UNIVERSITY OF MUMBAI

Bachelor of Engineering

Electrical Engineering (Sem. V to VIII), Revised course

(REV- 2012) from Academic Year 2014 -15,

Under

FACULTY OF TECHNOLOGY

(As per Semester Based Credit and Grading System)

Preamble

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education. The major emphasis of accreditation process is to measure the outcomes of the program that is being accredited. In line with this Faculty of Technology of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty of Technology, University of Mumbai, in one of its meeting unanimously resolved that, each Board of Studies shall prepare some Program Educational Objectives (PEO's) and give freedom to affiliated Institutes to add few (PEO's) and course objectives and course outcomes to be clearly defined for each course, so that all faculty members in affiliated institutes understand the depth and approach of course to be taught, which will enhance learner's learning process. It was also resolved that, maximum senior faculty from colleges and experts from industry to be involved while revising the curriculum. I am happy to state that, each Board of studies has adhered to the resolutions passed by Faculty of Technology, and developed curriculum accordingly. In addition to outcome based education, semester based credit and grading system is also introduced to ensure quality of engineering education.

Semester based Credit and Grading system enables a much-required shift in focus from teacher-centric to learner-centric education since the workload estimated is based on the investment of time in learning and not in teaching. It also focuses on continuous evaluation which will enhance the quality of education. University of Mumbai has taken a lead in implementing the system through its affiliated Institutes and Faculty of Technology has devised a transparent credit assignment policy and adopted ten points scale to grade learner's performance. Credit and grading based system was implemented for First Year of Engineering from the academic year 2012-2013. Subsequently this system will be carried forward for Second Year Engineering in the academic year 2013-2014, for Third Year and Final Year Engineering in the academic years 2014-2015 and 2015-2016 respectively.

Dr. S. K. Ukarande
Dean,
Faculty of Technology,
Member - Management Council, Senate, Academic Council
University of Mumbai, Mumbai

Preamble:

The overall technical education in our country is changing rapidly in manifolds. Now it is very much challenging to maintain the quality of education with its rate of expansion. To meet present requirement a systematic approach is necessary to build the strong technical base with the quality. Accreditation will provide the quality assurance in higher education and also to achieve recognition of the institution or program meeting certain specified standards. The main focus of an accreditation process is to measure the program outcomes, essentially a range of skills and knowledge that a student will have at the time of graduation from the program that is being accredited. Faculty of Technology of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

I, as Chairman, Board of Studies in Electrical Engineering of University of Mumbai, happy to state here that, Program Educational Objectives (PEOs) were finalized for undergraduate program in Electrical Engineering, more than twenty senior faculty members from the different institutes affiliated to University of Mumbai were actively participated in this process. Few PEOs were finalized for undergraduate program in Electrical Engineering are listed below;

- To provide the overall strong technical foundation to formulate, solve and analyse engineering problems during undergraduate program.
- To prepare students to demonstrate an ability to identify, formulate and solve electrical based issues.
- To prepare students to demonstrate an ability in the area of design, control, analyse and interpret the electrical and electronics systems.
- To prepare students for successful career in industry, research and development.
- To develop the ability among students for supervisory control and data acquisition for power system application.
- To provide opportunity for students to handle the multidisciplinary projects.
- To create the awareness of the life-long learning and to introduce them to professional ethics and codes of professional practice.

The affiliated institutes may include their own PEOs in addition to the above list

To support the philosophy of outcome based education, in addition to stated PEOs, objectives and expected outcomes are also included in the curriculum. I know, this is a small step taken to enhance and provide the quality education to the stake holders.

