UNIVERSITY OF MUMBAI
No. UG/ 41 of 2018-19

CIRCULAR:-

Attention of the Principals of the affiliated Colleges and Directors of the recognized Institutions in Science & Technology Faculty is invited to this office Circular No. UG/179 of 2017-18, dated 8th August, 2017 relating to syllabus of the Bachelor of Engineering (B.E.) degree course.

They are hereby informed that the recommendations made by the Board of Studies in Electrical Engineering at its meeting held on 9th April, 2018 have been accepted by the Academic Council at its meeting held on 5th May, 2018 **vide** item No. 4.52 and that in accordance therewith, the revised syllabus as per the (CBCS) for the T.E. & B.E. in Electrical Engineering (Sem - V to VIII) has been brought into force with effect from the academic year 2018-19 and 2019-2020, accordingly. (The same is available on the University's website www.mu.ac.in).

(Dr. Dinesh Kamble)
I/c REGISTRAR

MUMBAI – 400 032
25th June, 2018

To

The Principals of the affiliated Colleges & Directors of the recognized Institutions in Science & Technology Faculty. (Circular No. UG/334 of 2017-18 dated 9th January, 2018.)

A.C/4.52/05/05/2018

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No. UG/ 41 -A of 2018 MUMBAI-400 032 25th June, 2018

Copy forwarded with Compliments for information to:-

1) The I/c Dean, Faculty of Science & Technology,
2) The Chairman, Board of Studies in Electrical Engineering,
3) The Director, Board of Examinations and Evaluation,
4) The Director, Board of Students Development,
5) The Co-Ordinator, University Computerization Centre,

(Dr. Dinesh Kamble)
I/c REGISTRAR

AC
Item No.

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**

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

Scheme for Semester VI

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
EEC601	Protection and Switchgear Engineering	3	-	-	3	-	-	3
EEC602	Electrical Machines - IV	4	-	-	4	-	-	4
EEC603	Signal processing	3	-	1	3	-	1	4
EEC604	Microcontroller and its Applications	4	-	-	4	-	-	4
EEC605	Control System - II	4	-	-	4	-	-	4
EEDLO602X	Department Level Optional Course-II	3	-	1	3	-	1	4
EEL601	Electrical Protection Lab	-	2	-	-	1	-	1
EEL602	Electrical Machines Lab - IV	-	2	-	-	1	-	1
EEL603	Microcontroller Lab	-	2	-	-	1	-	1
EEL604	Simulation Lab – II	-	2	-	-	1	-	1
Total		**21**	**8**	**2**	**21**	**4**	**2**	**27**

Examination Scheme for Semester VI

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	
EEC601	Protection and Switchgear Engineering	80	32	20	8	-	-	-	-	-	-	-	-	100
EEC602	Electrical Machines - IV	80	32	20	8	-	-	-	-	-	-	-	-	100
EEC603	Signal processing	80	32	20	8	25	10	-	-	-	-	-	-	125
EEC604	Microcontroller and its Applications	80	32	20	8	-	-	-	-	-	-	-	-	100
EEC605	Control System - II	80	32	20	8	-	-	-	-	-	-	-	-	100
EEDLO602X	Department Level Optional Course-II	80	32	20	8	25	10	-	-	-	-	-	-	125
EEL601	Electrical Protection Lab	-	-	-	-	25	10	-	-	25	10	-	-	50
EEL602	Electrical Machines Lab - IV	-	-	-	-	25	10	-	-	-	-	25	10	50
EEL603	Microcontroller Lab	-	-	-	-	25	10	-	-	-	-	25	10	50
EEL604	Simulation Lab – II	-	-	-	-	25	10	-	-	25	10	-	-	50
Total		**480**	**-**	**120**	**-**	**150**	**-**	**-**	**-**	**50**	**-**	**50**	**-**	**850**

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:
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**
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.

University of Mumbai						
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**		**Credits Assigned**		
		Theory	**Tutorial**	**Theory**	**Tutorial**	**Total**
EEC601	**Protection and Switchgear Engineering (abbreviated as PSE)**	**3**	**-**	**3**	**-**	**3**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
EEC601	Protection and Switchgear Engineering	20	20	20	80	03	-	100

Course Objectives	• To impart basic knowledge of power system protection, substation equipment and protection schemes.
Course Outcomes	Students will be able • To select the appropriate switching/protecting device for substations. • To discriminate between the application of circuit breaker and fuses as a protective device. • To understand the basic concept of relay, types of relay and their applications in power system. • To select the specific protection required for different components of power system according to the type of fault. • To apply the specific protection provided for different types of transmission lines.

Module	Contents	Hours
1	**Substation Equipment and switching devices** **Substation Equipment:** Switchgear-Definition, Types, Location of switchgear in typical power system **Switching Devices**:- Isolator & Earthing switch (Requirements & definitions, types and construction, Pantograph Isolators, Ratings), Contactors: Basic working principle, Terms & Definitions, contactors as starters for motors, rated characteristics/ Utilization categories of contactors,	03
2	**Circuit Breakers and Fuses:** **Circuit Breaker:** Arc initiation, arc quenching principles, Restriking voltage, RRRV, Recovery voltage, Types of Circuit Breakers: MCB, MCCB, ELCB, air circuit breakers, oil circuit breakers, SF6 circuit breakers, vacuum circuit breakers (working principle, Construction, operating mechanisms, ratings & applications), Mechanical life, Electrical life and testing of circuit breakers. **HRC Fuses & their applications**-Introduction, types of devices with	09

	fuse, definitions, construction, fuse link of HRC fuse, Action of HRC fuse, shape of fuse element, specification of a fuse link, characteristics of fuse, cut-off, classification & categories, selection of fuse links, fuse for protection of motor, discrimination, fuse for protection of radial lines/meshed feeders, equipment incorporating fuses, high voltage current limiting fuses, expulsion type high voltage fuses, drop out fuse.	
3	**Introduction to Protective relaying:** About protective relaying, Shunt & Series Faults, causes and Effects of faults, Importance of protective relaying, Protective zones, primary & Back-up protection, Back-up protection by time grading principle, desirable qualities of protective relaying, some terms in protective relaying, Distinction between relay unit, protective scheme and Protective system, Actuating quantities, Thermal Relays, Electromechanical relays and static relays, Power line carrier channel, programmable relays, system security, role of engineers. **Electromagnetic relays** - Introduction, basic connections of relay, Auxiliary switch, sealing and auxiliary relays, measurement in relays, Pick up, drop off, Attracted armature & induction disc relays, Thermal, bimetal relays, Frequency relays, under/over voltage relays, DC relays, All or nothing relays. **Different Principles of protection** - Over current & earth fault (non-directional & directional types), differential protection, distance protection (Working Principle of Impedance relay, Causes and remedies of Over reach-under reach, Reactance and Mho relay, Power swing blocking relay).	09
4	**Protection Schemes Provided for major Apparatus:** **Generators** - Stator side (Differential, Restricted Earth fault, protection for 100% winding, Negative phase sequence, Reverse power, turn-turn fault), Rotor side (Field suppression, field failure, Earth fault, turn to turn fault) **Transformers**-Differential protection for star delta Transformer, Harmonic restraint relay, REF protection, Protection provided for incipient faults (Gas actuated relay). **Induction motors** - Protection of motor against over load, short circuit, earth fault, single phasing, unbalance, locked rotor, phase reversal, under voltage, winding temperature.	06
5	**Protection of Transmission Lines:** Feeder protection - Time grading, current grading, combined time & current grading protection provided for Radial, Ring Main, Parallel, T-Feeder. Bus Zone Protection - Differential protection provided for different types of bus zones. LV, MV, HV Transmission Lines - Protection provided by over current, earth fault, Differential and Stepped distance protection. EHV & UHV Transmission lines - Need for auto-reclosure schemes, Carrier aided distance protection (Directional comparison method), Power Line Carrier Current protection (Phase comparison method).	05
6	**Introduction to Static & Numerical Relays:** **Static Relays**- Introduction, Definition, Advantages and Disadvantages, Application of op-amps, logic gates, DSP, in static/ digital Relays. Relays as comparators (Amplitude & phase), Distance relays as	04

	comparators. **Numerical Relays-** Introduction, Block diagram of numerical relay, Signal sampling, Anti –Aliasing Filter, Introduction to the concept of Phase Measurement Unit	

Books Recommended:

Text Books:

1. Switchgear & Protection by Sunil.S.Rao, Khanna Publications
2. Power system Protection & Switchgear by Badriram Vishwakarma, TMH
3. Power System Protection And Switchgear by Bhuvanesh A O, Nirmal CN, Rashesh PM, Vijay HM, Mc Graw Hill

Reference Books:

1. Fundamentals of protection by Paithanker & Bhide.S.R, P.H.I
2. Static Relays by Madhava Rao, TMH
3. A text book on Power System Engineering by Soni, Gupta, Bhatnagar & Chakraborthi, Dhanpat Rai & Co
4. Protective Relaying by Lewis Blackburn, Thomas.J.Domin
5. Power System Protection by P.M.Anderson, Wiley Interscience

*6. A Web Course on Digital protection of power system by Prof. Dr. S.A.Soman, IIT Bombay.

*7. Modern Power System Protection – DivyeshOza, TMH 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**
EEC602	**Electrical Machines -IV (abbreviated as EMC - IV)**	**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.				
EEC602	Electrical Machines -IV	20	20	20	80	03	-	100

Course Objectives	• To impart knowledge of performance and operation of synchronous machine. • To study working, control and applications of brushless motor.
Course Outcomes	Students will be able • To determine the performance parameters of synchronous machines graphically and analytically by conducting different test. • To analyse the performance parameters of synchronous machines. • To understand the concept of direct and quadrature axis parameters of synchronous machines. • To understand and analyse the operation of synchronous motor. • To analyse abc to dq0 transformation and steady state operation of synchronous machine. • To understand the operation and analyse control of BLDC motors.

Module	Contents	Hours
1	**Synchronous Generator:** Construction, E.M.F. equation, Winding factors, Armature reaction, Phasor diagrams for cylindrical rotor generator, Voltage regulation, No load (OC) and SC test, Voltage regulation methods: EMF; MMF; ZPF; ASA; Saturated Synchronous Reactance.	12
2	**Performance of Synchronous Generator:** Power flow equations and maximum power conditions, Need for parallel operation and conditions, Effect of variation of field current and prime mover input on parallel operation, Concept of infinite bus, Effect of variation of field current on alternator connected to infinite bus, Numericals on parallel operation	08
3	**Salient pole synchronous generator:** Concept of direct and quadrature reactance, Blondel's two reaction theory, Phasor diagram of salient pole machine, Power angle characteristics, Synchronising power and torque.	05
4	**Synchronous Motor:** Principle of operation, Self starting methods, Phasor diagram, Load angle (δ), Power flow equations and maximum power conditions, Effect of change in excitation and mechanical power on performance of motor, V and Inverted V curves, Power factor control, Hunting, Excitation and power circles, Measurement of X_d and	12

	X_q by slip test, Starting against high torques	
5	**Theory of Synchronous Machines:** Ideal synchronous machine, Transformation to direct and quadrature axis variables, basic machine relations in dq0 variables, Steady state analysis.	06
6	**BLDC Motor**: Classification**,** Construction, Electronic commutation, Principal of operation, Microprocessor/DSP based control scheme of BLDC motor (block diagram and flow chart), **S**ensor less control, Comparison with DC motor, Applications.	05

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. E.G.Janardanan, Special Electrical Machines, PHI Publisher, 2016.
5. K. Venkataratnam, Special Electrical Machines, University Press, 2016.

Reference Books:

1. Ashfaq Husain, Electric Machines, Dhanpat Rai and co. publications
2. A.E. Fitzgerald, Kingsly, Stephen., Electric Machinery, Tata McGraw Hill

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**
EEC603	**Signal Processing (abbreviated as SP)**	**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.				
EEC603	Signal Processing	20	20	20	80	03	25	125

Course Objectives	• To impart knowledge on continuous and discrete time signals.
Course Outcomes	Students will be able • To discriminate continuous and discrete time signals and systems. • To understand the transformation of discrete time signal to Z domain. • To analyse frequency response of systems using Z domain. • To understand discrete and fast Fourier transform. • To design FIR system. • To design IIR System.

Module	Contents	Hours
1	**Introduction** **Classification of Signal and System:** Definition and classification of continuous and discrete signals. Standard signals, periodic/non periodic, Even and odd, Energy and power signal, Sampling Theorem (Derivation is not Required), Basic operations on signal (Folding, Scaling and Time shifting). Definition and classification of systems: Causal /Anti causal, Time-Variant/Invariant, Linear/Non-Linear, stable/unstable, Memory/ Memory less System (static and dynamic). Convolution in DT domain (Matrix Method only)	06
2	**Z-Transform** Z-Transform of bilateral signal, Definition of ROC, Properties of ROC, Properties of Z-transform, Inverse Z-Transform (only partial fraction)	06
3	**Frequency Response** Pole-zero plot in DT domain, Minimum phase, Maximum phase, Mixed phase and Linear, Phase System based on location of zeros, Low pass, high pass, Band pass and band reject system based on pass band frequency, Formation of Difference Equation, Solution of difference Equation (with & without initial Conditions), Zero input, zero state and Total Response of the system, Magnitude and phase response (only Analytical Method)	06
4	**Discrete and Fast Fourier Transform** DTFT, DFT & IDFT (Only Matrix Method), Properties of DFT, DIT FFT Algorithm (Radix-2)	06
5	**Design of FIR System**	06

	Introduction to FIR System, Group Delay, phase Delay, Condition for Linear phase FIR system, Window Technique (only Rectangular window function, Hamming Window function)	
6	**Design of IIR System** Introduction to IIR System & Bilinear Transformation, Digital Butterworth Filter design using Bilinear Transformation	06

Books Recommended:

Text Books:

1. Salivahan S.," Digital Signal Processing", TMH Publication,2012
2. Oppenhein & Schafer," Discrete Time Signal Processing," PHI Publication 1989.
3. Haykin S and Van Veen B," Signal and System", Wiley Publication, 2nd Ed.
4. Linder D.K.," Introduction to Signal & System," McGraw Hill International, 1999.

Reference Books:

1. Proakis & Manolakis," Digital Signal Processing", PHI Publication,1995.
2. Mitra S.K.," Digital Signal Processing," TMH Publication,2001.
3. Li Tan," Digital Signal Processing, Fundamental & Application", Elsevier Publisher, Academic Press

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**
EEC604	**Microcontroller and its Applications (abbreviated as MCA)**	**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.				
EEC604	Microcontroller and its Applications	20	20	20	03	80	-	100

Course Objectives	• To impart knowledge on PIC 18 microcontroller based embedded system using C programming.
Course Outcomes	Students will be able • To understand the features and architecture of PIC 18 microcontroller. • To understand the instructional set and apply to basic arithmetic and logical operations. • To understand the supportive devices of PIC 18 microcontrollers. • To understand the interfacing of PIC 18 microcontroller and it's peripheral. • To understand the coding of PIC 18 microcontroller using C language. • To design general purpose applications of PIC 18 microcontroller.

Module	Contents	Hours
1	**Introduction to Microcontroller** Block diagram of generic micro controller, Micro controller versus Microprocessor, A brief history of PIC microcontroller, Overview of PIC 18 family and features, Internal Bus structure of PIC microcontroller, Clock frequency, machine cycle and instruction cycle.	06
2	**PIC18F Programming Model and Instruction Set** PIC18 microcontroller programming model, Bus architecture, PIC microcontroller program memory and data memory organization, Special Function Registers (SFRs), General Purpose Registers (GPRs), CPU registers, Working Register (Wreg), Status Register, Bank Select Register (BSR), Instruction Decoder, Program Counter (PC) and program ROM, File Select Register (FSR) and File memory, Stack Pointer (STKPTR) and Stack, PIC 18 internal Architecture (ALU, EEPROM, RAM, IO Ports, Timer, CCP module, ADC), Concept of Pipelining. Instruction Set, Data transfer instructions, Arithmetic and Logical Instructions, Rotate instructions, Branch instructions, Bit manipulation instructions. (Assembly programs are restricted to basic	12

	arithmetic and logical operations only)`	
3	**PIC 18 Support Devices** Timer Module: Basic Concept of Timers and counters, Timer Registers, Control Registers, 8 bit and 16 bit operation (only for Timer 0 and 1), CCP module (Capture, Compare and PWM). ADC module: ADC Features, Block diagram of ADC module, ADC Registers, ADCON0, ADCON1. Interrupt Module: Basic concept of Interrupt, PIC 18 Interrupts, Interrupt versus polling, Interrupt sources, Interrupt vector, Interrupt service routine, Interrupt process, RCON Register, INTCON, IPR1, PIE1.	08
4	**Parallel Ports and Serial Communication** IO PORT Module: Basic concept of I/O interfacing, Port Registers, TRIS registers, LAT registers, Simple port interfacing and addressing, Interfacing input peripherals, Interfacing output peripherals. Serial communication: Basics of serial communication, USART module, SPBRG, TXREG, RCREG, TXSTA, RCSTA, PIR1.	06
5	**PIC Programming in C** IO programming: Byte size IO, Bit addressable IO. Timer programming: Generating delay, generating frequency. Interrupt programming: Timer0 and Timer1 interrupt to generate square wave. Serial port programming: Transmit data serially, Receive data serially.	08
6	**Microcontroller Applications** Interfacing matrix keyboard and Seven segments LED display, LCD Interfacing, ADC Interfacing, Traffic signal controller, DC motor interfacing, Stepper motor interfacing, PWM signal generation.	08

Books Recommended:

Reference Books:

1. Fundamentals of Microcontrollers and Applications in Embedded Systems (with the PIC 18 Microcontroller Family), Ramesh Gaonkar, Penram International publications (Ind) Pvt. Ltd.
2. PIC Microcontroller and Embedded Systems, Muhammad Ali Mazidi, Rolind D Mckinlay and Danny Causey, Pearson Education.
3. Microcontroller from Assembly Language to C using PIC18FXX2, Robert B. Reese, Davinici Engineering press.
4. PIC Microcontroller: An Introduction to Software and Hardware Interfacing, Han Way Huang, Cengage Learning.

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.

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Tutorial	Theory	Tutorial	Total
EEC605	**Control System -II (abbreviated as CS-II)**	**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.				
EEC605	Control System – II	20	20	20	80	03	-	100

Course Objectives	• To impart knowledge and skill on compensator design. • To study basics of digital control system and design of digital compensator.
Course Outcomes	Students will be able • To understand the basic design of various compensators. • To design compensators using root locus techniques. • To design compensators using frequency response techniques. • To design compensators using state variable approach. • To illustrate basics of digital control system. • To design digital compensators.

