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
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**

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:

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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.