Chairman,
Board of Studies in Electrical Engineering,
University of Mumbai

Scheme for Semester VIII

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract./Tut.	Theory	Pract./Tut.	Total
EEC801	Design, Management and Auditing of Electrical Systems	4	2	4	1	5
EEC802	Drives and Control	4	2	4	1	5
EEC803	Power System Planning and Reliability	3	2	4	1	5
EEE80X	Elective- II	4	2	4	1	5
EEC805	Project- II	--	12 ##	--	6	6
Total		**15**	**20**	**16**	**10**	**26**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract. / oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg.					
EEC801	Design, Management and Auditing of Electrical Systems	20	20	20	80	03	25	--	125
EEC802	Drives and Control	20	20	20	80	03	25	25*	150
EEC803	Power System Planning and Reliability	20	20	20	80	03	25	--	125
EEE80X	Elective- II	20	20	20	80	03	25	--	150
EEC805	Project- II	--	--	--	--	--	50	100	150
Total		**--**	**--**	**80**	**320**	**--**	**150**	**125**	**700**

* **Includes both Practical and Oral examination**

X- **Indicates elective one to seven**

Work load of learner in Semester-VII is equivalent to 12 hrs / wk

Course Code	Elective I	Course Code	Elective II
EEE701	High Voltage Engineering	EEE801	Flexible AC Transmission Systems
EEE702	Analysis and Design of Power Switching Converters	EEE802	Electric and Hybrid Electric Vehicle Technology
EEE703	Power System Modelling	EEE803	Power Quality
EEE704	Digital Signal Controllers and its Application	EEE804	Smart Grid Technology
EEE705	Advanced Lighting Systems	EEE805	Power System Dynamics and Control
EEE706	Renewable Energy and Energy Storage Systems	EEE806	Non-linear Control System
EEE707	Optimization Techniques and its Applications	EEE807	Entrepreneurship Development

Project Guidelines

Project –I and II: Students groups and load of faculty per week

Project Groups: Students can form groups with minimum 3 (Three) and not more than 4 (Four)

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

Each faculty is permitted to take (guide) maximum 4 (Four) project groups.

- **Project oral must be conducted by appointing external examiner**

Note: This aspect is discussed in FOT, where project load for students in VII semester is 3 hrs and in VIII semester it is 6 hrs

University of Mumbai						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits assigned		
		Theory	Pract. /Tut.	Theory	Pract.tut.	Total
EEC801	Design, Management and Auditing of Electrical System (abbreviated as DMAES)	4	2	4	1	5

Course Code	Course Name	Examination Scheme							
		Theory					Term work	Pract. / Oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEC801	Design, Management and Auditing of Electrical System (abbreviated as DMAES)	20	20	20	80	03	25	-	150

Course Code	Course Name	Credits
EEC801	Design, Management and Auditing of Electrical System	**5**
Course Objectives	1) To give the students basic knowledge of designing electrical distribution network 2) To give the students basic knowledge of electrical energy audit in the distribution system	
Course outcomes	1) Students will be sizing, selecting transformer, switchgear and cable as required for distribution system 2) 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,	02
2	**Design of Power Distribution System** Different types of distribution systems and selection criteria, temporary and permanent power supply, electrical load size, L.F, D.F, future estimates, substation equipment's options, design considerations in transformer selection, sizing and specifications, IS standards applicable in above design	08

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, busbars design; Basics of selection of emergency/backup supplies, UPS, DG Set, Batteries; Preliminary design of interior lighting system. IS standards applicable in above designs	16
4	**Energy Monitoring and Targeting:** Defining monitoring and targeting. Elements of monitoring and 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.	04
5	**Energy Audit:** Introduction to Energy Conservation Act 2001 and ECBC 2007. 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**: Maximum Demand controllers, Automatic Power Factor Controllers, Energy Efficient Motors, Soft starters, Variable Speed Drives, Energy Efficient Transformer. Energy saving potential of each technology. **Energy Efficient System Design:** Lighting System; Use of Energy Management system (EMS) and Building Management System (BMS).	08

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.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Term work:

It is desirable to invite the Certified or Practicing Energy auditor to showcase and present some case-studies of actual energy audits carried out which will help the students to relate the course contents with actual practice. Two group (preferably group of 6-8 students) assignments

should be given to carry out the preliminary Electrical Energy Audit and appropriate report should be presented as a part of the term work

Term work shall consist of minimum six experiments/ tutorials and two group assignments.