Module	Contents	Hours
1	**Introduction to the Compensator:** Basic concept of compensator design, its requirement, position of compensator in a control system, cascade compensator, feedback compensator, gain compensation, lag, lead and lag-lead compensator, proportional, derivative, integral Compensation, Three term PID, physical realization of compensator with passive and active components, basic block diagrams of a compensated closed loop control system	04
2	**Design of Compensators using Root Locus Technique:** Introduction, improving steady state error by gain compensation, transient response improvement by cascade compensation, improving steady state and transient response, design of rate feedback compensator, notch filter,	12
3	**Design of Compensators using Frequency response Technique (Bode Plot):** Introduction, transient response improvement by gain adjustment, Lag compensation, Lead compensation, Lag-lead compensation.	10
4	**Design of Compensators using State variable approach:** Introduction, pole placement topology, controller design by pole placement topology in phase variable form, controllability and complete controllability, controllability matrix, controllability by inspection, alternative approach to controller design, controller design by transformation. Introduction to Observer / estimator, full order and reduced order observer/ estimator, observability matrix, observability by inspection, observer design by pole placement alternative approach to Observer	8

	design, Observer design by transformation, steady state error design using integral control.	
5	**Digital control System:** Introduction, advantage of digital control, components of digital control system, derivation of digital/ pulse transfer function, block diagram reduction, stability of digital system on Z-plane, bilinear transformation, steady state error and error constants	6
6	**Design of Digital Compensators:** Transient response on the Z-plane, gain design on Z plane for transient response using root locus, stability design by root locus, cascade compensation (design of digital lead, lag and lag-lead compensator)of digital system using s-plane, implementing the digital compensator.	8

Books Recommended:

Text books:

1. Control system engineering by Norman Nise 2nd to latest edition

2. Control Engineering: An Introductory course by Wilkie J., Johnson M., Katebi R., Palgrave MacMillan, Ist to latest edition

3. Industrial Control Electronics: Devices, Systems and Applications by Bartelt, Delmar Thomson Learning, 1st edition

4. Introduction to Programmable Logic Controller by Dunning G, Delmar Thomson Learning, 2nd edition

Reference books:

1. Modern control Engineering by Richard C Dorf, SH Bishop, Wesley edition eighth Edition

2. Linear Control system Analysis and design with MATLAB, by J.J. Azzo, C. H. Houpis, S. N. Sheldon, Marcel Dekkar, ISBN 0824740386

3. Control System Engineering, Shivanagraju s. Devi L., New age International latest edition

4. Control System engineering by Nagrath and Gopal, 5th to latest edition , Wiley Eastern

5. Modern control system engineering by K. Ogata, printice Hall.

6. Automatic control systems, Basic analysis and Design, William A. Wolovich, Oxford

7. Process Control principles and applications, Surekha Bharot, Oxford Higher education

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
EEDLO 6021	**Digital Communication Engineering (abbreviated as DCE)**	**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 6021	Digital Communication Engineering	20	20	20	80	03	25	125

Course Objectives	• To impart knowledge and skill on digital communication engineering.
Course Outcomes	Students will be able • To understand the concept and blocks of digital communication system. • To understand and analyse the performance of base band and pass band digital communication system. • To analyse the different modulation techniques used in digital communication system. • To identify the presence of error in coded signal and design the error control system. • To understand basic concept of different type of digital communication systems.

Module	Contents	Hours
1	**Information theory** Block diagram of a digital communication system, Concept and measures of information, entropy and it's properties. Transmission rate and channel capacity of noisy channels, Shannon's theorem on channel capacity. Source Coding, Shannon's Source Coding Theorem, Shannon-Fano Source Coding, Huffman Source Coding. Introduction to Lempel Ziv coding	06
2	**Baseband Modulation and Transmission** Line codes and their desirable properties, PSD of digital data. Discrete PAM signals and its power spectra. Concept of inter channel and inter symbol interference, Nyquist criterion for zero ISI, sinusoidal roll-off filtering, correlative coding, equalizers, and eye pattern. Duo-binary encoding and modified duo-binary encoding	06
3	**Baseband Detection** Orthogonality, representation of signals. Maximum likelihood decoding Correlation receiver, equivalence with matched filter	04
4	**Modulation Techniques** Generation, detection, Coherent and non-coherent reception, signal space diagram, spectrum, bandwidth efficiency, and probability of error	08

	analysis of : Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK)Modulations, Binary Phase Shift Keying (BPSK) Modulation Quaternary Phase Shift Keying QPSK)	
5	**5. Error Control Systems**:- **5.1** Types of error control, error control codes, linear block codes, generator matrix, and systematic linear block. codes, parity check matrix, syndrome testing ,error correction, and decoder implementation **5.2** Cyclic codes: Algebraic structure of cyclic codes, binary cyclic code properties, encoding in systematic **5.3** Introduction of Convolution code: State diagram, code tree, trellis diagram	08
6	**Overview of different types of communication** :- Power Line Carrier communication, Satellite communication, OFC (Block Diagram level)	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
3. Amitabha Bhattacharya, "*Digital Communication*", Tata Mcgraw Hill

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.

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Tutorial	Theory	Tutorial	Total
EEDLO 6022	**Micro-Grid (abbreviated as MG)**	**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 6022	Micro-Grid	20	20	20	80	03	25	125

Course Objectives	• To impart knowledge of renewable energy based Microgrid technology, types and issues associated in their practical realization. • To elaborate the various control and operational strategies used for practical microgrids.
Course Outcomes	Students will be able • To identify and describe the evolvement Microgrid, its features and barriers. • To select, size and design the various microgrid resources. • To model, analyze and design the power electronics (PE) interfaces for various microgrid sources • To identify and describe the role communication in Microgrid realization. • To identify and describe various operational strategies and protection schemes suitable for Microgrid. • To apprise the different standards applicable for microgrid deployment

Module	Contents	Hours
1	**Introduction to Microgrid:** Microgrid: Definition, What is not a microgrid, Typical structure and configuration of a microgrid, Significance of microgrids, Sources of microgrid, Types of microgrids, AC, DC and hybrid microgrids; Technical implications and social fall out of microgrid, Market Models and business cases for microgrids.	03
2	**Microgrid Sources and Power Electronic Interfaces:** Review of Microgrid sources: basics characteristics and selection; Power Electronics (PE) interface and design for microgrid DC and AC sources. Protection and co-ordination, Power Quality issues and Solutions; Microgrid and Energy Storage Systems (ESS), Portable and Stationary ESS, Review of Flywheel, Battery and Ultra-capacitor; PE Interface design for ESS.	08
3	**Control and Design of Power Electronic Interfaces:** Determination of Control laws, Power relations and power control, Bi-directionality and its need in a Microgrid; Control of DC-DC converters and inverter and challenges in a Microgrid; Micro-grid Control Strategies: Centralized, Decentralized and Hierarchical control, Multi-Agent System based control; Power Control and Energy Management in Microgrids.	10

4	**Communication Infrastructure:** Requirement of Communication System in microgrids, Communication protocols and standards; Selection of communication protocols for microgrids. Event triggered system and Time triggered system, Unicast and Multicast Communication, Impact of time latencies on operation.	05
5	**Operation of Microgrid and Microgrid Protection:** Modes of Operation: Grid Connected Mode, Islanding Mode, Issues in Island Mode of operations, Islanding detection, Reliability and Stability Issues in islanding ; Protection: Fault Behavior in Grid Connected Mode and Island mode, Types of Protection Systems Fault Source Based protection, Adaptive protection.	07
6	**Microgrid Standards and Deployment:** IEEE-1547 series, Review of worldwide Microgrid installations, Economic evaluation and planning for microgrids; Microgrids in smart grid scenario.	03

Books Recommended:

Text Books:

1. Nikos Hatziargyriou, "Microgrids: Architectures and Control," Wiley-IEEE Press, 2013
2. Magdi S Mahmoud, "Microgrid: Advanced Control Methods and Renewable Energy System Integration", Butterworth-Heinemann, 2016
3. S. M. Sharkh , M. A. Abu-Sara, G. I. Orfanoudakis and B. Hussain, "Power Electronic Converters for Microgrids," Wiley – IEEE Press
4. Remus Teodorescu, Marco Liserre and Pedro Rodriguez, "Grid Converters for Photovoltaic and Wind Power Systems," Wiley Publications
5. Amirnaser Yazdani and Reza Iravani, "Voltage-Sourced Converters in Power Systems: Modeling, Control, and Applications," Wiley-IEEE Press

Reference Books:

1. Smart Grid:Fundamentals of Design and Analysis by James Momoh, IEEE Press and
2. Wiley Publications
3. Ali Keyhani, Mohammad N. Marwali, Min Dai "Integration of Green and Renewable Energy in Electric Power Systems", Wiley
4. Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response" CRC Press

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.

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Tutorial	Theory	Tutorial	Total
EEDLO 6023	**Advanced Power Electronics (abbreviated as APE)**	**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 6023	Advanced Power Electronics	20	20	20	80	03	25	125

Course Objectives	• To understand dc to dc conversion with isolation, the underlying principles of converter operation and hence to analyze different converter circuits for power conversion. • To understand the principles of design of magnetics such as high frequency transformers and inductors. • To keep abreast with the latest technologies and research going on in different areas related to power electronics. • To enhance the capability of problem solving skills. • To model the converter and design the controller for deeper understanding and detailed analysis.
Course Outcomes	Student will be able to • Select and design power electronic converter topologies for a broad range of energy conversion applications. • Analyze and simulate the performance of power electronic conversion systems. • Ability to model and design controllers for the closed loop operation of power converters. • Apply the basic concepts of power electronics to design the circuits in the fields of AC and DC drives, power generation and energy conversion, industrial applications, extraction of energy from renewable sources. • Build and troubleshoot power electronics circuits. • Deliver technological solution in the field of power electronics.

Module	Contents	Hours
1	Switching Voltage Regulators Introduction; Linear power supply (voltage regulators); Switching voltage regulators; unidirectional and bidirectional core excitation; Review of basic dc-dc voltage regulator configurations -Buck, Boost, Buck-Boost converters, Bidirectional Converter (BDC) and their analysis for continuous and discontinuous mode; Other converter configurations like Flyback converter, Forward converter, Push-pull converter; Design criteria for SMPS; Multi-output switch mode regulator.	10

2	**Resonant dc to dc converters:** Drawbacks of switch-mode converters, classification of resonant converters, basic resonant circuit concepts, Load resonant converters, series and parallel loaded, steady state operating characteristics, Resonant switch converters - ZVS, ZCS, comparison of resonant converters, applications of resonant converters	03
3	**Design of Magnetics (Boost, Buck, BDC and flyback only).:** Review of magnetic concepts, volt-sec balance, area product, design of inductor, design of high frequency transformer, numericals on design of inductor and transformer for dc to dc converters.	05
4	**Modeling and control converters and inverter (Boost, Buck, BDC and flyback only):** State space model of various dc to dc converters, state space averaging techniques, small signal analysis, transfer function, feedback control, compensator design, voltage mode control, current mode control. Modeling of grid connected Inverter with LC filter, Compensator design with current mode control and DC link voltage control loop. Digital control of power electronic converters	09
5	**Multi-Level Inverter:** Need for multilevel inverters, Diode clamped, flying capacitor and cascaded MLI, Phase shifted and level shifted PWM techniques, introduction to SVM for three level inverter, Applications of multilevel inverters.	04
6	**Applications of power electronic converters:** Solar PV Power Conditioning unit (PCU), Battery PCU, Active Filters, AC and DC drives. Thermal management and EMI issues in Practical power Electronics systems	05

Books Recommended:

Text Books:

1. N.Mohan, T.M.Undeland, W.P Robbins, ―Power Electronics, Converters, Applications & Design, Wiley India.
2. R W Erickson and D Maksimovic, ―Fundamental of Power Electronics, Springer, 2nd Edition.
3. M.H.Rashid, Hand book of Power Electronics" , Third edition Butterworth-Heinemann; 2011
4. Joseph Vithayathil ―Power Electronics‖, Tata McGraw Hill
5. Daniel.W.Hart, "Power Electronics", Mc GrawHill Publications 2010
6. P.S Bhimbra, "Power Electronics",Khanna Publishers.
7. Simon Ang, Alejandro Oliva, "Power-Switching Converters" Taylor and Francis group
8. L.Umanand, "Design of Magnetic Components for Switched Mode Power Converters", New Age International

Reference Books:

1. P. T. Krein, Elements of Power Electronics, Oxford University Press.
2. L. Umanad, "Power Electronics: Essentials & Applications," Wiley.
3. A Yazdani, R. Iravani, Voltage- Sourced Converters in Power Systems, Wiley, IEEE press.

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 six tutorials and one group mini project.

Mini-project: Group of students (4 in a group) will choose a fairly complex power electronics application in their preferred area, complete the analysis and detailed design of power converter and control for this application, and finally validate the design using hardware implementation supported with simulation(if necessary). A formal technical report is required on the last day of class.

The distribution of marks for term work shall be as follows:

Tutorials :10 marks
Group Mini Project :10 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.

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Practical	Theory	Practical	Total
EEL601	**Electrical Protection Lab (abbreviated as EP 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.					
EEL601	Electrical Protection Lab	-	-	-	-	25	-	25	50

Course Objectives	• To introduce the concept of different protection schemes.
Course Outcomes	Students will be able • To understand the concept of various over current protection scheme and its applications in power system. • To understand the concept of various over/under voltage, over/under frequency and temperature protection scheme and its applications. • To understand the working principle of various protective devices.

Syllabus: Same as that of Course EEC601 protection and switchgear Engineering.

Suggested List of Laboratory Experiment:

1. Demonstration of Inverse time Over-current Relay & Plotting the characteristics
2. Demonstration of Over-current protection Relay
3. Demonstration of Directional Over-current Protection Relay
4. Demonstration of Differential Over-current Protection Relay
5. Demonstration of Under/Overvoltage Protection
6. Demonstration of Motor winding temperature protection
7. Demonstration of Gas actuated Relays
8. Demonstration of working parts of different Fuses, MCB, MCCB, RCCB & Circuit Breakers.
9. Visit to a substation & a report preparation.

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

Term work:

Term work shall consist of minimum six 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	**Course Name**	**Teaching Scheme**	**Credits Assigned**

Code		(Contact Hours)				
		Theory	Practical	Theory	Practical	Total
EEL602	Electrical Machines Lab - IV (abbreviated as EMC Lab-IV)	-	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.					
EEL602	Electrical Machines Lab -IV	-	-	-	-	25	25	-	50

Course Objectives	• To impart practical knowledge on synchronous machines
Course Outcomes	Students will be able • To analyse the operation of synchronous machines. • To analyse the voltage regulation of synchronous machines. • To analyse the synchronization or parallel operation of synchronous machine. • To determine the parameters of synchronous machines for its analysis.

Syllabus: Same as that of Course EEC602 Electrical machines - IV

Suggested List of Laboratory Experiment:

1. Constructional details of Synchronous machine
2. Voltage regulation of Alternator by Direct loading method
3. Voltage regulation of Alternator by EMF and MMF method
4. Voltage regulation of Alternator by ZPF and ASA method
5. Synchronization / Parallel operation of Alternator
6. Starting methods of Synchronous motor
7. 'V' and inverted 'V' curve of Synchronous motor
8. Determination of X_d and X_q of Synchronous machine by Slip test
9. Use of Synchronous motor as a Synchronous condenser
10. Loading of Synchronous motor by Brake test with rated excitation

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

Term work:

Term work shall consist of minimum six 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.

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

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Practical	Theory	Practical	Total
EEL603	**Microcontroller Lab (abbreviated as MC 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.					
EEL603	Microcontroller Lab	-	-	-	-	25	25	-	50

Course Objectives	• To impart the programming knowledge of PIC 18 microcontroller.
Course Outcomes	Students will be able • To program simple arithmetic and logical operations using PIC 18 microcontroller. • To program timer and ADC of PIC 18 microcontroller for different applications. • To interface different IO devices with PIC 18 microcontroller.

Syllabus: Same as that of Course EEC604 Microcontroller and its applications

Suggested List of Laboratory Experiment:

Basic Programming

1. Addition, subtraction
2. Logical operations
3. Multiplication and division
4. Sort even and odd numbers
5. Sort negative and positive numbers
6. Toggle the bits of ports

Timer programming

1. Generate square wave
2. Generate time delay
3. Counter program
4. Generate the PWM pattern

ADC programming

1. Analog to digital conversion

Peripheral Interface programming

1. LCD interface
2. LED interface
3. Stepper motor interface
4. DC motor interface
5. Serial port interface

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

Term work:

The term work shall consist of minimum **eight** experiments based on PIC 18F microcontroller using embedded C language. 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**
EEL604	**Simulation Lab-II (abbreviated as Sim Lab - II)**	**-**	**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.					
EEL604	Simulation Lab-II	-	-	-	-	25	-	25	50

Course Objectives	• To impart knowledge on coding and simulation of electrical systems.
Course Outcomes	Students will be able • To code or simulate signal systems for its analysis. • To code or simulate power system for its analysis. • To code or simulate power electronics converter for its analysis. • To code or simulate electrical machines for its analysis.

Syllabus: Same as that of all core courses of semester VI.

Suggested List of Laboratory Experiment:

1. Algorithm for Basic operation on signal
2. Algorithm for Linear and Circular Convolution
3. Algorithm for step, impulse and frequency Response in Digital system
4. Algorithm for FFT for DFT Computation
5. Algorithm for Design of FIR System using Rectangular Window
6. Algorithm for Design of Butterworth Digital IIR System
7. Simulation of 1- phase full wave Rectifier with R-L Load
8. Simulation of Fault Analysis
9. Simulation of OC & SC Test of 3-phase IM.
10. Simulation of 1- phase full wave Controlled Rectifier with R-L Load

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

Term work:

Term work shall consist of minimum six 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.

AC
Item No.

