor test on single phase Induction Motor.
7) Study of different types of starters.
8) Speed control by v/f method.

Any other experiment based on syllabus which will help students to understand topic/concept.

Term work:

Term work shall consist of minimum six experiments, minimum two drawing sheets (full imperial size) or software based drawing of individual parts and the assembled views of three phase induction motor. Design should be based on the Indian Standard Specifications. The distribution of marks shall be as follows:

Experiments Performance :10 marks
Journal :10 marks
Attendance (Theory and Practical) :05 marks

The final certification and acceptance of term work ensures the minimum passing in the term work.

Practical/Oral Examination:
Practical/Oral examination will be based on entire syllabus.

University of Mumbai						
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**		**Credits Assigned**		
		Theory	**Practical**	**Theory**	**Practical**	**Total**
EEL504	**Power Electronics Lab (abbreviated as PE Lab)**	**-**	**2**	**-**	**1**	**1**

Course Code	Course Name	Examination Scheme							Total
		Theory				Practical			
		Internal Assessment			End Sem. Exam	Term Work	Pract. and Oral	Oral	
		Test 1	Test 2	Avg.					
EEL504	Power Electronics Lab	-	-	-	-	25	25	-	50

Course Objectives	• To impart knowledge about various power semiconductor devices related to its characteristics, ratings, protection and to select semiconductor devices for various applications. • To introduce different methods of power conversion such as ac to dc, dc to dc, dc to ac the underlying principles of converter operation and hence to analyse different converter circuits for power conversion. • To keep abreast with the latest technologies and research going on in different areas related to power electronics.
Course Outcomes	Student will be able to • Draw V-I characteristics of power electronic devices. • Simulate the performance of power electronic conversion systems. • Analyse various single phase and three phase power converter circuits and understand their applications. • Apply the basic concepts of power electronics to design the circuits in the fields of AC and DC drives, power generation and transmission and energy conversion, industrial applications. • Identify and describe various auxiliary circuits and requirements in power electronics applications such as Gate driver circuit, and snubber circuits along with electrical isolation and heat sinks

Syllabus: Same as that of Course EEC504 Power Electronics

Suggested List of Laboratory Experiment:

(A) Hardware Based Experiments

1. V-I Characteristics of SCR
2. Firing Circuit of SCR
3. Single phase half /full controlled rectifier circuit
4. Three phase half /fully controlled rectifier circuit with R load
5. Triac - Diac circuit based speed control of single phase motor
6. Gate Drive Circuit and snubber circuits (IGBT/MOSFET based)
7. Single phase Inverter (IGBT/MOSFET based)
8. Three phase Inverter (IGBT/MOSFET based)

9. Implementation of PWM techniques
10. Buck converter
11. Boost Converter /Buck-Boost
12. AC-AC converter

(B) Applications of Power Electronics Circuits Demonstration

13. Closed loop control of DC-DC converter
14. Power factor correction in converters
15. LED lamp intensity control
16. Solar PV based converter / inverter system

(C) Simulation

17. Three phase controlled rectifier including source inductance
18. PWM Rectifier
19. Three phase VSI (120° and 180° conduction mode)
20. Bidirectional DC-DC Converter
21. Buck Converter
22. AC voltage controllers: On-Off and phase control

Any other experiment based on syllabus which will help students to understand topic/concept.

Term work:

Term work shall consist of minimum six experiments and at least four simulations. The distribution of marks shall be as follows:

Experiments Performance	:10 marks
Journal	:10 marks
Attendance (Theory and Practical)	:05 marks

The final certification and acceptance of term work ensures the minimum passing in the term work.

Practical/Oral Examination:

Practical/Oral examination will be based on entire syllabus.