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

Laboratory work (Experiments simulations/tutorials and Journal) :10 marks.
Group assignments :10 marks.
Attendance (Practical and Theory) : 5 marks.

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and minimum passing in the term-work.

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:

1. "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

University Of Mumbai						
Course Code	**Course Name**	**Teaching Scheme(Contact Hours)**		**Credits assigned**		
EEC802	Drives and Control (Abbreviated as DC)	Theory	Pract./Tut.	Theory	Pract.tut.	Total
		4	2	4	1	5

Course Code	Course Name	Examination Scheme							
		Theory					Term work	Pract/ Oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEC802	Drives and Control (Abbreviated as DC)	20	20	20	80	03	25	25*	150

Course Code	Course Name	Credits
EEC802	**Drives and Control**	**5**
Course Objectives	• To expose the students to the Engineering fundamentals of various Drives and its control, Dynamic operation and their Applications.	
Course outcomes	• Gain an ability to design and conduct performance experiments, as well as to identify, formulate and solve drives related problems.	

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	04
4	**DC Drives:** Review of Speed Torque relations for Shunt, Series and Separately excited Motors, Review of Starting, Braking (Regenerative, Dynamic, Plugging),	

	Review of Speed control, Controlled rectifier fed DC drives (separately excited only): Single phase fully-controlled Rectifier, Single phase Half controlled Rectifier, Three phase fully-controlled Rectifier, Three phase Half-controlled Rectifier, Dual Converter Control, Chopper Control – Motoring and Braking of separately excited and Series Motor. (No numerical from this module)	06
5	**AC Drives:** Induction Motor drives, Review of Speed-Torque relations, Review of Starting methods, Braking (Regenerative, Plugging and AC dynamic braking), Transient Analysis, Speed Control: Stator voltage control, Variable frequency control from voltage source, Static Rotor Resistance control, Slip Power Recovery - Static Scherbius Drive, Review of d-q model of Induction Motor, Principle of Vector Control, Block diagram of Direct Vector Control Scheme, Comparison of Scalar control and Vector control, Basic Principle of Direct Torque Control (block diagram) of induction motor. Introduction to Synchronous Motor Variable Speed drives.	18
6	**Special Motor Drives:** Stepper Motor drives- Types, Torque vs. Stepping rate characteristics, Drive circuits, Introduction to Switched reluctance motor drives and Brushless DC motor drives.	06

***Includes both Practical and Oral examination**

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.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Practical and Oral examination:

The distribution of marks shall be as follows:

Performance of Experiments : 15 marks

Oral examination : 10 marks

Term work:

Term work shall consist of minimum **Six** experiments and **Two** simulations, Assignments (minimum **Two**)

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

Laboratory work (experiments) :10 marks

Assignments : 10 marks

Attendance : 05 marks

The final certification and acceptance of term-work ensures the satisfactory performance of practical work and minimum passing in the term-work.

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. Special Electrical Machines by E.G. Janardanan, PHI

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.

List of Laboratory Experiments Recommended:

1. Measurement of Moment of Inertia by Retardation test
2. Study of different Speed Sensing, Current Sensing and Voltage Sensing devices.
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 3φ Induction Motor.
9. Simulation of V control and V/f control of Induction motor using PWM Inverter.
10. Transient Analysis of 3φ Induction Motor (Simulation)
11. Hands on Experience in Programming a general purpose 3φ Induction Motor Industrial Drive.
12. Demonstration of Vector Control of 3φ Induction Motor (Simulation).
13. Demonstration of Direct Torque Control of 3φ Induction Motor (Simulation).
14. Study of Special Motor Drives.