UNIVERSITY OF MUMBAI

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

Under

FACULTY OF TECHNOLOGY

Electrical Engineering

Final Year with Effect from **AY 2019-20**

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

Program Structure for
BE Electrical Engineering
University of Mumbai
(With Effect from 2019-20)

Scheme for Semester VII

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
EEC701	Power System - III	4	-	1	4	-	1	5
EEC702	Drives and Control	4	-	-	4	-	-	4
EEC703	High Voltage Direct Current Transmission	4	-	-	4	-	-	4
EEDLO703X	Department Level Optional Course-III	3	-	1	3	-	1	4
ILO701X	Institute Level Optional Course-I	3	-	-	3	-	-	3
EEL701	Simulation Lab - III	-	2	-	-	1	-	1
EEL702	Drives and Control Lab	-	2	-	-	1	-	1
EEL703	Project-I	-	6	-	-	3	-	3
Total		**18**	**10**	**2**	**18**	**5**	**2**	**25**

Examination Scheme for Semester VII

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	
EEC701	Power System - III	80	32	20	8	25	10	-	-	-	-	-	-	125
EEC702	Drives and Control	80	32	20	8	-	-	-	-	-	-	-	-	100
EEC703	High Voltage Direct Current Transmission	80	32	20	8	-	-	-	-	-	-	-	-	100
EEDLO 703X	Department Level Optional Course-III	80	32	20	8	25	10	-	-	-	-	-	-	125
ILO701 X	Institute Level Optional Course-I	80	32	20	8	-	-	-	-	-	-	-	-	100
EEL701	Simulation Lab - III	-	-	-	-	25	10	-	-	25	10	-	-	50
EEL702	Drives and Control Lab	-	-	-	-	25	10	-	-	-	-	25	10	50
EEL703	Project-I	-	-	-	-	25	10	-	-	25	10	-	-	50
Total		**400**	**-**	**100**	**-**	**125**	**-**	**-**	**-**	**50**	**-**	**25**	**-**	**700**

Program Structure for
BE Electrical Engineering
University of Mumbai
(With Effect from 2019-20)

Scheme for Semester VIII

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
EEC801	Design, Management and Auditing of Electrical Systems	4	-	1	4	-	1	5
EEC802	Flexible AC Transmission System	4	-	-	4	-	-	4
EEDLO804X	Department Level Optional Course-IV	3	-	1	3	-	1	4
ILO802X	Institute Level Optional Course-II	3	-	-	3	-	-	3
EEL801	Simulation Lab - IV	-	2	-	-	1	-	1
EEL802	Electrical System Design Lab		2	-	-	1	-	1
EEL803	Project-II	-	12	-	-	6	-	6
Total		**14**	**16**	**2**	**14**	**8**	**2**	**24**

Examination Scheme for Semester VIII

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	
EEC801	Design, Management and Auditing of Electrical Systems	80	32	20	8	25	10	-	-	-	-	-	-	125
EEC802	Flexible AC Transmission System	80	32	20	8	-	-	-	-	-	-	-	-	100
EEDLO 804X	Department Level Optional Course-IV	80	32	20	8	25	10	-	-	-	-	-	-	125
ILO802 X	Institute Level Optional Course-II	80	32	20	8	-	-	-	-	-	-	-	-	100
EEL801	Simulation Lab - IV	-	-	-	-	25	10	-	-	25	10	-	-	50
EEL802	Electrical System Design Lab					25	10	-	-	25	10	-	-	50
EEL803	Project-II	-	-	-	-	50	20	-	-	50	20	-	-	100
Total		**320**	**-**	**80**	**-**	**150**	**-**	**-**	**-**	**100**	**-**	**-**	**-**	**650**

List of Department Level Optional Courses

Course Code	Department Level Optional Course - III
EEDLO7031	High Voltage Engineering
EEDLO7032	Electric Vehicle Technology
EEDLO7033	Industrial Controller
EEDLO7034	Power Quality

Course Code	Department Level Optional Course - IV
EEDLO8041	Illumination Engineering
EEDLO8042	Smart Grid
EEDLO8043	Power System Modeling and Control
EEDLO8044	Power System Planning and Reliability

List of Institute Level Optional Courses

Course Code	Institute Level Optional Course - I
ILO7011	Product Lifecycle Management
ILO7012	Reliability Engineering
ILO7013	Management Information System
ILO7014	Design of Experiments
ILO7015	Operation Research
ILO7016	Cyber Security and Laws
ILO7017	Disaster Management and Mitigation Measures
ILO7018	Energy Audit and Management
ILO7019	Development Engineering

Course Code	Institute Level Optional Course - II
ILO8021	Project Management
ILO8022	Finance Management
ILO8023	Entrepreneurship Development and Management
ILO8024	Human Resource Management
ILO8025	Professional Ethics and Corporate Social Responsibility (CSR)
ILO8026	Research Methodology
ILO8027	IPR and Patenting
ILO8028	Digital Business Management
ILO8029	Environmental Management

University of Mumbai						
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**		**Credits Assigned**		
		Theory	**Tutorial**	**Theory**	**Tutorial**	**Total**
EEC701	**Power System -III (abbreviated as PS -III)**	**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.				
EEC701	Power System – III	20	20	20	80	03	25	125

Course Objectives	• To impact knowledge in power system operation and its control. • To understand the formulation of unit commitment and economic load dispatch • To illustrate the automatic frequency and voltage control strategies for single and two area case • To study the different types of stability of power system and method to improve stability of power system
Course Outcomes	• Students will be able to analyze power system problem and find out its solutions • Identify and analyze the dynamics of power systems and methods to improve stability of system. • Study different methods of load flow solutions. • Application of optimization methods for task like economic load dispatch

Module	Contents	Hours
1	**Load Flow Studies** Introduction, network model formulation, formation of Y bus using step by step method, formation of Y bus by singular transformation, Load flow problem, Load flow Equation and methods of solution, Approximate Load flow study, Gauss-Seidel method, Newton-Raphson method ,Decoupled load flow method, Fast decoupled load flow method, comparison of load flow method. **(Numerical)**	12
2	**Economic Operation of Power System** Optimal operation of generators in thermal power station, heat rate curve, input-output curve, IFC curves, optimum generation scheduling neglecting Transmission losses(coordinate equation), optimum generation scheduling considering transmission losses (Exact coordinate equation),Transmission loss formula, Bmn coefficient, Inherent procedure of solving co-ordination equation, optimal unit commitment: dynamic programming method, Reliability considerations**(Numerical)**	10
3	**Automatic Generation and voltage control** Introduction, Basic control loops in generator, AVR loop, Thermal control, speed governing system and transfer function, steam turbine	08

	and power system transfer function, Load frequency control(single area),state and dynamic response. Load frequency control of Two area system, static and dynamic response analysis of two area system, Load frequency control with with generation rate constraints, Dead band and its effect on AGC**(Numerical)**	
4	**Power System Stability** Introduction to stability , types of stability, Power angle curve, dynamics of synchronous machine, power angle equation, steady state stability, swing equation, transient stability, equal area criterion, application of equal area criterion, point by point solution of swing equation, some techniques for improving transient stability.**(Numerical)**	10
5	**Voltage Stability** Introduction, definitions, short circuit capacity, comparison of rotor angle and voltage stability, reactive power flow and voltage collapse, voltage stability. Surge impedance loading, PV and V-Q curves, Various methods of voltage control shunt compensation, series compensation, and comparison of series and shunt compensation	03
6	**Power system security and interchange of power** **Power system security** Introduction, System state classification, security analysis, contingency analysis, sensitivity factor. **Interchange of power** Interchange of power between interconnected utilities, types of interchange ,capacity and diversity interchange ,energy banking ,power pools	05

Books Recommended:

Text Books:

1. Kothari.D.P,Nagrath.I.J, " Modern power system Analysis",TMH publication,Third Edition,2008.
2. Kothari.D.P,Nagrath.I.J, "Power system Engineering",TMH publication,second edition,2008.
3. George Kausic. "computer Aided Power System Analysis", Prentice Hall publication.2008
4. Chakrabarti.A,Halder.S., "Power System Analysis-Operation and Control" PHI, second Edision 2008
5. Allen.J.Wood.,Bruce.F.Wollenberg., " Power Generation operation and control",Wiley India,Second Edition,2007.
6. Prabha Kundur, 'Power System Stabilty and control',TMH publication,2008.
7. P.S.R.Murthy,"Power System Operation and control",Tata McGraw Hill publishing Co.Ltd.

Reference Books:

1. 1.Soman.S.A,Kharpade.S.A,and Subha Pandit 'Computer Methods for Large Power system Analysis , an object Oriented Approach',Kluwer Academic Publisher New York 2001.
2. 2.Anderson P.M.Fouad A.A, 'Power system control and stability',Wiley Interscience,2008 Edition
3. 3.Kimbark E W, 'Power system Stabilty',Volume I,II, and III,wiley Publication.
4. 4.Jr. W.D. Stevenson.,G.J.Grainger. 'Elements of power system'.Mc-GrawHill,Publication.
5. 5.Hadi saadat,Power system Analysis,TMH Publication,Second Edison,2002
6. 6.P.K.Nagsarkar,M.S.Sukhija, "Power System Analysis",Oxford,second edition 2014
7. 7.S.Sivanagaraju,G.Sreenivasan power system operation and contrl,person publication,2010.

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**
EEC702	**Drives and Control (abbreviated as D&C)**	**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.				
EEC702	Drives and Control	20	20	20	80	03	-	100

Course Objectives	• To impart knowledge on basic concept of DC and AC drives, various speed control techniques involved with both DC and AC drives and advanced speed control techniques using power electronic converter used in industry.
Course Outcomes	Students will be able • To understand the dynamics of electrical drive. • To understand the motor power rating calculation for a specific application for reliable operation. • To understand the modes of operation and close loop control of electrical drive. • To analyse the speed control of DC drives in an energy efficient manner using power electronics. • To analyse the speed control of induction motor drive using various methods. • To learn the advance control techniques for AC drives.

Module	Contents	Hours
1	**Electrical Drives: Introduction &Dynamics** Introduction, Advantages of Electrical Drives, Parts of Electrical Drives, Choice of Electrical Drives, Status of DC and AC Drives, Fundamental Torque equations, Speed Torque conventions and Multi-quadrant Operation, Equivalent values of Drive Parameter, Measurement of Moment of Inertia, Components of Load Torques, Nature and Classification of Load Torques, Calculation of Time and Energy-Loss in Transient Operations, Steady State Stability, Load Equalization	10
2	**Selection of Motor Power Rating:** Thermal Model of Motor for Heating and Cooling, Classes of Motor Rating, Determination of Motor Rating	04
3	**Control of Electrical Drives:** Modes of Operation, Speed Control, Drive Classification, Closed loop Control of Drives- Speed control loop with inner loop of current control. Current control techniques- PWM and hysteresis Static and dynamic performance of drive.	04

4	**DC Drives:** Basic multi-quadrant (T - ωm) characteristics and equations of DC motors. Single phase drives- full converter drive and its performance parameters (CCM), Duel converter drive Three phase drives- Half-converter drive, fully-converter drive DC-DC converter drive- principal of power control (step-down chopper), regenerative brake control, rheostatic brake control, performance parameters for braking and speed control Control of dc drives- open loop and closed loop control (transfer function approach and microcontroller control) clock diagrams (No Numerical on this module)	08
5	**AC Drives:** Basic multi-quadrant (T - ωm) characteristics and equations Induction Motor drives, Review of Speed-Torque relations, Review of Starting methods, Braking methods- Regenerative, Plugging and AC dynamic braking only, Speed Control: Stator voltage control, Variable frequency control, V/f control, Static Rotor Resistance control, Slip Power Recovery - Static Scherbius Drive, Review of d-q model of Induction Motor, Introduction to Synchronous Motor Variable Speed drives. (No Numerical on starters)	18
6	**Advanced control techniques-** Principle of Vector Control, Block diagram of Direct Vector Control Scheme, Comparison of Scalar control and Vector control, Direct Torque Control (DTC), field oriented control (FOC), comparison between control techniques.	04

Books Recommended:

Text Books:

1. Fundamentals of Electrical Drives by G.K.Dubey, Narosa Publication
2. A First Course on Electrical Drives by S.K.Pillai, New Age International.
3. Electrical Drives: Concepts and Applications by Vedam Subramanyam, T.M.H
4. Modern Power Electronics and AC Drives by B.K.Bose, Prentice Hall PTR
5. Power electronics by Muhammad H. Rashid, Pearson

Reference Books:

1. Electric Motor Drives: Modeling, Analysis and Control by Krishnan.R, PHI
2. Power Electronics by Joseph Vithayathil, Tata McGraw Hill
3. Power Semiconductor Controlled Drives by G. K. Dubey, Prentice Hall International

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**
EEC703	**High Voltage Direct Current Transmission (abbreviated as HVDCT)**	**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.				
EEC703	High Voltage Direct Current Transmission	20	20	20	80	03	-	100

Course Objectives	• To impart knowledge on HVDC system, its control, protection along with brief analysis of HVDC converters.
Course Outcomes	Students will be able to • Identify significance of dc over ac transmission systems, types of HVDC link, Components of HVDC system and applications. • Analyse multi-pulse converters. • Understand the basic control of HVDC system and its limitation, features and implementation. • Understand converter firing control schemes for starting and stopping of HVDC link. • Understand and analyse faults and protection of HVDC system. • Understand harmonics, their causes, effects and use of different filters.

Module	Contents	Hours
1	**Introduction to HVDC transmission:** Early discoveries and applications, Limitation and advantages of AC and DC transmission, Classification of HVDC links, Components HVDC Transmission system, Ground Return Advantages and Problems, Advances in HVDC transmission. HVDC system application in wind power generation	04
2	**Analysis of the Bridge rectifier:** Analysis of six pulse converter with grid control but no overlap, Current and phase relations, Analysis of six pulse converter with grid control and overlap less than 60°, Relation between AC and DC quantities, Analysis with overlap greater than 60^0, Rectifier operation output voltage, thyristor voltage waveforms with and without overlap, Inverter operation output voltage waveforms. Equivalent circuit of rectifier and inverter, Multi bridge converter, Numerical from converter circuits and multiple bridge converters.	12
3	**HVDC System Control:** Basic means of control, Limitation of manual control, Constant current	06

	verses constant voltage control, Desired features of control, Actual control characteristics, Significance of current margin, Power reversal, Control implementation	
4	**Converter Control:** Converter Firing Control Schemes (EPC and IPC. Starting and shutting down the HVDC link	03
5	**Faults and protection:** By pass valve, Causes and analysis of arc back, arc through, misfire, current extinction, single commutation failure, double commutation failure, short circuits in converter station Protection against over current, over voltage	08
6	**Harmonics & Filters:** Characteristics Harmonics and Un-Characteristics Harmonics, Causes, Consequences, Trouble Caused by Harmonics, Means of Reducing Harmonics, Filters, AC & DC Filters.	03

Books Recommended:

Text Books:

1. Edward Wilson Kimbark "Direct Current Transmission" Wiley publication Inter science
2. K R Padiyar "HVDC power transmission systems" second edition, New Age International (p)Ltd
3. S. Kamkshaiah and V Kamraju "HVDC transmission" Tata McGraw Hill Education Pvt. Ltd, New Delhi
4. SN Singh, "Electric Power Generation, Transmission and Distribution, PHI, New Delhi 2nd edition, 2008

Reference Books:

1. S. Rao "EHVAC and HVDC Transmission Engineering and Practice" -Khanna publication, 1990
2. J. Arrillaga "HVDC Transmission" - Wiley publication Inter science
3. C.L. Wadhwa "Electrical Power System (2nd 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

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 7031	**High Voltage Engineering (abbreviated as HVE)**	**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 7031	High Voltage Engineering	20	20	20	80	03	25	125

Course Objectives	• To make students able to explain the various breakdown processes in solid, liquid and gaseous materials. • To provide knowledge of Testing, Generation & Measurement methods adopted for DC, AC and Impulse voltages and currents. • To understand the modern numerical tools available in high-voltage equipment design and set-up of H.V. Laboratory.
Course Outcomes	Student will be able • To know the fundamentals properties of the materials and their failure mechanisms to get appropriate and optimal design. • Of testing of different dielectric materials and the major requirements for setting up of HV Laboratories.

Module	Contents	Hours
1	**Electrostatic Fields, Their Control and Estimation:** • Electric field Stress, its control and Estimation • Analysis of Electric field intensity in Homogenous Isotropic Single dielectric and multi dielectric system. • Numerical methods – Finite difference, Finite Element and Charge simulation method for estimation of Electric Field. Surge voltage, their distribution and control	04
2	**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)	07
3	**Breakdown in Liquid and Solid Dielectrics:**	06

	• 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. • Breakdown of composite insulation. • Application of insulating materials in electrical power apparatus, electronic equipment's.	
4	**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 impulse generators, Generation of high impulse current	**07**
5	**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. • Measurement of High DC, AC and impulse currents	05
6	**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.	07

Books Recommended:

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 Co. Ltd. New Delhi

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

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 7032	**Electric Vehicle Technology (abbreviated as EVT)**	**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 7032	Electric Vehicle Technology	20	20	20	80	03	25	125

Course Objectives	• Know the history of electric hybrid electric vehicles (EV & HEV) and emphasize the need and importance of EV-HEV for sustainable future. • Introduce the fundamental concepts and principles of electric and hybrid electric vehicles drive train topologies • Develop a thorough understanding of the key elements of EV/HEV: Electric Machines for Propulsion Applications and Energy Sources • Model, analyze and design electric and hybrid electric vehicles drive train and to understand energy management strategies
Course Outcomes	Students will be able • To identify and describe the history and evolvement of electric & hybrid electric vehicles to emphasize on the need and importance of EV/HEV for sustainable future. • To identify and describe the principles of various EV/HEVs drive train topologies along with their power flow control and fuel efficiency estimation. • To design and select electric propulsion system components for EV/HEV drives suitability for the desirable performance and control**.** • To compare and evaluate various energy sources and energy storage components for EV and HEV applications. • To model, analyze and design EV/HEV drive train with energy management strategies**.** • To recognize the need to adapt and engage in operations EV/HEV with the absolute technological change in the transportation system for sustainable future.

Module	Contents	Hours
1	**Introduction:** Basics of vehicles mechanisms**,** history of electric vehicles (EV) and hybrid electric vehicles (HEV), need and importance of EV and HEV, Power/Energy supplies requirements for EV/HEV applications, vehicle power source characterization, and transmission characteristics.	05

2	**Drive-train Topologies:** Review of electric traction, various electric drive-train topologies, basics of hybrid traction system, various hybrid drive-train topologies, power flow control in drive-train topologies, fuel efficiency analysis.	08
3	**DC and AC Machines for Propulsion Applications:** Electric system components for EV/HEV, suitability of DC and AC machines for EV/HEV applications, AC and DC Motor drives. Advanced permanent magnet and switch reluctance machines, configuration and control of drives.	05
4	**Energy Sources for EV/HEV:** Requirements of energy supplies and storage in EV/HEV, Review of batteries, fuel cells, flywheels and ultra-capacitors as energy sources for EV/HEV, characteristics and comparison of energy sources for EV/HEV, hybridization of different energy sources.	05
5	**Modeling and design of the drive trains:** Modeling and analysis of EV/HEV drive train, sizing of motor, and design of traction power electronics, various vehicle subsystems.	08
6	**Energy Management Strategies and Energy Efficiency:** EV/HEV energy management strategies, classification and comparison of various energy management strategies, energy efficiency comparison for various EV and HEV variants	05

Books Recommended:

Reference Books:

1. I. Hussein, *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press, 2003.
2. M. Ehsani, Y. Gao, S.E. Gay and Ali Emadi, *Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design*, CRC Press. 2005
3. Sheldon Williamsom, Energy Management Strategies for Electric and Plug-in Hybrid Vehicles, Springer 2013
4. J. Larminie and J. Lowry, *Electric Vehicle Technology Explained*, Wiley, 2003
5. C. MI, M. Abul and D. W. Gao, *Hybrid Electrical Vehicle Principles and Application with Practical Perspectives*, Wiley 2011
6. Robert A. Huggins, *Energy Storage*, Springer 2010
7. N.Mohan, T.M.Undeland, W.P Robbins, *Power Electronics, Converters, Applications & Design*, Wiley India Pvt. Ltd., 2003
8. B. K Bose, *Modern Power Electronics and AC Drives*, Pearson Education 2002

Website Reference:

1. http://nptel.iitm.ac.in: Introduction to Hybrid and Electric Vehicles - Web course

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 7033	**Industrial Controller (abbreviated as IC)**	**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 7033	Industrial Controller	20	20	20	80	03	25	125

Course Objectives	• To provide knowledge level needed for PLC programming and operation. • To train the students to create ladder diagram from process control descriptions. • To provide with detailed knowledge f various terms and operation techniques of PID controllers. • To make the students understand the various methods of PID tuning manually and practically.
Course Outcomes	Students will be able to • Understand significance of P, I and D controlled techniques, disturbance rejection and reference tracking of PI and PD controllers and fuzzy logic implementation. • Understand the various manual tuning methods of PID controllers and their design. • Understand the common notation of industrial PID and digital PID and learn various issues in implementation of industrial PID. • Ability to represent various components of PLC in a block diagram and understand the different type of I/O devices that can be connected to PLC. • Understand the instruction set of PLC and analyse the given problem statement to develop a ladder logic for it. • Analyse the various types of I/O modules of PLC.