University of Mumbai						
Subject Code	**Subject Name**	**Teaching Scheme (Contact Hours)**		**Credits assigned**		
EEC803	Power System Planning and Reliability (abbreviated as PSPR)	Theory	Pract./Tut.	Theory	Pract./Tut.	Total
		3	2	3	1	4

Subject Code	Subject Name	Examination Scheme							
		Theory					Term work	Pract/ Oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEC803	Power System Planning and Reliability (abbreviated as PSPR)	20	20	20	80	03	25	-	125

Subject Code	Subject Name	Credits
EEC803	**Power System Planning and Reliability**	**4**
Course Objectives	• To understand the different power system planning and forecasting, techniques and reliability evaluation in terms of basic reliability indices.	
Course outcomes	• Should be able to make a Generation System Model for the Power system in terms of frequency and duration of failure. • Should be able to calculate reliability indices of the power system based on system model and the load curve. • Should be able 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, D.C load flow equation,	06

	Introduction to Successive Expansion and Successive Backward methods.	
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 and Frequency & Duration method**: Basic Probability Methods: Introduction, Generation system model, capacity outage probability table, recursive algorithm for rated and derated states, Evaluation of: loss of load indices, Loss of load expectation, Loss of energy. Frequency and Duration Method: Basic concepts, Numericals 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

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.

End Semester Examination: Some guidelines for setting the question papers are as: six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Term Work

Term Work shall consist of minimum 02 computer programs/simulations and six tutorials covering the entire syllabus.

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

Laboratory work (experiments)	:10 marks
Assignments	: 10 marks
Attendance	: 05 marks

The final certification and acceptance of term-work ensures the satisfactory performance of practical work and minimum passing in the term-work.

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 Book:

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

University of Mumbai						
Course Code	Course Name	Teaching Scheme(Contact Hours)		Credits assigned		
		Theory	Pract./Tut.	Theory	Pract.tut.	Total
EEE801	Flexible AC Transmission Systems (abbreviated as FACTS)	4	2	4	1	5

Course Code	Course Name	Examination Scheme							
		Theory					Term work	Pract./ Oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEE801	Flexible AC Transmission (abbreviated as FACTS)	20	20	20	80	03	25	-	125

Course Code	Course Name	Credits
EEE801	**Flexible AC Transmission**	**5**
Course Objectives	• To understand problems in high voltage AC transmission • To find solutions to various problems in AC transmission using power electronic devices.	
Course outcomes	• Students should be able suggest proper solution to mitigate the problems in power system	

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	6
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	12

	of controllable VAR generation, Variable impedance type static Var generator(TCR,TSR,TSC,FC-TCR), Switching converter type Var generators, basic operating principle	
4	**Static series compensation**: Objectives of series compensation- Variable impedance type series compensation(only TSSC) , 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

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.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Term work shall consist minimum Five Tutorials /and experiments and Three simulations.

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

Tutorial/experiments/simulations : 10 marks
Assignments : 10 marks
Attendance : 05 marks

The final certification and acceptance of term-work ensures the satisfactory performance of practical work and minimum passing in the term-work.

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

University of Mumbai						
Course Code	Course Name	Teaching Scheme(Contact Hours)		Credits assigned		
EEE802	Electric and Hybrid Electric Vehicle Technology (abbreviated as EHEVT)	Theory	Pract./Tut.	Theory	Pract.tut.	Total
		4	2	4	1	5

Course Code	Course Name	Examination Scheme							
		Theory					Term work	Pract./ Oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEE802	Electric and Hybrid Electric Vehicle Technology (abbreviated as EHEVT)	20	20	20	80	03	25	-	125

Course Code	Course Name	Credits
EEE802	**Electric and Hybrid Electric Vehicle Technology**	**5**
Course Objectives	• To introduces the fundamental concepts, principles, analysis and design of electric and hybrid electric vehicles.	
Course outcomes	• Students will understand the basics of new unconventional vehicular power systems, their current technology and future trends in automotive industry.	

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.	06
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.	06
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.	10

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.	08
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.	10
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	08

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.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Term work: Term Work will consist of four **assignments**, minimum two **simulations.**
The distribution of marks for the term work shall be as follows:

Laboratory work (simulations/experiments) :10 marks
Assignments : 10 marks
Attendance : 05 marks

The final certification and acceptance of term-work ensures the satisfactory performance of practical work and minimum passing in the term-work.

Books Recommended:

Reference Book:

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. J. Larminie and J. Lowry, *Electric Vehicle Technology Explained*, Wiley, 2003
4. C. MI, M. Abul and D. W. Gao, *Hybrid Electrical Vehicle Principles and Application with Practical Perspectives,*
5. B.D. McNicol and D.A.J. Rand, *Power Sources for Electric Vehicles,* Elsevier Publications. *1998*
6. N.Mohan, T.M.Undeland, W.P Robbins, *Power Electronics, Converters, Applications & Design,* Wiley India Pvt. Ltd., 2003
7. Modern Power Electronics and AC Drives by B. K Bose, Pearson Education

Website Reference:

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

University of Mumbai						
Course Code	Course Name	Teaching Scheme(Contact Hours)		Credits assigned		
EEE803	Power Quality (abbreviated as PQ)	Theory	Pract./Tut.	Theory	Pract.tut.	Total
		4	2	4	1	5

Course Code	Course Name	Examination Scheme							
		Theory					Term work	Pract. /Oral	Total
		Internal Assessment			End Sem. Exam	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEE803	Power Quality (abbreviated as PQ)	20	20	20	80	03	25	-	125

Course Code	Course Name	Credits
EEE803	**Power Quality**	**5**
Course Objectives	• To get awareness about non-linear loads in power system • To understand how non-linear loads affects power quality • To study the solution to improve power quality	
Course outcomes	• Students should be able to analyze the problems due to non-linear load and suggest solution for the same	

Module	Contents	Hours
1	**Introduction:** Disturbances, Unbalance, Distortion, Voltage Fluctuations, Flicker, Quality Assessment	06
2	**Harmonics:** Definition of harmonics, odd and even harmonics, Harmonic phase rotation and phase angle relationship, Causes of voltage and current harmonics, non-sinusoidal voltage and current waveform equations(numerical included), individual and total harmonic distortion with problems, Power assessment under waveform distortion with numerical	10
3	**Power Quality monitoring & standards:** Introduction, transducers current transformers, voltage transformers, Power quality instrumentation, Harmonic monitoring, Power quality standards IEEE 519	06
4	**Effects of harmonics:** Rotating Machines – Transformers – Cables – Capacitors – Harmonic resonance – Voltage Notching – EMI (Electromagnetic Interference) –	06

	Overloading of Neutral conductor– Protective relays and Meters	
5	**Power factor and its improvement under sinusoidal and non-sinusoidal conditions:** Power factor when both voltage and current sinusoidal, Power factor compensation using capacitor (vector diagram and numerical included), power factor when voltage is sinusoidal and current is non-sinusoidal (numerical included), Effect of capacitor compensation in power factor improvement under non-sinusoidal condition.	12
6	**Harmonic mitigation and power factor improvement** Mitigation of harmonics- Passive filters- Advantages and disadvantages of passive filters- Active filters-shunt connection, series connection and hybrid connection(Detailed diagram with inverters and its working), Power factor improvement using shunt active filter(both reactive power and harmonic power compensation), Generating reference currents for shunt active filter using Instantaneous PQ Theory	08

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.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Term work shall consist of minimum **Six** tutorials/experiments and **Two** simulations,

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

Laboratory work (simulations/experiments) :10 marks
Assignments : 10 marks
Attendance : 05 marks

The final certification and acceptance of term-work ensures the satisfactory performance of practical work and minimum passing in the term-work.