Module	Contents	Hours
1	**Introduction to controllers Principles:** Control modes, on-off control, proportional control, proportional –integral control, proportional derivative control, proportional integrator derivative control, selection of controllers structure, disturbance rejection and reference tracking with proportional, Integral, Proportional and integrator, proportional and derivative and PID with the help of first order model. Introduction to fuzzy logic, fuzzy sets, memberships function, a fuzzy logic application,	10
2	**PID controller tuning method:** Understanding PID tuning procedure, Manual tuning methods, PID controller design by pole placement, oscillation and quarter amplitude oscillation method, process reaction	05

	curve PID tuning, damped decay PID tuning, the relay experiment	
3	**The practical aspect of PID tuning:** Understanding common notation for industrial PID controllers, Industrial PID control technology, the issues in implementing the industrial PID controller, integral windup and antiwindup circuits, implementing the derivative terms, industrial PID controller structure, different form of industrial PID controllers, reverse acting controllers, digital PID control	05
4	**Introduction to programmable controller:** Industrial motor control and starter circuit, building a ladder diagram, PLC Block diagram and components of PLC, rack assembly, power supply, PLC programming unit, input/ output section, processor unit, addressing, relationship to data file addresses to I/O module	06
5	**Fundamental PLC Programming:** PLC program execution, Ladder diagram programming language, ladder diagram programming, relay logic instructions, timer instructions , counter instructions, Data manipulation instructions, arithmetic instructions, writing small program based on above instruction	05
6	**Advanced programming, PLC interfacing, troubleshooting:** Introduction to Jump command, data manipulation, programmable controller interfacing discrete input/output module, troubleshooting I/O interfaces, analog input and output signals, special purpose module, troubleshooting programmable controllers	05

Books Recommended:

Text Books:

1. Industrial Control Electronics, Terry Bartelt, Delmar Thomson Learning
2. Control Engineering An introductory course, Jacqueline Wilkie, Michael A Johnson, Reza Katebi, Palgrave
3. Process control instrumentation technology, Curtis D Johnson, Pearson education
4. Programmable Logic controller, Dunning

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 7034	**Power Quality (abbreviated as PQ)**	**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 7034	Power Quality	20	20	20	80	03	25	125

Course Objectives	• To impart knowledge on various power quality issues, mitigation methods and it's monitoring.
Course Outcomes	Students will be able to • Identify various power quality issues, its causes and effects. • Identify and analyse the harmonics created due to nonlinear load. • Learn and analyse the power factor compensation for linear and nonlinear loads. • Understand various power quality mitigation techniques. • Identify various power quality issues in distributed generation system. • Understand power quality measuring equipment and monitoring standards.

Module	Contents	Hours
1	**Introduction:** Overview of Power Quality-Transients, long duration voltage variation, short duration voltage variation, voltage imbalance, waveform distortion, power frequency variations, power quality standards.	06
2	**Harmonics and Indices:** Harmonic distortion, voltage versus current distortion, harmonics and transients, harmonic indices (Numerical to be covered on all indices), harmonic sources from commercial loads and industrial loadsalong with its typical current waveforms, Locating harmonic sources, System response characteristics, effects of harmonic distortion, Inter-harmonics.	12
3	**Power Factor Compensation:** Linear circuits with Sinusoidal supply-Basic relationship, complex power, apparent power and powerfactor, power factor compensation in linear sinusoidal circuits , Nonlinear circuits with sinusoidal supply-Basic relationship, complex power, apparent power and power factor, Power factor compensation in linear and non-linear circuits with sinusoidal supply- Problems related to power factor calculations included.	10
4	**Power Quality Mitigation Techniques:** Passive Filters, Shunt Active filters, Series Active Filters, Unified Power Quality Compensators.	06

5	**Distributed Generation and Power Quality:** DG Technologies, Interface to the Utility System, Power Quality Issues, Operating Conflicts, Interconnection Standards.	08
6	**Power Quality Monitoring:** Monitoring Considerations, Power Quality Measurement Equipment, Assessment of Power Quality Measurement Data, Application of Intelligent Systems, Power Quality Monitoring Standards.	06

Books Recommended:

Text Books:

1. Power System Quality Assessment, J.Arrillaga, N.R.Watson, S.Chen
2. Electric Power Systems and Quality, Roger C. Dugan, Mark F. McGranaghan, H.WayneBeaty
3. Power Quality Enhancement using Custom Devices, Arindam Gosh, Gerard Ledwich
4. Power Electronics, Ned Mohan, Undeland, Robbins, John Wiley Publication
5. Power System Analysis- Short Circuit Load Flow and Harmonics, J.C.Das.
6. Understanding Power Quality Problems, Voltage Sag and Interruptions, Math H.J.Bollen
7. Energy flow and power factor in non-sinusoidal circuits., W. Shepherd and P. Zand, ― ‖
8. Cambridge university press

Reference Books:

1. Power System Harmonics, Jos Arrillaga, Neville R Watson
2. Electric Power Quality, G.T.Heydt
3. IEEE-519 standard

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**
ILO7011	**Product Lifecycle Management (abbreviated as PLM)**	**3**	**-**	**3**	**-**	**3**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
ILO7011	Product Lifecycle Management	20	20	20	80	03	-	100

Course Objectives	• To familiarize the students with the need, benefits and components of PLM • To acquaint students with Product Data Management & PLM strategies • To give insights into new product development program and guidelines for designing and developing a product • To familiarize the students with Virtual Product Development
Course Outcomes	Student will be able to… • Gain knowledge about phases of PLM, PLM strategies and methodology for PLM feasibility study and PDM implementation. • Illustrate various approaches and techniques for designing and developing products. • Apply product engineering guidelines / thumb rules in designing products for moulding, machining, sheet metal working etc. • Acquire knowledge in applying virtual product development tools for components, machining and manufacturing plan

Module	Contents	Hours
1	**Introduction to Product Lifecycle Management (PLM):**Product Lifecycle Management (PLM), Need for PLM, Product Lifecycle Phases, Opportunities of Globalization, Pre-PLM Environment, PLM Paradigm, Importance & Benefits of PLM, Widespread Impact of PLM, Focus and Application, A PLM Project, Starting the PLM Initiative, PLM Applications **PLM Strategies:** Industrial strategies, Strategy elements, its identification, selection and implementation, Developing PLM Vision and PLM Strategy , Change management for PLM	12
2	**Product Design:** Product Design and Development Process, Engineering Design, Organization and Decomposition in Product Design, Typologies of Design Process Models, Reference Model, Product Design in the Context of the Product Development Process, Relation with the Development Process Planning Phase, Relation with the Post design Planning Phase, Methodological Evolution in Product Design, Concurrent Engineering, Characteristic Features of Concurrent	09

	Engineering, Concurrent Engineering and Life Cycle Approach, New Product Development (NPD) and Strategies, Product Configuration and Variant Management, The Design for X System, Objective Properties and Design for X Tools, Choice of Design for X Tools and Their Use in the Design Process	
3	**Product Data Management (PDM):**Product and Product Data, PDM systems and importance, Components of PDM, Reason for implementing a PDM system, financial justification of PDM, barriers to PDM implementation	06
4	**Virtual Product Development Tools:** For components, machines, and manufacturing plants, 3D CAD systems and realistic rendering techniques, Digital mock-up, Model building, Model analysis, Modeling and simulations in Product Design, Examples/Case studies	06
5	**Integration of Environmental Aspects in Product Design:** Sustainable Development, Design for Environment, Need for Life Cycle Environmental Strategies, Useful Life Extension Strategies, End-of-Life Strategies, Introduction of Environmental Strategies into the Design Process, Life Cycle Environmental Strategies and Considerations for Product Design	06
6	**Life Cycle Assessment and Life Cycle Cost Analysis:** Properties, and Framework of Life Cycle Assessment, Phases of LCA in ISO Standards, Fields of Application and Limitations of Life Cycle Assessment, Cost Analysis and the Life Cycle Approach, General Framework for LCCA, Evolution of Models for Product Life Cycle Cost Analysis	06

Books Recommended:

Reference Books:

1. John Stark, "Product Lifecycle Management: Paradigm for 21st Century Product Realisation", Springer-Verlag, 2004. ISBN: 1852338105
2. Fabio Giudice, Guido La Rosa, AntoninoRisitano, "Product Design for the environment-A life cycle approach", Taylor & Francis 2006, ISBN: 0849327229
3. SaaksvuoriAntti, ImmonenAnselmie, "Product Life Cycle Management", Springer, Dreamtech, ISBN: 3540257314
4. Michael Grieve, "Product Lifecycle Management: Driving the next generation of lean thinking", Tata McGraw Hill, 2006, ISBN: 0070636265

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**
ILO7012	**Reliability Engineering (abbreviated as RE)**	**3**	**-**	**3**	**-**	**3**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
ILO7012	Reliability Engineering	20	20	20	80	03	-	100

Course Objectives	• To familiarize the students with various aspects of probability theory • To acquaint the students with reliability and its concepts • To introduce the students to methods of estimating the system reliability of simple and complex systems • To understand the various aspects of Maintainability, Availability and FMEA procedure
Course Outcomes	Student will be able to… • Understand and apply the concept of Probability to engineering problems • Apply various reliability concepts to calculate different reliability parameters • Estimate the system reliability of simple and complex systems • Carry out a Failure Mode Effect and Criticality Analysis

Module	Contents	Hours
1	**Probability theory:** Probability: Standard definitions and concepts; Conditional Probability, Baye's Theorem. **Probability Distributions:** Central tendency and Dispersion; Binomial, Normal, Poisson, Weibull, Exponential, relations between them and their significance. **Measures of Dispersion:** Mean, Median, Mode, Range, Mean Deviation, Standard Deviation, Variance, Skewness and Kurtosis.	10
2	**Reliability Concepts:** Reliability definitions, Importance of Reliability, Quality Assurance and Reliability, Bath Tub Curve. **Failure Data Analysis:** Hazard rate, failure density, Failure Rate, Mean Time To Failure (MTTF), MTBF, Reliability Functions. **Reliability Hazard Models:** Constant Failure Rate, Linearly increasing, Time Dependent Failure Rate, Weibull Model. Distribution functions and reliability analysis.	10
3	**System Reliability** System Configurations: Series, parallel, mixed configuration, k out of n structure, Complex systems.	05
4	**Reliability Improvement** Redundancy Techniques: Element redundancy, Unit redundancy,	10

	Standby redundancies. Markov analysis. System Reliability Analysis – Enumeration method, Cut-set method, Success Path method, Decomposition method.	
5	**Maintainability and Availability** System downtime, Design for Maintainability: Maintenance requirements, Design methods: Fault Isolation and self-diagnostics, Parts standardization and Interchangeability, Modularization and Accessibility, Repair Vs Replacement. Availability – qualitative aspects.	05
6	**Failure Mode, Effects and Criticality Analysis:** Failure mode effects analysis, severity/criticality analysis, FMECA examples. Fault tree construction, basic symbols, development of functional reliability block diagram, Fau1t tree analysis and Event tree Analysis	05

Books Recommended:

Reference Books:

1. L.S. Srinath, "Reliability Engineering", Affiliated East-Wast Press (P) Ltd., 1985.
2. Charles E. Ebeling, "Reliability and Maintainability Engineering", Tata McGraw Hill.
3. B.S. Dhillion, C. Singh, "Engineering Reliability", John Wiley & Sons, 1980.
4. P.D.T. Conor, "Practical Reliability Engg.", John Wiley & Sons, 1985.
5. K.C. Kapur, L.R. Lamberson, "Reliability in Engineering Design", John Wiley & Sons.
6. Murray R. Spiegel, "Probability and Statistics", Tata McGraw-Hill Publishing Co. Ltd.

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**
ILO7013	**Management Information System (abbreviated as MIS)**	**3**	**-**	**3**	**-**	**3**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
ILO7013	Management Information System	20	20	20	80	03	-	100

Course Objectives	• The course is blend of Management and Technical field. • Discuss the roles played by information technology in today's business and define various technology architectures on which information systems are built • Define and analyze typical functional information systems and identify how they meet the needs of the firm to deliver efficiency and competitive advantage • Identify the basic steps in systems development • Define and analyze various MIS management responsibilities, including planning, budgeting, project management, and personnel management • Discuss critical ethical and social issues in information systems
Course Outcomes	Student will be able to… • Explain how information systems Transform Business • Identify the impact information systems have on an organization • Describe IT infrastructure and its components and its current trends • Understand the principal tools and technologies for accessing information from databases to improve business performance and decision making • Identify the types of systems used for enterprise-wide knowledge management and how they provide value for businesses

Module	Contents	Hours
1	Introduction To Information Systems (IS): Computer Based Information Systems, Impact of IT on organizations, Importance of IS to Society. Organizational Strategy, Competitive Advantages and IS.	7
2	Data and Knowledge Management: Database Approach, Big Data, Data warehouse and Data Marts, Knowledge Management. Business intelligence (BI): Managers and Decision Making, BI for Data analysis and Presenting Results	9

3	Ethical issues and Privacy: Information Security. Threat to IS, and Security Controls	6
4	Social Computing (SC): Web 2.0 and 3.0, SC in business-shopping, Marketing, Operational and Analytic CRM, E-business and E-commerce – B2B B2C. Mobile commerce.	7
5	Computer Networks Wired and Wireless technology, Pervasive computing, Cloud computing model.	6
6	Information System within Organization: Transaction Processing Systems, Functional Area Information System, ERP and ERP support of Business Process. Acquiring Information Systems and Applications: Various System development life cycle models.	10

Books Recommended:

Reference Books:

1. Management Information Systems: Kelly Rainer, Brad Prince by Wiley
2. Management Information Systems: Managing the Digital Firm (10th Edition). K.C. Laudon and J.P. Laudon, Prentice Hall, 2007.
3. Managing Information Systems: Strategy and Organization, D. Boddy, A. Boonstra, Prentice Hall, 2008

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**
ILO7014	**Design of Experiments (abbreviated as DoE)**	**3**	**-**	**3**	**-**	**3**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
ILO7014	Design of Experiments	20	20	20	80	03	-	100

Course Objectives	1. To understand the issues and principles of Design of Experiments (DOE). 2. To list the guidelines for designing experiments. **3.** To become familiar with methodologies that can be used in conjunction with experimental designs for robustness and optimization
Course Outcomes	Student will be able to… • Plan data collection, to turn data into information and to make decisions that lead to appropriate action. • Apply the methods taught to real life situations. • Plan, analyze, and interpret the results of experiments

Module	Contents	Hours
1	**Introduction:** Strategy of Experimentation, Typical Applications of Experimental Design, Guidelines for Designing Experiments, Response Surface Methodology.	6
2	**Fitting Regression Models:** Linear Regression Models, Estimation of the Parameters in Linear Regression Models, Hypothesis Testing in Multiple Regression, Confidence Intervals in Multiple Regression, Prediction of new response observation, Regression model diagnostics, Testing for lack of fit.	8
3	**Two-Level Factorial Designs:** The 2^2Design, The 2^3 Design, The General 2^k Design, A Single Replicate of the 2^kDesign, The Addition of Center Points to the 2^kDesign, Blocking in the 2^kFactorial Design, Split-Plot Designs.	7
4	**Two-Level Fractional Factorial Designs:** The One-Half Fraction of the 2^k Design, The One-Quarter Fraction of the 2^k Design, The General 2^{k-p} Fractional Factorial Design, Resolution III Designs, Resolution IV and V Designs, Fractional Factorial Split-Plot Designs.	7
5	**Conducting Tests:** Testing Logistics, Statistical aspects of conducting tests, Characteristics of good and bad data sets, Example experiments, Attribute Vs Variable data sets.	7
6	**Taguchi Approach:** Crossed Array Designs and Signal-to-Noise Ratios, Analysis Methods, Robust design examples.	4

Books Recommended:

Reference Books:

1. Raymond H. Mayers, Douglas C. Montgomery, Christine M. Anderson-Cook, Response Surface Methodology: Process and Product Optimization using Designed Experiment, 3rd edition, John Wiley & Sons, New York, 2001
2. D.C. Montgomery, Design and Analysis of Experiments, 5th edition, John Wiley & Sons, New York, 2001
3. George E P Box, J Stuart Hunter, William G Hunter, Statics for Experimenters: Design, Innovation and Discovery, 2nd Ed. Wiley
4. W J Dimond, Peactical Experiment Designs for Engineers and Scintists, John Wiley and Sons Inc. ISBN: 0-471-39054-2
5. Design and Analysis of Experiments (Springer text in Statistics), Springer by A.M. Dean, and D. T.Voss
6. Philip J Ross, "Taguchi Technique for Quality Engineering," McGraw Hill.
7. Madhav S Phadake, "Quality Engineering using Robust Design," Prentice Hall.