Books Recommended:

Text Books:

1. "Power System Quality Assessment", J. Arrillaga, N.R.Watson, S.Chen
2. "Power Quality" , C. Shankaran, CRC press
3. "Reactive power control in electric systems" by Timothy J. E. Miller
4. "Power Quality Enhancement Using Custom Devices" Arindam Ghosh, Gerard Ledwich
5. "Power Electronics" Ned Mohan, Undeland, Robbins, John Wiley Publication
6. "Power System Analysis- Short Circuit Load Flow and Harmonics" J.C.Das.

7. “Understanding Power Quality Problems,Voltage Sag and Interruptions ” Math H.J.Bollen

Reference Book:

a. “Power System Harmonics” Jos Arrillaga, Neville R Watson
b. “Electric Power Quality” , G.T.Heydt
c. “Electric Power Systems and Quality” , Roger C. Dugan,Mark F. McGranaghan, H.Wayne Beaty
d. “IEEE-519 Standard”

University of Mumbai						
Course Code	**Course Name**	**Teaching Scheme(Contact Hours)**		**Credits assigned**		
EEE804	Smart Grid Technology (abbreviated as SMT)	Theory	Pract./Tut.	Theory	Pract.tut.	Total
		4	2	4	1	5

Course Code	**Course Name**	**Examination Scheme**							
		Theory					Term work	Pract./ Oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEE804	Smart Grid Technology (abbreviated as SMT)	20	20	20	80	03	25	-	125

Course Code	**Course Name**	**Credits**
EEE804	**Smart Grid Technology**	**5**
Course Objectives	• To impart knowledge of futuristic power grid technology and the path on which development is taking place.	
Course outcomes	• Students will get an exposure to the fundamentals of various technologies and tools which will play vital role in formation of the Smart grids in near future.	

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.	08
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 Vehicles(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	08

	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. Smart storage like Battery, SMES, Pumped Hydro, Compressed Air Energy Storage. 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, Power Quality Audit.	08
6	**Communication Technology for Smart Grid:** Home Area Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN). Bluetooth, ZigBee, GPS, Wi-Fi, Wi-Max based communication; Wireless Mesh Network, Basics of CLOUD Computing & Cyber Security for Smart Grid. IP based protocols.	08

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.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Term work:

Term work shall consist of minimum six tutorial/simulations and assignments (Min Two).

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

Laboratory work (experiments) :10 marks
Assignments : 10 marks
Attendance : 05 marks

The final certification and acceptance of term-work ensures the satisfactory performance of practical work and minimum passing in the term-work.

Books Recommended:

Text Books:

1. Smart Grid:Fundamentals of Design and Analysis by James Momoh, IEEE Press and Wiley Publications
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. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", Wiley
5. Jean Claude Sabonnadière, Nouredine Hadjsaïd, "Smart Grids", Wiley Blackwell

University Of Mumbai						
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**		**Credits assigned**		
EEE805	Power System Dynamics and Control (PSDC)	Theory	Pract./Tut.	Theory	Pract.tut.	Total
		4	2	4	1	5

Course Code	Course Name	Examination Scheme							
		Theory					Term work	POE	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEE805	Power System Dynamics and Control (PSDC)	20	20	20	80	03	25	-	125

Course Code	Course Name	Credits
EEE805	**Power System Dynamics and Control**	**5**
Course Objectives	• To study the system dynamics and its control which has a significant bearing on integrality of the system following major disturbances.	
Course outcomes	• The students will be able to analyse system dynamics and its control	

Module	Contents	Hours
1	**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.	14
2	**Excitation System:** 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
3	**Small Signal Stability (SSS):** Fundamental concept of stability of dynamic system, Eigen properties of state matrix, SSS of single machine infinite bus system, Effect of AVR on synchronizing and damping torque, Power system stabilizer, SSS of multi-machine system, Special techniques to analyze large system, Characteristics	12

	of SSS, SSS Enhancement.	
4	**Voltage Stability:** Basic concepts, Voltage collapse, Voltage stability analysis, Prevention of voltage collapse.	12

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.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Term work:

Term Work shall consist of minimum four, computer programs or four Simulations, and four tutorials covering the entire syllabus.

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

Laboratory work (experiments) :10 marks
Assignments : 10 marks
Attendance : 05 marks

The final certification and acceptance of term-work ensures the satisfactory performance of practical work and minimum passing in the term-work.

Recommended Computer Simulations:

1. Demonstration of the Three-Phase Programmable Source, Sequence Analyzer, and abc_dq0 transformation blocks.
2. Synchronous generator powered by hydraulic turbine with excitation and governor systems.
3. Torque amplification study: IEEE second benchmark on sub synchronous resonance (case 1A)
4. Performance of Three PSS for Inter area Oscillations.
5. Transient stability of a two-machine transmission system with Power System Stabilizers (PSS) and Static Var Compensator (SVC).

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.

3. Anderson P.M, Fouad A.A, Power System Control and Stability, Wiley Inter-Science, 2008 Edition
4. Saur P W, Pai M A, Power System Dynamics and Stability, Pearson Education Asia
5. Pai, Sen Gupat, Padiyar, Small Signal Analysis of Power System, Narosa Publication, 2007 Edition.

University of Mumbai						
Course Code	**Course Name**	**Teaching Scheme(Contact Hours)**		**Credits assigned**		
EEE806	Nonlinear control system (abbreviated as NCS)	Theory	Pract./Tut.	Theory	Pract.tut.	Total
		4	2	4	1	5

Course Code	Course Name	Examination Scheme							
		Theory					Term work	Pract./ Oral.	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEE806	Non-linear control system (abbreviated as NCS)	20	20	20	80	03	25	-	125

Course Code	Course Name	Credits
EEE806	Non-linear control system	**5**
Course Objectives	• The aim of the course is to learn to recognize nonlinear control problems, to master the most important analysis techniques for nonlinear systems, and to learn how to use practical tools for nonlinear control design.	
Course Outcomes	• Students will have knowledge of the complexity of nonlinear systems and various tools for the analysis and control of nonlinear systems.	

Module	Contents	Hours
1	Characteristics of nonlinear systems, multiple equilibria, limit cycle, jump phenemona, method of analysis, clasisification of nonlinearities, Common Physical Nonlinearities.	06
2	**Phase Plane Analysis**: Phase Plane Method, phase portraits, Analytical Methods for the Construction of Phase Trajectories, Graphical Method of Construction of Phase Trajectory, Qualitative behavior of Linear systems, phase plane analysis of nonlinear systems, Multiple equilibria, existence of limit cycles, Linearization techniques.	08
3	**Describing Function Analysis of Nonlinear Systems**: Introduction, Basic Definition of Describing Function, Basis of Describing Function Analysis, Describing Function for Typical Nonlinearities (saturation, dead zone, relay, backlash, hysteresis) , Closed Loop Stability Using Describing Function, Stability of the Limit Cycles, Relative Stability from Describing Function.	08
4	**Stability of Systems**: Concept of stability, Stability analysis of autonomous and nonautonomous systems. LaSalle Invariance Principle, stability in the	12

	sense of Lyapunov and absolute stability. Zero - input and BIBO stability. Second (or direct) method of Lyapunov stability theory for continuous and discrete time systems.	
5	**Passivity**: Power and energy of passive systems, Definitins, passivity and small gain, Passivity of linear time invariant systems, strictly positive real functions .	06
6	**Frequency domain analysis of feedback systems**: Circle, popov criteria, Popov's stability criterion, generalized circle criterion,	08

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.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Term work: Term work should consist of four programs/simulation and one test paper.

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

Practical Work (Design, drawing sheets, report on recent trends) :10 marks
Assignments :10 marks
Attendance :05 marks

The final certification and acceptance of term-work ensures the satisfactory performance of practical work and minimum passing in the term-work.