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**
ILO7015	**Operation Research (abbreviated as OR)**	**3**	**-**	**3**	**-**	**3**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
ILO7015	Operation Research	20	20	20	80	03	-	100

Course Objectives	• Formulate a real-world problem as a mathematical programming model. • Understand the mathematical tools that are needed to solve optimization problems. • Use mathematical software to solve the proposed models.
Course Outcomes	Student will be able to… • Understand the theoretical workings of the simplex method for linear programming and perform iterations of it by hand. • Understand the relationship between a linear program and its dual, including strong duality and complementary slackness. • Perform sensitivity analysis to determine the direction and magnitude of change of a model's optimal solution as the data change. • Solve specialized linear programming problems like the transportation and assignment problems. • Solve network models like the shortest path, minimum spanning tree, and maximum flow problems. • Understand the applications of, basic methods for, and challenges in integer programming • Model a dynamic system as a queuing model and compute important performance measures

Module	Contents	Hours
1	**Introduction to Operations Research***:* Introduction, Historical Background, Scope of Operations Research , Features of Operations Research, Phases of Operations Research, Types of Operations Research Models, Operations Research Methodology, Operations Research Techniques and Tools , Structure of the Mathematical Model, Limitations of Operations Research	2
2	**Linear Programming***:* Introduction, Linear Programming Problem, Requirements of LPP, Mathematical Formulation of LPP, Graphical method, *Simplex Method* Penalty Cost Method or Big M-method, Two Phase Method, Revised simplex method, ***Duality***, Primal – Dual construction, Symmetric and Asymmetric Dual, Weak Duality Theorem, Complimentary Slackness Theorem, Main Duality Theorem, Dual Simplex Method, Sensitivity Analysis	6
3	**Transportation Problem***:* Formulation, solution, unbalanced	6

	Transportation problem. Finding basic feasible solutions – Northwest corner rule, least cost method and Vogel's approximation method. Optimality test: the stepping stone method and MODI method. **Assignment Problem***:* Introduction, Mathematical Formulation of the Problem, Hungarian Method Algorithm, Processing of n Jobs Through Two Machines and m Machines, Graphical Method of Two Jobs m Machines Problem Routing Problem, Travelling Salesman Problem	
4	**Integer Programming Problem***:* Introduction, Types of Integer Programming Problems, Gomory's cutting plane Algorithm, Branch and Bound Technique. Introduction to Decomposition algorithms.	6
5	**Queuing models**: queuing systems and structures, single server and multi-server models, Poisson input, exponential service, constant rate service, finite and infinite population	6
6	**Simulation***:* Introduction, Methodology of Simulation, Basic Concepts, Simulation Procedure, Application of Simulation *Monte-Carlo Method:* Introduction, Monte-Carlo Simulation, Applications of Simulation, Advantages of Simulation, Limitations of Simulation	4
7	**Dynamic programming**. Characteristics of dynamic programming. Dynamic programming approach for Priority Management employment smoothening, capital budgeting, Stage Coach/Shortest Path, cargo loading and Reliability problems.	4
8	**Games Theory**. Competitive games, rectangular game, saddle point, minimax (maximin) method of optimal strategies, value of the game. Solution of games with saddle points, dominance principle. Rectangular games without saddle point – mixed strategy for 2 X 2 games.	4
9	**Inventory Models**: Classical EOQ Models, EOQ Model with Price Breaks, EOQ with Shortage, Probabilistic EOQ Model,	4

Books Recommended:

Reference Books:

1. Taha, H.A. "Operations Research - An Introduction", Prentice Hall, (7th Edition), 2002.
2. Ravindran, A, Phillips, D. T and Solberg, J. J. "Operations Research: Principles and Practice", John Willey and Sons, 2nd Edition, 2009.
3. Hiller, F. S. and Liebermann, G. J. "Introduction to Operations Research", Tata McGraw Hill, 2002.
4. Operations Research, S. D. Sharma, KedarNath Ram Nath-Meerut.
5. Operations Research, KantiSwarup, P. K. Gupta and Man Mohan, Sultan Chand & Sons.

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**
ILO7016	**Cyber Security and Laws (abbreviated as CSL)**	**3**	**-**	**3**	**-**	**3**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
ILO7016	Cyber Security and Laws	20	20	20	80	03	-	100

Course Objectives	• To understand and identify different types cyber crime and cyber law • To recognized Indian IT Act 2008 and its latest amendments • To learn various types of security standards compliances
Course Outcomes	Student will be able to… • Understand the concept of cyber crime and its effect on outside world • Interpret and apply IT law in various legal issues • Distinguish different aspects of cyber law • Apply Information Security Standards compliance during software design and development

Module	Contents	Hours
1	**Introduction to Cybercrime:** Cybercrime definition and origins of the world, Cybercrime and information security, Classifications of cybercrime, Cybercrime and the Indian ITA 2000, A global Perspective on cybercrimes.	4
2	**Cyber offenses & Cybercrime:** How criminal plan the attacks, Social Engg, Cyber stalking, Cybercafé and Cybercrimes, Botnets, Attack vector, Cloud computing, Proliferation of Mobile and Wireless Devices, Trends in Mobility, Credit Card Frauds in Mobile and Wireless Computing Era, Security Challenges Posed by Mobile Devices, Registry Settings for Mobile Devices, Authentication Service Security, Attacks on Mobile/Cell Phones, Mobile Devices: Security Implications for Organizations, Organizational Measures for Handling Mobile, Devices-Related Security Issues, Organizational Security Policies and Measures in Mobile Computing Era, Laptops	10
3	**Tools and Methods Used in Cyberline:** Phishing, Password Cracking, Keyloggers and Spywares, Virus and Worms, Steganography, DoS and DDoS Attacks, SQL Injection, Buffer Over Flow, Attacks on Wireless Networks, Phishing, Identity Theft (ID Theft)	6
4	**The Concept of Cyberspace:** E-Commerce , The Contract Aspects in Cyber Law ,The Security Aspect of Cyber Law ,The Intellectual Property Aspect in Cyber Law, The Evidence Aspect in Cyber Law , The Criminal Aspect in Cyber Law, Global Trends in Cyber Law , Legal Framework for Electronic Data Interchange Law Relating to	8

	Electronic Banking , The Need for an Indian Cyber Law	
5	**Indian IT Act.:** Cyber Crime and Criminal Justice : Penalties, Adjudication and Appeals Under the IT Act, 2000,IT Act. 2008 and its Amendments	8
6	**Information Security Standard compliances** SOX, GLBA, HIPAA, ISO, FISMA, NERC, PCI.	6

Books Recommended:

Reference Books:

1. Nina Godbole, Sunit Belapure, *Cyber Security*, Wiley India, New Delhi
2. The Indian Cyber Law by Suresh T. Vishwanathan; Bharat Law House New Delhi
3. The Information technology Act, 2000; Bare Act- Professional Book Publishers, New Delhi.
4. Cyber Law & Cyber Crimes By Advocate Prashant Mali; Snow White Publications, Mumbai
5. Nina Godbole, *Information Systems Security*, Wiley India, New Delhi
6. Kennetch J. Knapp, *Cyber Security &Global Information Assurance* Information Science Publishing.
7. William Stallings, *Cryptography and Network Security*, Pearson Publication
8. Websites for more information is available on : The Information Technology ACT, 2008- TIFR : https://www.tifrh.res.in
9. Website for more information , A Compliance Primer for IT professional : https://www.sans.org/reading-room/whitepapers/compliance/compliance-primer-professionals-33538

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**
ILO7017	**Disaster Management and Mitigation Measures (abbreviated as DMMM)**	**3**	**-**	**3**	**-**	**3**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
ILO7017	Disaster Management and Mitigation Measures	20	20	20	80	03	-	100

Course Objectives	• To understand the various types of disaster occurring around the world • To identify extent and damaging capacity of a disaster • To study and understand the means of losses and methods to overcome /minimize it. • To understand role of individual and various organization during and after disaster • To know warning systems, their implementation and based on this to initiate training to a laymen • To understand application of GIS in the field of disaster management • To understand the emergency government response structures before, during and after disaster
Course Outcomes	Student will be able to… • Understand natural as well as manmade disaster and their extent and possible effects on the economy. • Planning of national importance structures based upon the previous history. • Understand government policies, acts and various organizational structure associated with an emergency. • Know the simple do's and don'ts in such extreme events and act accordingly

Module	Contents	Hours
1	Introduction: Definition of Disaster, hazard, global and Indian scenario, general perspective, importance of study in human life, Direct and indirect effects of disasters, long term effects of disasters. Introduction to global warming and climate change.	03
2	Natural Disaster and Manmade disasters: Natural Disaster: Meaning and nature of natural disaster, Flood, Flash flood, drought, cloud burst, Earthquake, Landslides, Avalanches, Volcanic eruptions, Mudflow, Cyclone, Storm, Storm Surge, climate change, global warming, sea level rise, ozone depletion . Manmade Disasters: Chemical, Industrial,	06

	Nuclear and Fire Hazards. Role of growing population and subsequent industrialization, urbanization and changing lifestyle of human beings in frequent occurrences of manmade disasters.	
3	Disaster Management, Policy and Administration: Disaster management: meaning, concept, importance, objective of disaster management policy, disaster risks in India, Paradigm shift in disaster management. Policy and administration: Importance and principles of disaster management policies, command and co-ordination of in disaster management, rescue operations-how to start with and how to proceed in due course of time, study of flowchart showing the entire process.	06
4	Institutional Framework for Disaster Management in India: Importance of public awareness, Preparation and execution of emergency management programme. Scope and responsibilities of National Institute of Disaster Management (NIDM) and National disaster management authority (NDMA) in India. Methods and measures to avoid disasters, Management of casualties, set up of emergency facilities, importance of effective communication amongst different agencies in such situations. Use of Internet and softwares for effective disaster management. Applications of GIS, Remote sensing and GPS in this regard.	06
5	Financing Relief Measures: Ways to raise finance for relief expenditure, Role of government agencies and NGO's in this process, Legal aspects related to finance raising as well as overall management of disasters. Various NGO's and the works they have carried out in the past on the occurrence of various disasters, Ways to approach these teams. International relief aid agencies and their role in extreme events.	09
6	Preventive and Mitigation Measures: Pre-disaster, during disaster and post-disaster measures in some events in general, Structural mapping: Risk mapping, assessment and analysis, sea walls and embankments, Bio shield, shelters, early warning and communication. Non Structural Mitigation: Community based disaster preparedness, risk transfer and risk financing, capacity development and training, awareness and education, contingency plans. Do's and don'ts in case of disasters and effective implementation of relief aids.	06

Books Recommended:

Reference Books:

1. 'Disaster Management' by Harsh K.Gupta, Universities Press Publications.
2. 'Disaster Management: An Appraisal of Institutional Mechanisms in India' by O.S.Dagur, published by Centre for land warfare studies, New Delhi, 2011.
3. 'Introduction to International Disaster Management' by Damon Copolla, Butterworth Heinemann Elseveir Publications.
4. 'Disaster Management Handbook' by Jack Pinkowski, CRC Press Taylor and Francis group.
5. 'Disaster management & rehabilitation' by Rajdeep Dasgupta, Mittal Publications, New Delhi.
6. 'Natural Hazards and Disaster Management, Vulnerability and Mitigation – R B Singh, Rawat Publications
7. Concepts and Techniques of GIS –C.P. Lo Albert, K.W. Yonng – Prentice Hall (India) Publications.

(Learners are expected to refer reports published at national and International level and updated information available on authentic web sites)

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**
ILO7018	**Energy Audit and Management (abbreviated as EAM)**	**3**	**-**	**3**	**-**	**3**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
ILO7018	Energy Audit and Management	20	20	20	80	03	-	100

Course Objectives	• To understand the importance of energy security for sustainable development and the fundamentals of energy conservation. • To introduce performance evaluation criteria of various electrical and thermal installations to facilitate the energy management • To relate the data collected during performance evaluation of systems for identification of energy saving opportunities
Course Outcomes	Student will be able to… • To identify and describe present state of energy security and its importance. • To identify and describe the basic principles and methodologies adopted in energy audit of an utility. • To describe the energy performance evaluation of some common electrical installations and identify the energy saving opportunities. • To describe the energy performance evaluation of some common thermal installations and identify the energy saving opportunities • To analyze the data collected during performance evaluation and recommend energy saving measures

Module	Contents	Hours
1	**Energy Scenario:** Present Energy Scenario, Energy Pricing, Energy Sector Reforms, Energy Security, Energy Conservation and its Importance, Energy Conservation Act-2001 and its Features. Basics of Energy and its various forms, Material and Energy balance	4
2	**Energy Audit Principles:** Definition, Energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution. Elements of monitoring& targeting; Energy audit Instruments; Data and information-analysis. Financial analysis techniques: Simple payback period, NPV, Return on investment (ROI), Internal rate of return (IRR)	8
3	**Energy Management and Energy Conservation in Electrical System:** Electricity billing, Electrical load management and maximum	10

	demand Control; Power factor improvement, Energy efficient equipments and appliances, star ratings. **Energy efficiency measures in lighting system, Lighting control:** Occupancy sensors, daylight integration, and use of intelligent controllers. Energy conservation opportunities in: water pumps, industrial drives, induction motors, motor retrofitting, soft starters, variable speed drives.	
4	**Energy Management and Energy Conservation in Thermal Systems:** Review of different thermal loads; Energy conservation opportunities in: Steam distribution system, Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system. General fuel economy measures in Boilers and furnaces, Waste heat recovery use of insulation- types and application. HVAC system: Coefficient of performance, Capacity, factors affecting Refrigeration and Air Conditioning system performance and savings opportunities	10
5	**Energy Performance Assessment:** On site Performance evaluation techniques, Case studies based on: Motors and variable speed drive, pumps, HVAC system calculations; Lighting System: Installed Load Efficacy Ratio (ILER) method, Financial Analysis.	4
6	**Energy conservation in Buildings:** Energy Conservation Building Codes (ECBC): Green Building, LEED rating, Application of Non-Conventional and Renewable Energy Sources	3

Books Recommended:

Reference Books:

1. Handbook of Electrical Installation Practice, Geofry Stokes, Blackwell Science
2. Designing with light: Lighting Handbook, By Anil Valia, Lighting System
3. Energy Management Handbook, By W.C. Turner, John Wiley and Sons
4. Handbook on Energy Audits and Management, edited by A. K. Tyagi, Tata Energy Research Institute (TERI).
5. Energy Management Principles, C.B.Smith, Pergamon Press
6. Energy Conservation Guidebook, Dale R. Patrick, S. Fardo, Ray E. Richardson, Fairmont Press
7. Handbook of Energy Audits, Albert Thumann, W. J. Younger, T. Niehus, CRC Press
8. www.energymanagertraining.com
9. www.bee-india.nic.in

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**
ILO7019	**Development Engineering (abbreviated as DE)**	**3**	**-**	**3**	**-**	**3**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
ILO7019	**Development Engineering**	20	20	20	80	03	-	100

Course Objectives	• To understand the characteristics of rural Society and the Scope, Nature and Constraints of rural • To study Implications of 73rd CAA on Planning, Development and Governance of Rural Areas • An exploration of human values, which go into making a 'good' human being, a 'good' professional, a 'good' society and a 'good life' in the context of work life and the personal life of modern Indian professionals • To understand the Nature and Type of Human Values relevant to Planning Institutions
Course Outcomes	Student will be able to… • Apply knowledge for Rural Development • Apply knowledge for Management Issues. • Apply knowledge for Initiatives and Strategies. • Develop acumen for higher education and research. • Master the art of working in group of different nature. • Develop confidence to take up rural project activities independently.

Module	Contents	Hours
1	Introduction to Rural Development Meaning, nature and scope of development; Nature of rural society in India; Hierarchy of settlements; Social, economic and ecological constraints for rural development. Roots of Rural Development in India Rural reconstruction and Sarvodaya programme before independence; Impact of voluntary effort and Sarvodaya Movement on rural development; Constitutional direction, directive principles; Panchayati Raj - beginning of planning and community development; National extension services.	08
2	Post-Independence rural Development Balwant Rai Mehta Committee - three tier system of rural local. Government; Need and scope for people's participation and Panchayati Raj; Ashok Mehta Committee - linkage between Panchayati Raj, participation and rural development.	04
3	Rural Development Initiatives in Five Year Plans Five Year Plans and Rural Development; Planning process at National, State, Regional and District levels; Planning, development, implementing and monitoring	06

	organizations and agencies; Urban and rural interface - integrated approach and local plans; Development initiatives and their convergence; Special component plan and sub-plan for the weaker section; Micro-eco zones; Data base for local planning; Need for decentralized planning; Sustainable rural development.	
4	Post 73rd Amendment Scenario 73rd Constitution Amendment Act, including - XI schedule, devolution of powers, functions and finance; Panchayati Raj institutions - organizational linkages; Recent changes in rural local planning; Gram Sabha - revitalized Panchayati Raj; Institutionalization; resource mapping, resource mobilization including social mobilization; Information Technology and rural planning; Need for further amendments.	04
5	Values and Science and Technology Material development and its values; the challenge of science and technology; Values in planning profession, research and education. Types of Values Psychological values — integrated personality; mental health; Societal values — the modern search for a good society; justice, democracy, rule of law, values in the Indian constitution; Aesthetic values — perception and enjoyment of beauty; Moral and ethical values; nature of moral judgment; Spiritual values; different concepts; secular spirituality; Relative and absolute values; Human values— humanism and human values; human rights; human values as freedom, creativity, love and wisdom.	10
6	Ethics Canons of ethics; ethics of virtue; ethics of duty; ethics of responsibility; Work ethics; Professional ethics; Ethics in planning profession, research and education	04

Books Recommended:

Reference Books:

1. ITPI, Village Planning and Rural Development, ITPI, New Delhi
2. Thooyavan, K.R. Human Settlements: A 2005 MA Publication, Chennai
3. GoI, Constitution (73rd GoI, New Delhi Amendment) Act, GoI, New Delhi
4. Planning Commission, Five Year Plans, Planning Commission
5. Planning Commission, Manual of Integrated District Planning, 2006, Planning Commission
New Delhi
6. Planning Guide to Beginners
7. Weaver, R.C., The Urban Complex, Doubleday.
8. Farmer, W.P. et al, Ethics in Planning, American Planning Association, Washington.
9. How, E., Normative Ethics in Planning, Journal of Planning Literature, Vol.5, No.2, pp. 123-150.
10. Watson, V. , Conflicting Rationalities: -- Implications for Planning Theory and Ethics, Planning Theory and
Practice, Vol. 4, No.4, pp.395 – 407

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	**Practical**	**Theory**	**Practical**	**Total**
EEL701	**Simulation Lab -III (abbreviated as Sim. 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.					
EEL701	Simulation Lab-III	-	-	-	-	25		25	50

Course Objectives	• To impart knowledge on coding and simulation of electrical systems.
Course Outcomes	Students will be able • To code or simulate HVDCT systems for its analysis. • To code or simulate power system for its analysis. • To code or simulate electrical drives for its analysis.