Books Recommended:

Text books:

1. Nonlinear Systems: Third Edition by H. Khalil, 2002.
2. M. Vidyasagar Nonlinear System Analysis, Second Edition, Prentice Hall.
3. Modern Control Engineering by Dr. K. P. Mohandas, Sanguine publishers,
4. Non linear control systems Analysis and design, Horacio Márquez, John Wiley and sons Introduction to Programmable Logic Controller by Dunning G, Delmar Thomson Learning , 2nd edition

Reference books:

1. Modern control system engineering by K. Ogata, printice Hall.
2. Automatic Control System: George J. Thaler Brown, Jaico Publications
3. Control Systems Theory and Application: Samarjit Ghosh, Pearson Education
4. Systems & Control , Stanislaw H. Zak, Oxford

University of Mumbai						
Course Code	Course Name	Teaching Scheme(Contact Hours)		Credits assigned		
		Theory	Pract./Tut.	Theory	Pract.tut.	Total
EEE807	Entrepreneurship Development (Abbreviated as ED)	4	2	4	1	5

Course Code	Course Name	Examination Scheme							
		Theory					Term work	Pract. / Oral	Total
		Internal Assessment			End Sem. Exam .	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEE807	Entrepreneurship Development (Abbreviated as ED)	20	20	20	80	03	25	-	125

Course Code	Course Name	Credits
EEE807	**Entrepreneurship Development**	**5**
Course Objectives	• To understand the concept and process of Entrepreneurship, its contribution, role in the growth & development of individual and the nation.	
Course Outcomes	• Acquiring Entrepreneurial knowledge &Spirit and be Enterprising in all walks of life	

Module	Contents	Hours
1	**Entrepreneurship Concept:** Entrepreneur, Entrepreneurship, Rural Entrepreneurship, Women Entrepreneurship, Factors affecting Entrepreneurial growth, Motivation, competencies, mobility, EDPs.	06
2	**Start-UP:** Small Enterprises an introduction to framework, Ownership structures, Retail Entrepreneurship in India, Pre-feasibility Analysis, Project identification and selection, Project formulation, Project Appraisal, Financing of Enterprises, Feasibility report preparation and evaluation criteria	12
3	**Support:** Institutional finance to Entrepreneurs, Lease financing and hire purchase, Institutional support to Entrepreneurs, Taxation benefits to Small scale industries, Government Policies & Regulations, International Business.	10

4	**Business Management:** Nature and scope, Fundamentals of Management, Management of Working Capital, Inventory, Production & operation, Marketing, Human Resource and TQM.	10
5	**Monitoring and Evaluation of Business:** Accounting, Growth strategies, sickness in small business, e-commerce, Franchising, Intellectual Property Rights.	06
6	**Case studies:** Case studies of Entrepreneurs, Model proposals and Feasibility reports to be discussed.	04

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.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Term work: Term work should consist of Minimum of 6 Tutorials / Practicals Recommended:

1) Case study on an important topic in each module to be prepared by the students
2) At the end of semester, a complete Business Proposal report to be submitted and presented by the students.

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

Practical Work (Design, drawing sheets, report on recent trends) :10 marks
Assignments :10 marks
Attendance :05 marks

The final certification and acceptance of term-work ensures the satisfactory performance of practical work and minimum passing in the term-work.

Books Recommended:

Text Books:

1. Entrepreneurial Development, S.S.Kanaka, S.Chand & Company
2. Entrepreneurship Development, SL Gupta, Arun Mittal, International Book House, Pvt Ltd
3. Entrepreneurship, Rober D.Hisrich, Michael P.Peters, Dean.A.Shepherd,Tata McGraw-Hill

Reference Books:

1. Entrepreneurship, Rajeev Roy, OXFORD university Press
2. Entrepreneurship-Creating & Leading an Entrepreneurial organization, Arya Kumar, Pearson

3. Entrepreneurship-A south Asian Perspective, DF Kuratko, TV Rao, Cengage Learning
4. Entrepreneurship Development in India , Dr.CB Gupta, Dr.NP Srinivasan, Sultan Chand & Sons