Syllabus: Same as that of Courses of semester VII

Suggested List of Laboratory Experiment:

1. (A) Simulation of full wave bridge rectifier.
(i) with R-load, R=20Ω ,at α = (90 – Roll No.)
(ii) with R-L-load, R=20 Ω , L=100mH, at α=(90 – Roll No.)
(B) Harmonic analysis of ac and dc side voltage and current of full wave bridge rectifier.
(i) with R-load, R=20 Ω ,at α=(90 – Roll No.)
(ii) with R-L-load, R=20 Ω , L=100mH, at α=(90 – Roll No.)
2. (A) Simulation of full wave bridge rectifier with source inductance (Ls=10mH).
(a) with R-load, R=20 Ω ,at α=(90 + Roll No.)
(b) with R-L-load, R=20 Ω , L=100mH, at α=(90 + Roll No.)
(B) Harmonic analysis of ac and dc side voltage and current of full wave bridge rectifier with source inductance (Ls = 10mH).
(a) with R-load, R=20 Ω ,at α=(90 + Roll No.)
(b) with R-L-load, R=20 Ω, L=100mH, at α=(90 + Roll No.)
3. Simulation of 6-pulse converter in rectifier mode.
(a) with R-load, R=20 Ω ,at α=(90 - Roll No.)
(b) with R-L-load, R=20 Ω , L=100mH, at α=(90 - Roll No.)
4. Harmonic analysis of ac and dc side voltage and current of 6-pulse converter in rectifier mode.
(a) with R-load, R=20 Ω,at α=(90 - Roll No.)
(b) with R-L-load, R=20 Ω , L=100mH, at α=(90 - Roll No.)
5. Simulation of 6-pulse converter in inverter mode.
(a) with R-load, R=20 Ω,at α=1100 & α=1600

(b) with R-L-load, R=20 Ω , L=100mH, at α=1100 & α=1600
6. Harmonic analysis of ac and dc side voltage and current of 6-pulse converter in inverter mode.
(a) with R-load, R=20 Ω,at α=1100 & α=1600
(b) with R-L-load, R=20 Ω , L=100mH, at α=1100 & α=1600
7. Simulation of 12-pulse converter in inverter mode.
(a) with R-load, R=20 Ω ,at α= 00
(b) with R-L-load, R=20 Ω , L=100mH, at α=00
8. Harmonic analysis of ac and dc side voltage and current of 12-pulse converter in inverter mode.
(a) with R-load, R=20 Ω ,at α=00
(b) with R-L-load, R=20 Ω , L=100mH, at α=00
9. Simulation of 3-phase SPWM inverter and its harmonic analysis.
10. Simulation of Homopolar / Bipolar HVDC link.
11. Simulation of Misfire is 6-pulse converter.
12. Simulation of 'Symmetrical pulse control'.
13. Simulation of IGBT based converters.
14. Simulation of Single commutation failure.
15. Simulation of Double commutation failure.
16. Simulation of Individual phase control.
17. Simulation of Equidistant pulse control.
18. Load flow analysis of power system
19. Optimum generation scheduling
20. Braking of dc machines
21. Braking of ac machines

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

Term work:

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

Simulation Performance	:10 marks
Journal	:10 marks
Attendance (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**
EEL702	**Drives and Control Lab (abbreviated as D&C 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.					
EEL702	Drive and Control Lab	-	-	-	-	25	25	-	50

Course Objectives	• To impart knowledge on electrical drives and its control.
Course Outcomes	Students will be able • To analyse the dynamic performance of electrical ac and dc drives. • To analyse the dynamics of braking of electrical ac and dc motors.

Syllabus: Same as that of Course Drives and Control (EEC702)

Suggested List of Laboratory Experiment:

1. Measurement of Moment of Inertia by Retardation test
2. Study of different Speed Sensing, Current Sensing and Voltage Sensing devices or practical closed loop controlled drive.
3. Single phase fully-controlled rectifier fed DC drive/Single phase half controlled rectifier fed DC drive / Three phase fully-controlled rectifier fed DC drive/ Three phase half controlled rectifier fed DC drive/Dual Converter controlled fed DC drive. (Simulation/ Hardware)
4. Chopper Controlled DC drive. (Simulation/ Hardware)
5. Closed loop Control of DC drive.
6. Simulation of Starting of DC motor (Conventional resistance start and any one Soft start scheme)
7. Dynamic braking, Plugging of DC motor.
8. Plugging of three phase Induction Motor.
9. V control and V/f control of Induction motor using PWM Inverter.
10. Hands on Experience in Programming a general purpose three phase Induction Motor Industrial Drive.
11. Demonstration of Vector Control of three phase Induction Motor (Simulation).
12. Demonstration of DTC, FOC of three phase Induction Motor (Simulation).

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.

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	**Tutorial**	**Theory**	**Tutorial**	**Total**
EEC801	**Design, Management and Auditing of Electrical System (abbreviated as DMAES)**	**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.				
EEC801	Design, Management and Auditing of Electrical System	20	20	20	80	03	25	125

Course Objectives	• To give the students basic knowledge of designing electrical distribution network • To give the students basic knowledge of electrical energy audit in the distribution system
Course Outcomes	Students will be able • To do sizing, selecting transformer, switchgear and cable as required for distribution system • To illustrate Engineering knowledge in energy audit and energy efficient technologies to improve energy efficiency

Module	Contents	Hours
1	**Introduction** Types of electrical Projects, Types of electrical system, review of components of electrical system, different plans/ drawings in electrical system design, single line diagram in detail, Tendering, Estimation	5
2	**Design of Power Distribution System** Different types of distribution systems and selection criteria, Electrical Earthing, Electrical load size, L.F, D.F, future estimates, substation equipment options, design considerations in transformer selection, sizing and specifications, IS standards applicable in above design	7
3	**Design of Switchgear Protection and Auxiliary system** Selection of HT/LT switchgears, metering, switchboards and MCC, protection systems, coordination and discrimination. Cables selection and sizing, cable installation and management systems, bus bars design; Basics of selection of emergency/backup supplies, UPS, DG Set, Batteries; Preliminary design of interior lighting system. IS standards applicable in above designs	10
4	**Energy Monitoring and Targeting:** Defining monitoring and targeting. Elements of monitoring and	7

	Targeting. Analysis techniques for energy optimization, Cumulative Sum of Differences (CUSUM), Electricity billing. **Energy Management of Electrical Systems:** Electrical load management and maximum demand control, Power factor improvement and its benefit, selection and location of capacitors, distribution and transformer losses.	
5	**Energy Audit:** Introduction to Energy Conservation Act 2001 . Energy Audit: Definition,-need, Types of energy audit, Energy Management (audit) approach understanding energy costs, Bench marking, Maximizing system efficiencies, optimizing input energy requirement, fuel and energy substitution. Energy Audit instruments. **Electrical Energy Performance Assessment**: Motors And Variable Speed Drives, Lighting Systems. Basics of HVAC system assessment for electrical energy usage.	10
6	**Energy Efficient Technologies**: Energy efficient BLDC Fans, Smart lighting system for indoor and outdoor applications, Maximum Demand controllers, Automatic Power Factor Controllers, Energy Efficient Motors, Soft starters, Variable Speed Drives, Energy Efficient Transformer. Energy saving potential of each technology. Use of Energy Management system (EMS) and Building Management System (BMS).	9

Books Recommended:

Text Books:

1. “Handbook of Electrical Installation Practice” Fourth Edition, by Geofry Stokes, Blackwell Science
2. “Energy-Efficient Electric Motor”, Third Edition, By Ali Emadi, New Marcel Dekker, Inc., 2005.
3. “Electrical Energy Efficiency: Technologies And Applications” by Andreas Sumper and Angelo Baggini, John Wiley & Sons, Ltd., 2012
4. “Electrical Calculations and Guidelines for Generating Stations and Industrial Plants” by Thomas E. Baker, CRC Publications, 2012
5. “Electrical Installations Handbook” , Third Edition, by Gunter Seip, MCD Verilag, 2000
6. “Electrical Installation Designs”, Fourth Edition by Bill Atkinson, Roger Lovegrove and Gary Gundry, John Wiley & Sons, Ltd, 2013.
7. “Handbook of International Electrical Safety Practices”, by Princeton Energy Resources International, Scrivener Publishing, 2010.
8. “Designing with Light: Lighting Handbook”, by Anil Valia, Lighting System
9. “Energy Management Handbook”, by W.C. Turner, John Wiley and sons
10. “Handbook on Energy Audits and Management”, by Amit Kumar Tyagi, TERI
11. “Introduction to Efficient Electrical System Design” , by Stephen Ayraud and Albert Thumann, The Fairmount Press

Reference Books:

“Energy Auditing Made Simple”, by P. Balasubramanian, Seperation Engineers (P) Ltd

2. “Electrical Installation Calculations: for Compliance with BS 7671:200”, Fourth Edition, by Mark Coates, Brian Jenkins, John Wiley & Sons, Ltd, 2010
3. “Energy Management Principles”, by C.B.Smith, Peragamon Press
4. “Energy Conservation Guidebook”, by Dale R.Patrick, Stephon Fadro, E. Richardson, Fairmont Press
5. “Handbook of Energy Audits”, by Albert Thumann, William J. Younger, Terry Niehus, CRC Press

Websites:

www.energymanagertraining.com
www.bee-india.nic.in

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**
EEC802	**Flexible AC Transmission System (abbreviated as FACTS)**	**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.				
EEC802	Flexible AC Transmission System	20	20	20	80	03	-	100

Course Objectives	• To understand the concept of Flexible AC Transmission System • To introduce the operation of various FACTS controllers.
Course Outcomes	Student will be able to • Illustrate the aspects of flexible ac transmission system over conventional ac transmission system • Analyze the concept of load compensation. • Categorize the static shunt and series compensation for transmission line. • Outline the concept of voltage and phase angle regulators. • Understand unified power flow controllers using circuit diagram and phasors.

Module	Contents	Hours
1	**FACTS Concepts and General System Considerations**: Transmission Interconnections, Flow of Power in AC system, What Limits the Loading Capability, Power Flow and Dynamic Stability Considerations of a Transmission Interconnection, Relative Importance of controllable Parameters, Basic Types of FACTS Controllers, Brief Description and Definitions, Benefits from FACTS Technology	08
2	**Load Compensation**: Objectives in load compensation, ideal compensator, Practical considerations, Power factor correction and Voltage Regulation in single phase systems, Approximate reactive power characteristics with example, Load compensator as a voltage regulator, Phase balancing and power factor correction of unsymmetrical loads	12
3	**Static shunt compensators:** Objectives of shunt compensation, Methods of controllable VAR generation, Variable impedance type static Var generator (TCR,TSR,TSC,FC-TCR), Switching converter type Var generators, basic operating principle	10
4	**Static series compensation**: Objectives of series compensation-Variable impedance type series compensation (only GCSC, TSSC and TCSC), Switching converter type series compensation (only SSSC)	08

5	**Static voltage and phase angle regulators-** Objectives of voltage and phase angle regulators- TCVR and TCPAR, Switching converter based voltage and phase angle regulators	06
6	**Unified Power Flow Controller (UPFC):** Basic operating principle, Conventional transmission control capabilities	04

Books Recommended:

Text Books:

1. 'Hingorani N.G.. & Gyugi L., "Understanding FACTS : Concepts and Technology of Flexible AC Transmission Systems," Wiley-1EEE Press

2. Timothy J. E. Miller "Reactive power control in Electric Systems," Wiley India Edition.

Reference Books:

1. Yong Hua Song "Flexible AC transmission system" Institution of Electrical Engineers, London

2. Arindam Ghosh and Gerard Ledwich, " Power Quality Enhancement Using Custom Power Devices," Kluwer Academic Publishers

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**
EEDLO 8041	**Illumination Engineering (abbreviated as IE)**	**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 8041	Illumination Engineering	20	20	20	80	03	25	125

Course Objectives	• To introduce various laws of illumination, lighting parameters, light sources, luminaries and their characteristics to be used for lighting design. • To introduce lighting design considerations for interior and exterior applications. • To adapt to the LED based solid state lighting with different lighting control technologies and standards.
Course Outcomes	Student will be able to • Identify and describe the various laws of illumination, lighting parameters, light sources, luminaries and their Photometric characteristics. • Identify and describe various LED lighting components / subsystems, thermal management and lifetime studies. • Formulate and design an Interior Lighting system through standards, design considerations and calculation for different application areas. • Formulate and design an Exterior Lighting system through standards, design considerations and calculation for different application areas. • Identify and describe different Lighting Control schemes. • Identify and describe Solid-State Lighting technology, it's applications in Lighting for health and safety and solar powered schemes.

Module	Contents	Hours
1	**Introduction:** Review of Light, Color and Photometry: Laws of illumination, illumination entities. Radiometric and photometric standards, Photometric measurement procedure- assessment of lamp efficacy, Color temperature, Colorimetry- Measurement of CRI, Glare	03
2	**Lamps and Luminaries:** Lamp: Review of development, construction and characteristics: Incandescent lamp, Discharge lamps, induction lamp, and LED lamp; LED Lighting Components and Subsystems, OLEDs, light-emitting polymers (LEPs) Thermal Management and Lifetime Studies; Luminaire: optical control, Control gear: ballast, standard and electronic, Luminaries photometry, Luminaire testing procedures	8

3	**Interior Lighting Design & Calculation:** Objectives, quality and quantity of lighting. Lamp /Luminaire selection and placement, design considerations and calculation. Glare Consideration and control. Indoor lighting design by lumen method, by point by point method. Applications: residential, educational institute, industries, sports centers, commercial premises: retail stores, offices etc. Applicable standards.	06
4	**Exterior Lighting Design & Calculation:** Exterior lighting system- Road lighting system, Utility area lighting, Sports lighting, Decorative flood lighting. Applicable standards	04
5	**Lighting Control:** Introduction to Lighting Control, Controls, Selection of Lighting Controls, Design of Lighting Control Scheme, Lighting and LEED, Day-lighting control, Controlling LED Lighting Systems, Smart Lighting Fixtures, Digital Lighting Networks, DMX control. BACnet: Building Automation Standard Protocol.	03
6	**Solid-State Lighting:** Drivers for LED lamps, standards and regulations, LED luminaries, LED Light Distributions, Indoor Lighting Applications Smart Street Lighting with Remote Monitoring and Control System, Solar Powered LED Lighting, Tunable White Lighting and RGB LED based Colored Lighting. Lighting for health and safety, Circadian Rhythm and Human Centric Lighting.	12

Books Recommended:

Text Books:

1. Anil Valia, "Designing With Light – A Lighting Handbook" International Lighting Academy
2. M. Nisa Khan "Understanding LED Illumination," CRC Press 2013
3. Anil Valia, "LED LIGHTING SYSTEMS All you need to know," International Lighting Academy
4. National Lighting Code- 2011
5. Kao Chen , "Energy Management in Illumination Systems," CRC Press.
6. John L. Fetters , "The Hand Book of Lighting Surveys and Audits ," CRC Press.

Reference Books:

1. Illuminating Engineering Society, "The IES Lighting Handbook", 10th Edition
2. J. L. Lindsey and S. C. Dunning, "Applied Illumination Engineering," ThirdEdition, Fairmont Press, 2016
3. Lamps and Lighting – Edited by J.R.Coaton and A.M.Marsden, 4th Edition
4. Lighting for health and safety – N.A.Smith, Butterworth-Heimann.
5. Human Factors in Lighting – Peter R. Boyce, Taylor & Francis.

Website Reference:

1. http://nptel.iitm.ac.in: 'Illumination Engineering' web-course

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 8042	**Smart Grid (abbreviated as SG)**	**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 8042	Smart Grid	20	20	20	80	03	25	125

Course Objectives	• To impart knowledge of futuristic power grid technology and the path on which development is taking place. • To elaborate the fundamentals of various technologies and tools which will play vital role in formation of the Smart grids in near future.
Course Outcomes	Students will be able • To identify and describe the history and evolvement Smart Grid, its features /functions and Barriers • To classify and describe the principles of various Smart Grid enabling Technologies. • To evaluate and compare applications of Smart Measurement and Monitoring Technologies. • To identify and describe the role Microgrids and Distributed Energy Resources in evolvement of Smartgrid • To Identify and describe the importance of various communication technology used for Smart Grid. • To assess the Power Quality issues and its Management in Smart Grid..

Module	Contents	Hours
1	**Introduction to Smart Grid:** Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Functions of Smart Grid, Opportunities & Barriers of Smart Grid, Difference between conventional grid & smart grid, Concept of Resilient & Self Healing Grid. Present development & International policies in Smart Grid. Case studies of Smart Grid. CDM opportunities in Smart Grid.	05
2	**Smart Grid enabling Technologies:** Introduction to Smart Meters, Real Time Prizing, Smart Appliances, Automatic Meter Reading(AMR), Outage Management System (OMS), Plug in Hybrid Electric Vehicle (PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation.	08
3	**Smart Measurement and Monitoring Technologies:** Smart Substations, Substation Automation, Feeder Automation. Geographic Information System (GIS), Intelligent Electronic Devices (IED) & their application for monitoring & protection, Wide Area	05

	Measurement System(WAMS), Phase Measurement Unit(PMU).	
4	**Microgrids and Distributed Energy Resources:** Concept of microgrid, need & applications of microgrid, formation of microgrid, Issues of interconnection, protection & control of microgrid. Review of fundamentals and Integration of renewable energy sources. Storage like Battery, Pumped Hydro. Microgrid and Smart grid comparison.	08
5	**Power Quality Management in Smart Grid:** Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring.	05
6	**Communication Technology for Smart Grid:** Home Area Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN). ZigBee, GPS; Wireless Mesh Network, Basics of CLOUD Computing & Cyber Security for Smart Grid.	05

Books Recommended:

Text Books:

1. James Momoh, "Smart Grid:Fundamentals of Design and Analysis," IEEE Press and Wiley Publications, 2015
2. Ali Keyhani, Mohammad N. Marwali, Min Dai "Integration of Green and Renewable Energy in Electric Power Systems", Wiley
3. Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response" CRC Press
4. J. C. Sabonnadière, N. Hadjsaïd, "Smart Grids", Wiley Blackwell
5. L.T.Berger and K. Iniewski, "Smart Grid Applications, Communications and Security," Wiley Publications , 2015

Reference Books:

1. K. Liyanage, Jianzhong Wu, A. Yokoyama, Nick Jenkins J.Ekanayake, " Smart Grid: Technology and Applications," Wiley Publications , 2015
2. Stuart Borlase, "Smart Grids: Infrastructure, Technology, and Solutions," CRC Press, 2012
3. Yang Xiao, "Communication and Networking in Smart Grids," CRC Press, 2012
4. H. T. Mouftah, and M. Erol-Kantarci, "Smart Grid: Networking, Data Management, and Business Models," CRC Press, 2016

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 8043	**Power System Modeling and Control (abbreviated as PSMC)**	**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 8043	Power System Modeling and Control	20	20	20	80	03	25	125

Course Objectives	• To impart knowledge power system stability and control. • To elaborate the fundamentals of electrical machines and do the modeling of various components of power system.
Course Outcomes	Students will be able • To understand the basic concept of stability and its types • To evaluate the models of synchronous machine, induction machine, excitation system and load. • To analyse the dynamic stability of power system.

Module	Contents	Hours
1	**Introduction** **Basic Concepts and Definitions:**-Rotor angle stability, voltage Stability and voltage collapse, Mid term and long term stability, Classification of stability, Historical review of stability problem in India and world.	04
2	**Synchronous Machine Modeling and Representation** Basic equations of synchronous machine, dqo transformation, Per unit-voltage- flux- torque- power equations and reactance, Equivalent circuit d-q axis, Voltage current flux linkage relation- phasor representation-rotor angle-steady state equivalent circuit. Three phase short circuit, Magnetic saturation and representation Simplifications for large scale studies, Constant flux linkage model.	10
3	**Modeling Of Other Components** Basic load modeling concept, Modeling of induction motor, Acquisition of load model parameters	8
4	**Excitation System Modeling and Control** Excitation system requirement, Elements of excitation system, Types of excitation system, Dynamic performance measures, Control and protective functions, Basic elements of different types of excitation system.	10
5	**Small Signal Stability (SSS) and Control** Fundamental concept of stability of dynamic system, Eigen properties of state matrix, SSS of single machine infinite bus system, Effect of AVR	10

	on synchronizing and damping torque, Power system stabilizer, SSS of multi- machine system, Special techniques to analyze large system, Characteristics.	
6	**Voltage Stability and Control** Basic concepts, Voltage collapse, Voltage stability analysis, Prevention of voltage collapse. Counter measure for Sub Synchronous Resonance	06

Books Recommended:

Text Books:

1. Prabha Kundur , Power System Stability and Control , TMH Publication,2008
2. Padiyar K R, Power System Dynamics- Stability and Control, BSP Publication.

Reference Books:

1. Kimbark E W, Power System Stability, Volume I, III, Wiley publication.
2. Jr W.D. Stevenson., G. J. Grainger. Elements of Power System. Mc-Graw-Hill 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

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 8044	**Power System Planning and Reliability (abbreviated as PSPR)**	**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 8044	Power System Planning and Reliability	20	20	20	80	03	25	125

Course Objectives	• To understand the different power system planning and forecasting, techniques and reliability evaluation in terms of basic reliability indices.
Course Outcomes	Students will be able • To make a Generation System Model for the Power system in terms of frequency and duration of failure. • To calculate reliability indices of the power system based on system model and the load curve. • To plan a small Generation and Transmission system, predict its behavior, and do the required change in order to achieve reliability.

Module	Contents	Hours
1	**Load Forecasting:** Introduction, Classification of Load, Load Growth Characteristics, Peak Load Forecasting, Extrapolation and Co-Relation methods of load Forecasting, Reactive Load Forecasting, Impact of weather on load forecasting.	06
2	**System Planning:** Introduction to System Planning, Short, Medium and Long Term strategic planning, Reactive Power Planning**.** Introduction to Generation and Network Planning.	06
3	**Reliability of Systems:** Concepts, Terms and Definitions, Reliability models, Markov process, Reliability function, Hazard rate function, Bathtub Curve. Serial Configuration, Parallel Configuration, Mixed Configuration of systems, Minimal Cuts and Minimal Paths, Methods to find Minimal Cut Sets, System reliability using conditional probability method, cut set method and tie set method.	08
4	**Generating Capacity:** Basic Probability Methods introduction, Generation system model, capacity outage probability table, recursive algorithm, Evaluation of: loss of load indices, Loss of load expectation, Loss of energy. Frequency and Duration Method basic concepts, Numerical based on Frequency and Duration method.	08

5	**Operating Reserve:** General concept, PJM method, Modified PJM method.	04
6	**Composite generation and transmission system:** Data requirement, Outages, system and load point indices, Application to simple system	04

Books Recommended:

Text Books:

1. Power System Planning - R.L. Sullivan, Tata McGraw Hill Publishing Company
2. Electrical Power System Planning – A.S Pabla, Macmillan India Ltd.
3. Reliability Evaluation of Power System - Roy Billinton and Ronald N Allan, Springer Publishers

Reference Books:

1. Reliability Assessment of Large Electric Power Systems - Roy Billinton and Ronald N Allan, Kluwer academic publishers, 1988
2. Reliability Evaluation of Engineering System- Roy Billinton and Ronald N Allan, Springer Publishers
3. Electrical Power System Planning: Issues, Algorithms and Solutions – Hossein Seifi and M.S Sepasian, Springer Publishers
4. Modern Power System Planning – X. Wang and J.R. McDonald, McGraw Hill

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**
ILO8021	**Project Management (abbreviated as PM)**	**3**	**-**	**3**	**-**	**3**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
ILO8021	Project Management	20	20	20	80	03	-	100

Course Objectives	• To familiarize the students with the use of a structured methodology/approach for each and every unique project undertaken, including utilizing project management concepts, tools and techniques. • To appraise the students with the project management life cycle and make them knowledgeable about the various phases from project initiation through closure.
Course Outcomes	Student will be able to… • Apply selection criteria and select an appropriate project from different options. • Write work break down structure for a project and develop a schedule based on it. • Identify opportunities and threats to the project and decide an approach to deal with them strategically. • Use Earned value technique and determine & predict status of the project. • Capture lessons learned during project phases and document them for future reference

Module	Contents	Hours
1	**Project Management Foundation:** Definition of a project, Project Vs Operations, Necessity of project management, Triple constraints, Project life cycles (typical & atypical) Project phases and stage gate process. Role of project manager. Negotiations and resolving conflicts. Project management in various organization structures. PM knowledge areas as per Project Management Institute (PMI).	5
2	**Initiating Projects:** How to get a project started, Selecting project strategically, Project selection models (Numeric /Scoring Models and Non-numeric models), Project portfolio process, Project sponsor and creating charter; Project proposal. Effective project team, Stages of team development & growth (forming, storming, norming & performing), team dynamics.	6
3	**Project Planning and Scheduling:** Work Breakdown structure (WBS) and linear responsibility chart, Interface Co-ordination and concurrent engineering, Project cost estimation and budgeting, Top down and	8

	bottoms up budgeting, Networking and Scheduling techniques. PERT, CPM, GANTT chart. Introduction to Project Management Information System (PMIS).	
4	**Planning Projects:** Crashing project time, Resource loading and leveling, Goldratt's critical chain, Project Stakeholders and Communication plan. Risk Management in projects: Risk management planning, Risk identification and risk register. Qualitative and quantitative risk assessment, Probability and impact matrix. Risk response strategies for positive and negative risks	6
5	**Executing Projects:** Planning monitoring and controlling cycle. Information needs and reporting, engaging with all stakeholders of the projects. Team management, communication and project meetings. **Monitoring and Controlling Projects:** Earned Value Management techniques for measuring value of work completed; Using milestones for measurement; change requests and scope creep. Project audit. **Project Contracting** Project procurement management, contracting and outsourcing,	8
6	**Project Leadership and Ethics:** Introduction to project leadership, ethics in projects. Multicultural and virtual projects. **Closing the Project:** Customer acceptance; Reasons of project termination, Various types of project terminations (Extinction, Addition, Integration, Starvation), Process of project termination, completing a final report; doing a lessons learned analysis; acknowledging successes and failures; Project management templates and other resources; Managing without authority; Areas of further study.	6

Books Recommended:

Reference Books:

1. Jack Meredith & Samuel Mantel, Project Management: A managerial approach, Wiley India, 7th Ed.
2. A Guide to the Project Management Body of Knowledge (PMBOK® Guide), 5th Ed, Project Management Institute PA, USA
3. Gido Clements, Project Management, Cengage Learning.
4. Gopalan, Project Management, , Wiley India
5. Dennis Lock, Project Management, Gower Publishing England, 9 th Ed.

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**
ILO8022	**Finance Management (abbreviated as FM)**	**3**	**-**	**3**	**-**	**3**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
ILO8022	Finance Management	20	20	20	80	03	-	100

Course Objectives	• Overview of Indian financial system, instruments and market • Basic concepts of value of money, returns and risks, corporate finance, working capital and its management • Knowledge about sources of finance, capital structure, dividend policy
Course Outcomes	Student will be able to… • Understand Indian finance system and corporate finance • Take investment, finance as well as dividend decisions

Module	Contents	Hours
1	**Overview of Indian Financial System:** Characteristics, Components and Functions of Financial System. **Financial Instruments:** Meaning, Characteristics and Classification of Basic Financial Instruments — Equity Shares, Preference Shares, Bonds-Debentures, Certificates of Deposit, and Treasury Bills. **Financial Markets:** Meaning, Characteristics and Classification of Financial Markets — Capital Market, Money Market and Foreign Currency Market. **Financial Institutions:** Meaning, Characteristics and Classification of Financial Institutions — Commercial Banks, Investment-Merchant Banks and Stock Exchanges	6
2	**Concepts of Returns and Risks:** Measurement of Historical Returns and Expected Returns of a Single Security and a Two-security Portfolio; Measurement of Historical Risk and Expected Risk of a Single Security and a Two-security Portfolio. **Time Value of Money:** Future Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Present Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Continuous Compounding and Continuous Discounting.	6
3	**Overview of Corporate Finance:** Objectives of Corporate Finance; Functions of Corporate Finance—Investment Decision, Financing Decision, and Dividend Decision. **Financial Ratio Analysis:** Overview of Financial Statements—Balance Sheet, Profit and Loss Account, and Cash Flow Statement; Purpose of Financial Ratio Analysis; Liquidity Ratios; Efficiency or Activity Ratios; Profitability Ratios; Capital Structure Ratios; Stock Market	9

	Ratios; Limitations of Ratio Analysis.	
4	**Capital Budgeting:** Meaning and Importance of Capital Budgeting; Inputs for Capital Budgeting Decisions; Investment Appraisal Criterion—Accounting Rate of Return, Payback Period, Discounted Payback Period, Net Present Value(NPV), Profitability Index, Internal Rate of Return (IRR), and Modified Internal Rate of Return (MIRR) **Working Capital Management:** Concepts of Meaning Working Capital; Importance of Working Capital Management; Factors Affecting an Entity's Working Capital Needs; Estimation of Working Capital Requirements; Management of Inventories; Management of Receivables; and Management of Cash and Marketable Securities.	10

Books Recommended:

Reference Books:

1. Fundamentals of Financial Management, 13th Edition (2015) by Eugene F. Brigham and Joel F. Houston; Publisher: Cengage Publications, New Delhi.
2. Analysis for Financial Management, 10th Edition (2013) by Robert C. Higgins; Publishers: McGraw Hill Education, New Delhi.
3. Indian Financial System, 9th Edition (2015) by M. Y. Khan; Publisher: McGraw Hill Education, New Delhi.
4. Financial Management, 11th Edition (2015) by I. M. Pandey; Publisher: S. Chand (G/L) & Company Limited, New Delhi.

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**
ILO8023	**Entrepreneurship Development and Management (abbreviated as EDM)**	**3**	**-**	**3**	**-**	**3**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
ILO8023	Entrepreneurship Development and Management	20	20	20	80	03	-	100

Course Objectives	• To acquaint with entrepreneurship and management of business • Understand Indian environment for entrepreneurship • Idea of EDP, MSME
Course Outcomes	Student will be able to… • Understand the concept of business plan and ownerships • Interpret key regulations and legal aspects of entrepreneurship in India • Understand government policies for entrepreneurs

Module	Contents	Hours
1	**Overview Of Entrepreneurship:** Definitions, Roles and Functions/Values of Entrepreneurship, History of Entrepreneurship Development, Role of Entrepreneurship in the National Economy, Functions of an Entrepreneur, Entrepreneurship and Forms of Business Ownership Role of Money and Capital Markets in Entrepreneurial Development: Contribution of Government Agencies in Sourcing information for Entrepreneurship	4
2	**Business Plans And Importance Of Capital To Entrepreneurship:** Preliminary and Marketing Plans, Management and Personnel, Start-up Costs and Financing as well as Projected Financial Statements, Legal Section, Insurance, Suppliers and Risks, Assumptions and Conclusion, Capital and its Importance to the Entrepreneur **Entrepreneurship And Business Development:** Starting a New Business, Buying an Existing Business, New Product Development, Business Growth and the Entrepreneur Law and its Relevance to Business Operations	9
3	Women's Entrepreneurship Development, Social entrepreneurship-role and need, EDP cell, role of sustainability and sustainable development for SMEs, case studies, exercises	5
4	**Indian Environment for Entrepreneurship:** key regulations and legal aspects , MSMED Act 2006 and its implications, schemes and policies	8

	of the Ministry of MSME, role and responsibilities of various government organisations, departments, banks etc., Role of State governments in terms of infrastructure developments and support etc., Public private partnerships, National Skill development Mission, Credit Guarantee Fund, PMEGP, discussions, group exercises etc	
5	**Effective Management of Business:** Issues and problems faced by micro and small enterprises and effective management of M and S enterprises (risk management, credit availability, technology innovation, supply chain management, linkage with large industries), exercises, e-Marketing	8
6	**Achieving Success In The Small Business:** Stages of the small business life cycle, four types of firm-level growth strategies, Options – harvesting or closing small business Critical Success factors of small business	5

Books Recommended:

Reference Books:

1. Poornima Charantimath, Entrepreneurship development- Small Business Enterprise, Pearson
2. Education Robert D Hisrich, Michael P Peters, Dean A Shapherd, Entrepreneurship, latest edition, The McGrawHill Company
3. Dr TN Chhabra, Entrepreneurship Development, Sun India Publications, New Delhi
4. Dr CN Prasad, Small and Medium Enterprises in Global Perspective, New century Publications, New Delhi
5. Vasant Desai, Entrepreneurial development and management, Himalaya Publishing House
6. Maddhurima Lall, Shikah Sahai, Entrepreneurship, Excel Books
7. Rashmi Bansal, STAY hungry STAY foolish, CIIE, IIM Ahmedabad
8. Law and Practice relating to Micro, Small and Medium enterprises, Taxmann Publication Ltd.
9. Kurakto, Entrepreneurship- Principles and Practices, Thomson Publication
10. Laghu Udyog Samachar
11. www.msme.gov.in
12. www.dcmesme.gov.in
13. www.msmetraining.gov.in

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**
ILO8024	**Human Resource Management (abbreviated as HRM)**	**3**	**-**	**3**	**-**	**3**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
ILO8024	Human Resource Management	20	20	20	80	03	-	100

Course Objectives	• To introduce the students with basic concepts, techniques and practices of the human resource management. • To provide opportunity of learning Human resource Management (HRM) processes, related with the functions, and challenges in the emerging perspective. • To familiarize the students about the latest developments, trends & different aspects of HRM. • To acquaint the student with the importance of behavioral skills, Inter-personal, inter- group in an organizational setting. • To prepare the students as future organizational change facilitators, stable leaders and managers, using the knowledge and techniques of human resource management.
Course Outcomes	Learner will be able to… • Gain knowledge and understand the concepts about the different aspects of the human resource management. • Understand and tackle the changes and challenges in today's diverse, dynamic organizational setting and culture. • Utilize the behavioral skill sets learnt, in working with different people, teams & groups within the national and global environment. • Apply the acquired techniques, knowledge and integrate it within the engineering/ non engineering working environment emerging as future engineers and managers.

Module	Contents	Hours
1	**Introduction to HR:** Human Resource Management- Concept, Scope and Importance, Interdisciplinary Approach Relationship with other Sciences, Competencies of HR Manager, HRM functions. Human resource development (HRD): changing role of HRM – Human resource Planning, Technological change, Restructuring and rightsizing,	05

	Empowerment, TQM, Managing ethical issues.	
2	**Organizational Behavior (OB) :** Introduction to OB Origin, Nature and Scope of Organizational Behavior, Relevance to Organizational Effectiveness and Contemporary issues, Personality: Meaning and Determinants of Personality, Personality development, Personality Types, Assessment of Personality Traits for Increasing Self Awareness, Perception: Attitude and Value, Effect of perception on Individual Decision-making, Attitude and Behavior. Motivation: Theories of Motivation and their Applications for Behavioral Change (Maslow, Herzberg, McGregor); Group Behavior and Group Dynamics: Work groups formal and informal groups and stages of group development. Team Effectiveness: High performing teams, Team Roles, cross functional and self-directed team. Case study	07
3	**Organizational Structure & Design:** Structure, size, technology, Environment of organization; Organizational Roles & conflicts: Concept of roles; role dynamics; role conflicts and stress. Leadership: Concepts and skills of leadership, Leadership and managerial roles, Leadership styles and contemporary issues in leadership. Power and Politics: Sources and uses of power; Politics at workplace, Tactics and strategies.	06
4	**Human resource Planning:** Recruitment and Selection process, Job-enrichment, Empowerment - Job-Satisfaction, employee morale. Performance Appraisal Systems: Traditional & modern methods, Performance Counseling, Career Planning. Training & Development: Identification of Training Needs, Training Methods	05
5	**Emerging Trends in HR :** Organizational development; Business Process Re-engineering (BPR), BPR as a tool for organizational development , managing processes & transformation in HR. Organizational Change, Culture, Environment, Cross Cultural Leadership and Decision Making**:** Cross Cultural Communication and diversity at work**,** Causes of diversity, managing diversity with special reference to handicapped, women and ageing people, intra company cultural difference in employee motivation.	06
6	**HR & MIS:** Need, purpose, objective and role of information system in HR, Applications in HRD in various industries (e.g. manufacturing R&D, Public Transport, Hospitals, Hotels and service industries **Strategic HRM** Role of Strategic HRM in the modern business world, Concept of Strategy, Strategic Management Process, Approaches to Strategic Decision Making; Strategic Intent – Corporate Mission, Vision, Objectives and Goals **Labor Laws & Industrial Relations** Evolution of IR, IR issues in organizations, Overview of Labor Laws in India; Industrial Disputes Act, Trade Unions Act, Shops and	10

	Establishments Act	

Books Recommended:

Reference Books:

1. Stephen Robbins, Organizational Behavior, 16th Ed, 2013
2. V S P Rao, Human Resource Management, 3rd Ed, 2010, Excel publishing
3. Aswathapa, Human resource management: Text & cases, 6th edition, 2011
4. C. B. Mamoria and S V Gankar, Dynamics of Industrial Relations in India, 15th Ed, 2015, Himalaya Publishing, 15thedition, 2015
5. P. Subba Rao, Essentials of Human Resource management and Industrial relations, 5th Ed, 2013, Himalaya Publishing
6. Laurie Mullins, Management & Organizational Behavior, Latest Ed, 2016, Pearson Publications

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**
ILO8025	**Professional Ethics and Corporate Social Responsibility (abbreviated as PECSR)**	**3**	**-**	**3**	**-**	**3**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
ILO8025	Professional Ethics and Corporate Social Responsibility	20	20	20	80	03	-	100

Course Objectives	• To understand professional ethics in business • To recognized corporate social responsibility
Course Outcomes	Student will be able to… • Understand rights and duties of business • Distinguish different aspects of corporate social responsibility • Demonstrate professional ethics • Understand legal aspects of corporate social responsibility

Module	Contents	Hours
1	**Professional Ethics and Business:** The Nature of Business Ethics; Ethical Issues in Business; Moral Responsibility and Blame; Utilitarianism: Weighing Social Costs and Benefits; Rights and Duties of Business	04
2	**Professional Ethics in the Marketplace:** Perfect Competition; Monopoly Competition; Oligopolistic Competition; Oligopolies and Public Policy **Professional Ethics and the Environment:** Dimensions of Pollution and Resource Depletion; Ethics of Pollution Control; Ethics of Conserving Depletable Resources	08
3	**Professional Ethics of Consumer Protection:** Markets and Consumer Protection; Contract View of Business Firm's Duties to Consumers; Due Care Theory; Advertising Ethics; Consumer Privacy **Professional Ethics of Job Discrimination:** Nature of Job Discrimination; Extent of Discrimination; Reservation of Jobs.	06
4	**Introduction to Corporate Social Responsibility:** Potential Business Benefits—Triple bottom line, Human resources, Risk management, Supplier relations; Criticisms and concerns—Nature of business;	05

	Motives; Misdirection. Trajectory of Corporate Social Responsibility in India	
5	**Corporate Social Responsibility:** Articulation of Gandhian Trusteeship Corporate Social Responsibility and Small and Medium Enterprises (SMEs) in India, Corporate Social Responsibility and Public-Private Partnership (PPP) in India	08
6	**Corporate Social Responsibility in Globalizing India:** Corporate Social Responsibility Voluntary Guidelines, 2009 issued by the Ministry of Corporate Affairs, Government of India, Legal Aspects of Corporate Social Responsibility—Companies Act, 2013.	08

Books Recommended:

Reference Books:

1. Business Ethics: Texts and Cases from the Indian Perspective (2013) by Ananda Das Gupta; Publisher: Springer.
2. Corporate Social Responsibility: Readings and Cases in a Global Context (2007) by Andrew Crane, Dirk Matten, Laura Spence; Publisher: Routledge.
3. Business Ethics: Concepts and Cases, 7th Edition (2011) by Manuel G. Velasquez; Publisher: Pearson, New Delhi.
4. Corporate Social Responsibility in India (2015) by Bidyut Chakrabarty, Routledge, New Delhi.

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**
ILO8026	**Research Methodology (abbreviated as RM)**	**3**	**-**	**3**	**-**	**3**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
ILO8026	Research Methodology	20	20	20	80	03	-	100

Course Objectives	• To understand Research and Research Process • To acquaint students with identifying problems for research and develop research strategies • To familiarize students with the techniques of data collection, analysis of data and interpretation
Course Outcomes	Student will be able to… • Prepare a preliminary research design for projects in their subject matter areas • Accurately collect, analyze and report data • Present complex data or situations clearly • Review and analyze research findings

Module	Contents	Hours
1	**Introduction and Basic Research Concepts:** Research – Definition; Concept of Construct, Postulate, Proposition, Thesis, Hypothesis, Law, Principle. Research methods vs Methodology, Need of Research in Business and Social Sciences , Objectives of Research, **Issues** and Problems in Research, Characteristics of Research: Systematic, Valid, Verifiable, Empirical and Critical	10
2	**Types of Research:** Basic Research, Applied Research, Descriptive Research, Analytical Research, Empirical Research, Qualitative and Quantitative Approaches	08
3	**Research Design and Sample Design :** Research Design – Meaning, Types and Significance, Sample Design – Meaning and Significance Essentials of a good sampling Stages in Sample Design Sampling methods/techniques Sampling Errors	08
4	**Research Methodology :** Meaning of Research Methodology, Stages in Scientific Research Process **a.** Identification and Selection of Research Problem **b.** Formulation of Research Problem **c.** Review of Literature **d.** Formulation of Hypothesis	08

	e. Formulation of research Design **f**. Sample Design **g.** Data Collection **h.** Data Analysis **i.** Hypothesis testing and Interpretation of Data **j.** Preparation of Research Report	
5	**Formulating Research Problem:** Considerations: Relevance, Interest, Data Availability, Choice of data, Analysis of data, Generalization and Interpretation of analysis	04
6	**Outcome of Research:** Preparation of the report on conclusion reached, Validity Testing & Ethical Issues, Suggestions and Recommendation	04

Books Recommended:

Reference Books:

1. Dawson, Catherine, 2002, Practical Research Methods, New Delhi, UBS Publishers Distributors.
2. Kothari, C.R., 1985, Research Methodology-Methods and Techniques, New Delhi, Wiley Eastern Limited.
3. Kumar, Ranjit, 2005, Research Methodology-A Step-by-Step Guide for Beginners, (2nd ed), Singapore, Pearson Education

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**
ILO8027	**IPR and Patenting (abbreviated as IPRP)**	**3**	**-**	**3**	**-**	**3**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
ILO8027	IPR and Patenting	20	20	20	80	03	-	100

Course Objectives	• To understand intellectual property rights protection system • To promote the knowledge of Intellectual Property Laws of India as well as International treaty procedures • To get acquaintance with Patent search and patent filing procedure and • applications
Course Outcomes	Student will be able to… • understand Intellectual Property assets • assist individuals and organizations in capacity building • work for development, promotion, protection, compliance, and enforcement of Intellectual Property and Patenting

Module	Contents	Hours
1	**Introduction to Intellectual Property Rights (IPR)**: Meaning of IPR, Different category of IPR instruments - Patents, Trademarks, Copyrights, Industrial Designs, Plant variety protection, Geographical indications, Transfer of technology etc. **Importance of IPR in Modern Global Economic Environment:** Theories of IPR, Philosophical aspects of IPR laws, Need for IPR, IPR as an instrument of development	05
2	**Enforcement of Intellectual Property Rights:** Introduction, Magnitude of problem, Factors that create and sustain counterfeiting/piracy, International agreements, International organizations (e.g. WIPO, WTO) activein IPR enforcement **Indian Scenario of IPR:** Introduction, History of IPR in India, Overview of IP laws in India, Indian IPR, Administrative Machinery, Major international treaties signed by India, Procedure for submitting patent and Enforcement of IPR at national level etc.	07
3	**Emerging Issues in IPR:** Challenges for IP in digital economy, e-commerce, human genome, biodiversity and traditional knowledge etc.	06
4	**Basics of Patents:** Definition of Patents, Conditions of patentability,	07

	Patentable and non-patentable inventions, Types of patent applications (e.g. Patent of addition etc), Process Patent and Product Patent, Precautions while patenting, Patent specification Patent claims, Disclosures and non-disclosures, Patent rights and infringement, Method of getting a patent	
5	**Patent Rules:** Indian patent act, European scenario, US scenario, Australia scenario, Japan scenario, Chinese scenario, Multilateral treaties where India is a member (TRIPS agreement, Paris convention etc.)	08
6	**Procedure for Filing a Patent (National and International):** Legislation and Salient Features, Patent Search, Drafting and Filing Patent Applications, Processing of patent, Patent Litigation, Patent Publicationetc, Time frame and cost, Patent Licensing, Patent Infringement **Patent databases:** Important websites, Searching international databases	07

Books Recommended:

Reference Books:

1. Rajkumar S. Adukia, 2007, A Handbook on Laws Relating to Intellectual Property Rights in India, The Institute of Chartered Accountants of India
2. Keayla B K, Patent system and related issues at a glance, Published by National Working Group on Patent Laws
3. T Sengupta, 2011, Intellectual Property Law in India, Kluwer Law International
4. Tzen Wong and Graham Dutfield,2010, Intellectual Property and Human Development: Current Trends and Future Scenario, Cambridge University Press
5. Cornish, William Rodolph&Llewelyn, David. 2010, Intellectual Property: Patents, Copyrights, Trade Marks and Allied Right, 7th Edition, Sweet & Maxwell
6. LousHarns, 2012, The enforcement of Intellactual Property Rights: A Case Book, 3rd Edition, WIPO
7. PrabhuddhaGanguli, 2012, Intellectual Property Rights, 1st Edition, TMH
8. R Radha Krishnan & S Balasubramanian, 2012, Intellectual Property Rights, 1st Edition, Excel Books
9. M Ashok Kumar andmohdIqbal Ali, 2-11, Intellectual Property Rights, 2nd Edition, Serial Publications
10. KompalBansal and PraishitBansal, 2012, Fundamentals of IPR for Engineers, 1st Edition, BS Publications
11. Entrepreneurship Development and IPR Unit, BITS Pilani, 2007, A Manual on Intellectual Property Rights,
12. Mathew Y Maa, 2009, Fundamentals of Patenting and Licensing for Scientists and Engineers, World Scientific Publishing Company
13. N S Rathore, S M Mathur, PritiMathur, AnshulRathi**,** IPR: Drafting,Interpretation of Patent Specifications and Claims**,** New India Publishing Agency

14. Vivien Irish, 2005,Intellectual Property Rights for Engineers,IET
15. Howard B Rockman, 2004, Intellectual Property Law for Engineers and scientists, Wiley-IEEE Press

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**
ILO8028	**Digital Business Management (abbreviated as DBM)**	**3**	**-**	**3**	**-**	**3**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
ILO8028	Digital Business Management	20	20	20	80	03	-	100

Course Objectives	• To familiarize with digital business concept • To acquaint with E-commerce • To give insights into E-business and its strategies
Course Outcomes	Student will be able to ….. • Identify drivers of digital business • Illustrate various approaches and techniques for E-business and management • Prepare E-business plan

Module	Contents	Hours
1	**Introduction to Digital Business:** Introduction, Background and current status, E-market places, structures, mechanisms, economics and impacts Difference between physical economy and digital economy, **Drivers of digital business**- Big Data & Analytics, Mobile, Cloud Computing, Social media, BYOD, and Internet of Things(digitally intelligent machines/services) Opportunities and Challenges in Digital Business,	09
2	**Overview of E-Commerce: E-Commerce-** Meaning, Retailing in e-commerce-products and services, consumer behavior, market research and advertisement B2B-E-commerce-selling and buying in private e-markets, public B2B exchanges and support services, e-supply chains, Collaborative Commerce, Intra business EC and Corporate portals Other E-C models and applications, innovative EC System-From E-government and learning to C2C, mobile commerce and pervasive computing EC Strategy and Implementation-EC strategy and global EC, Economics and Justification of EC, Using Affiliate marketing to promote your e-commerce business, Launching a successful online business and EC project, Legal, Ethics and Societal impacts of EC	06
3	**Digital Business Support services**: ERP as e –business backbone, knowledge Tope Apps, Information and referral system, **Application**	06

	Development: Building Digital business Applications and Infrastructure	
4	**Managing E-Business**-Managing Knowledge, Management skills for e-business, Managing Risks in e –business, Security Threats to e-business -Security Overview, Electronic Commerce Threats, Encryption, ryptography, Public Key and Private Key Cryptography, Digital Signatures, Digital Certificates, Security Protocols over Public Networks: HTTP, SSL, Firewall as Security Control, Public Key Infrastructure (PKI) for Security, Prominent Cryptographic Applications	06
5	**E-Business Strategy**-E-business Strategic formulation- Analysis of Company's Internal and external environment, Selection of strategy, E-business strategy into Action, challenges and E-Transition (Process of Digital Transformation)	04
6	**M Materializing e-business: From Idea to Realization**-Business plan preparation **Case Studies and presentations**	08

Books Recommended:

Reference Books:

1. A textbook on E-commerce**,** Er Arunrajan Mishra, Dr W K Sarwade,Neha Publishers & Distributors, 2011
2. E-commerce from vision to fulfilment, Elias M. Awad, PHI-Restricted, 2002
3. Digital Business and E-Commerce Management, 6th Ed, Dave Chaffey, Pearson, August 2014
4. Introduction to E-business-Management and Strategy, Colin Combe, ELSVIER, 2006
5. Digital Business Concepts and Strategy, Eloise Coupey, 2nd Edition, Pearson
6. Trend and Challenges in Digital Business Innovation, Vinocenzo Morabito, Springer
7. Digital Business Discourse Erika Darics, April 2015, Palgrave Macmillan
8. E-Governance-Challenges and Opportunities in : Proceedings in 2nd International Conference theory and practice of Electronic Governance
9. Perspectives the Digital Enterprise –A framework for Transformation, TCS consulting journal Vol.5
10. Measuring Digital Economy-A new perspective -DOI:10.1787/9789264221796-en OECD Publishing

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**
ILO8029	**Environmental Management (abbreviated as EVM)**	**3**	**-**	**3**	**-**	**3**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
ILO8029	Environmental Management	20	20	20	80	03	-	100

Course Objectives	• Understand and identify environmental issues relevant to India and global concerns • Learn concepts of ecology • Familiarise environment related legislations
Course Outcomes	Student will be able to… • Understand the concept of environmental management • Understand ecosystem and interdependence, food chain etc. • Understand and interpret environment related legislations

Module	Contents	Hours
1	Introduction and Definition of Environment: Significance of Environment Management for contemporary managers, Career opportunities. Environmental issues relevant to India, Sustainable Development, The Energy scenario.	10
2	Global Environmental concerns : Global Warming, Acid Rain, Ozone Depletion, Hazardous Wastes, Endangered life-species, Loss of Biodiversity, Industrial/Man-made disasters, Atomic/Biomedical hazards, etc.	06
3	Concepts of Ecology: Ecosystems and interdependence between living organisms, habitats, limiting factors, carrying capacity, food chain, etc.	05
4	Scope of Environment Management, Role & functions of Government as a planning and regulating agency. Environment Quality Management and Corporate Environmental Responsibility	10
5	Total Quality Environmental Management, ISO-14000, EMS certification.	05
6	General overview of major legislations like Environment Protection Act, Air (P & CP) Act, Water (P & CP) Act, Wildlife Protection Act, Forest Act, Factories Act, etc.	03

Books Recommended:

Reference Books:

1. Environmental Management: Principles and Practice, C J Barrow, Routledge Publishers London, 1999
2. A Handbook of Environmental Management Edited by Jon C. Lovett and David G. Ockwell, Edward Elgar Publishing
3. Environmental Management, **T V Ramachandra and Vijay Kulkarni, TERI Press**
4. Indian Standard Environmental Management Systems — Requirements With Guidance For Use, Bureau Of Indian Standards, February 2005
5. Environmental Management: An Indian Perspective, S N Chary and Vinod Vyasulu, Maclillan India, 2000
6. Introduction to Environmental Management, Mary K Theodore and Louise Theodore, CRC Press Environment and Ecology, Majid Hussain, 3rd Ed. Access Publishing.2015

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	**Practical**	**Theory**	**Practical**	**Total**
EEL801	**Simulation Lab- IV (abbreviated as Sim Lab-IV)**	**-**	**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.					
EEL801	Simulation Lab- IV	-	-	-	-	25	-	25	50

Course Objectives	• To design the transmission systems with various FACTS controllers • To design various electrical system
Course Outcomes	Student will be able to • Analyze the transmission line performance with and without FACTS controllers using simulations. • Analyze the operation of various electrical systems using simulation.

Syllabus: Same as that of Courses of Sem-VIII

Suggested List of Laboratory Experiment:
Software Based Design and Implementation /Simulation

1. PCB Design and Implementation for any of the electrical application using suitable CAD software
2. Simulation of any of the electrical circuits using circuit simulator software
3. PCB design for implementation of Basic electrical network theorem based experiments
4. Software based design of Solar PV power generating plant
5. Software Based Lighting system design for Indoor or Outdoor application
6. Virtual Instrumentation Software based circuit implementation
7. Load Compensation
8. FACTS Controllers
9. Simulations based on Department/Institute Level Optional Courses

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**
EEL802	**Electrical System Design Lab (abbreviated as ESD 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.					
EEL802	Electrical System Design Lab	-	-	-	-	25	-	25	50

Course Objectives	• To impart hardware knowledge related to electrical system in the students
Course Outcomes	Student will be able to • Design electrical system for different applications.

Syllabus: Same as that of Courses of Sem-VIII

Suggested List of Laboratory Experiment:

Design and Implementation of Hardware Circuits

1. Design of basic electrical network theorem based experiments
2. Design and Implementation of Single /Multi output Power supply
3. Design and Implementation of Multi output Switched Mode Power supply
4. Design and Implementation of DOL/Star delta starter for Electrical Machines
5. Design and Implementation of Electro-magnetic relays based on/off control of Electrical loads
6. Design and Implementation of Auxiliary Circuits for Power Electronics Applications: (a) Gate drive circuits (b) Snubber circuits
7. Design and Implementation of High frequency magnetics
8. Design and Implementation of Buck/Boost/ Buck-boost dc-dc Converter.
9. Design and Implementation of Voltage and Current sensing circuits in DC and AC circuits
10. Design and Implementation Signal Processing amplifier system for sensor outputs
11. Design and Implementation of a closed loop controlled converter/Inverter circuit
12. Solar Photovoltaic fed Battery charge controller
13. IoT based Home automation System
14. Design and Implementation of small scale Solar PV (upto 2 kW) power generating plant.

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

Term work:

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

Experiments Performance	:15 marks
Journal	:05 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**
EEL703/EEL803	**Project-I/II**	**-**	**6/12**	**-**	**3/6**	**3/6**

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.					
EEL703/EEL803	Project-I/II	-	-	-	-	25/50	-	25/50	50/100

Course Objectives	• To acquaint with the process of undertaking literature survey/industrial visit and identifying the problem • To familiarize the process of problem solving in a group • To acquaint with the process of applying basic engineering fundamental in the domain of practical applications • To inculcate the process of research
Course Outcomes	Student will be able to… • Do literature survey/industrial visit and identify the problem • Apply basic engineering fundamental in the domain of practical applications • Cultivate the habit of working in a team • Attempt a problem solution in a right approach • Correlate the theoretical and experimental/simulations results and draw the proper inferences • Prepare report as per the standard guidelines.

Guidelines for Project

Students should do literature survey/visit industry/analyse current trends and identify the problem for Project and finalize in consultation with Guide/Supervisor.

Students should use multiple literatures and understand the problem.

Students should attempt solution to the problem by experimental/simulation methods. The solution to be validated with proper justification and report to be compiled in standard format.

Guidelines for Assessment of Project I

Project I should be assessed based on following points

1. Quality of problem selected

2. Clarity of Problem definition and Feasibility of problem solution

3. Relevance to the specialization

4. Clarity of objective and scope

5. Breadth and depth of literature survey

Project Report has to be prepared strictly as per University of Mumbai report writing guidelines. Project I should be assessed through a presentation by the student project group to a panel of Internal and External Examiner approved by the University of Mumbai

Guidelines for Assessment of Project II

Project II should be assessed based on following points

1. Quality of problem selected

2. Clarity of Problem definition and Feasibility of problem solution

3. Relevance to the specialization / Industrial trends

4. Clarity of objective and scope

5. Quality of work attempted

6. Validation of results

7. Quality of Written and Oral Presentation

Project Report has to be prepared strictly as per University of Mumbai report writing guidelines. Project II should be assessed through a presentation by the student project group to a panel of Internal and External Examiner approved by the University of Mumbai Students should be motivated to publish a paper in Conferences/students competitions based on the work.

Faculty Load

In semester VII - 1 (one) period of 1/2 hour per week per project group

In semester VIII - 2 (Two) period of 1 hour each per week per project group