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Item No. – 4.28

UNIVERSITY OF MUMBAI

Bachelor of Engineering

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

(REV- 2012) TE from A.Y. 2014 -15 and BE 2015-16,

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 VII

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract./Tut.	Theory	Pract./Tut.	Total
EEC701	Power System Operation and Control	4	2	4	1	5
EEC702	High Voltage DC Transmission	3	2	3	1	4
EEC703	Electrical Machine Design	4	2	4	1	5
EEC704	Control System – II	4	2	4	1	5
EEE70X	Elective I	4	2	4	1	5
EEC706	Project- I	--	6#	--	3	3
Total		**19**	**16**	**19**	**8**	**27**

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.					
EEC701	Power System Operation and Control	20	20	20	80	03	25	--	125
EEC702	High Voltage Transmission	20	20	20	80	03	25	--	125
EEC703	Electrical Machine Design	20	20	20	80	03	25	25	150
EEC704	Control System – II	20	20	20	80	03	25	25*	150
EEE70X	Elective I	20	20	20	80	03	25	--	125
EEC706	Project- I	--	--	--	--	--	50	--	50
Total		**--**	**--**	**100**	**400**	**--**	**175**	**50**	**725**

*** Includes both Practical and Oral examination**

X- **Indicates elective one to seven**

 # workload of learner in sem-VII is equivalent to 6 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: (Four) Students can form groups with minimum 3 (Three) and not more than 4

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
EEC701	Power System Operation and Control (Abbreviated as PSOC)	4	2	4	1	5

Course Code	Course Name	Examination Scheme			
		Theory	Term	Pract./	Total

							work	Oral.	
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEC701	Power System Operation and Control (Abbreviated as PSOC)	20	20	20	80	03	25	-	125

Course Code	Course Name	Credits
EEC701	**Power System Operation and Control**	**5**
Course Objectives	• To impart knowledge in power system operation and its control. • To study steady state and transient analysis in power system.	
Course outcomes	• Student should be capable to analyze power system problem and find out its solutions.	

Module	Contents	Hours
1	**Load Flow Studies:** Network model formulation, Y bus formation and singular matrix transformation. Load flow problem, Gauss Seidel (GS) methods. Newton Raphson methods (NR) (Polar, Rectangular form). Decoupled, Fast Decoupled load flow and comparison. Concept of DC loads flow.	10
2	**Economic System Operation:** Generator operating cost:- input-output, Heat rate and IFC curve, Constraints in operation, Coordinate equation, Exact coordinate equation, Bmn coefficients, transmission loss formula. Economic operation with limited fuel supply and shared generators, Economic exchange of power between the areas Optimal unit commitment and reliability considerations	08
3	**Automatic Generation and control:** Load frequency control problem, Thermal Governing system and transfer function. Steam Turbine and Power system transfer function. Isolated power system:- static and dynamic response PI and control implementation Two area load frequency control, static and dynamic response Frequency biased Tie line Bias control-implementation and effect Implementation of AGC, AGC in restructured power system, under frequency load shedding, GRC, Dead band and its effect.	12
4	**Inter Change of Power and Energy:** Multiple utility interchange transaction, Other types of transactions, Power Pool.	04
5	**Power System Stability:**	10

	Types of Stability Study, Dynamics of synchronous machine, Power angle equation, Node elimination technique, Simple Systems, Steady state stability, Transient stability, Equal area criteria and its applications, Numerical solution of swing equation, Modified Euler's method.	
6	**Voltage stabilty:** Introduction, reactive power transmission, short circuit capacity, Problems of reactive power transmission, rotor angle stability and voltage stability, surge impedance loading, P-V and V- Q curve, various methods of voltage control –shunt and series compensation. Voltage Control- Tap changing transformers, Booster transformers, Static voltage compensators, Thyristorised series voltage injection	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 four programs or four Simulations based on above syllabus 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.

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 Edition 2008.
5. Allen. J. Wood., Bruce. F. Wollenberg., 'Power Generation operation and Control', Wiley India, Second Edition, 2007.
6. Prabha Kundur , 'Power System Stability and Control' , TMH Publication,2008.

Reference Books:

1. Soman. S. A, Kharphade. S. A, and Subha Pandit 'Computer Methods for Large Power System Analysis, an Object Oriented Approach', Kluwer Academic Publisher New York 2001
2. Anderson P.M, Fouad A.A, 'Power System Control and Stability', Wiley Inter-Science, 2008 Edition
3. Kimbark E W, 'Power System Stability', Volume I, and III, Wiley Publication.
4. Jr W.D. Stevenson., G. J. Grainger. 'Elements of Power System'. Mc-Graw-Hill, Publication.
5. Hadi Saadat, Power System Analysis**,** TMH Publication ,Second Edition, 2002
6. S.Sivanagaraju, G.Sreenivasan Power System Operation and Control, pearson Publication,2010.

Recommended Programs and Simulations

1. Y bus formation by singular matrix transformation Y bus formation by adding one element at a time.
2. Gauss Siedel Load flow
3. Optimal loading of generator
4. Transient stability of single machine.
5. Simulation of LFC of Isolated power system under different conditions
6. Simulation of LFC of Two Area power system under different conditions

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits assigned		
		Theory	Pract./Tut.	Theory	Pract.tut.	Total
EEC702	High Voltage DC Transmission (Abbreviated as HVDCT)	3	2	3	1	4

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					
EEC702	High Voltage DC Transmission (Abbreviated as HVDCT)	20	20	20	80	03	25	-	125

Course Code	Course Name	Credits
EEC702	**High Voltage DC Transmission**	**4**
Course Objectives	• To give the students in depth knowledge of the configuration and working of HVDC system	
Course outcomes	• Student should able to analyze HVDC system and its impact on existing power system.	

Module	Contents	Hours
1	**Introduction to HVDC transmission**: Early discoveries and applications, , Limitation and advantages of AC and DC transmission, Economic factors, Classification of HVDC links, Components HVDC Transmission system, Application of DC transmission , Ground Return Advantages and Problems	4
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 60^0, Relation between AC and DC quantities, Analysis with overlap greater than 60^0, Rectifier operation and inverter operation, Equivalent circuit of rectifier and inverter, Multi bridge converter, Numerical from converter circuits and multiple bridge converter.	10
3	**Control:** Basic means of control, Limitation of manual control, Constant current verses constant voltage control, Desired features of control, Actual control characteristics, Significance of current margin, Power reversal, Alternative	6

	Inverter Control Mode.	
4	**Converter Firing Control:** Control Implementation, Converter Firing Control Schemes.	4
5	**Faults and protection:** Malfunction of mercury arc valves, By pass valves:- transfer of current from main valves to bypass valves and back to main valves (both rectifier and inverter), Commutation failure: causes and analysis, double commutation failure, Protection against over current, over voltage, Surge arrester.	8
6	**Harmonics & Filters:** Characteristics Harmonics and Un-Characteristics Harmonics, Causes, Consequences, Trouble Caused by Harmonics, Means of Reducing Harmonics, Filters, AC & DC Filters.	4

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 two programs or two Simulations based on above syllabus and six tutorials covering the entire syllabus

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

Simulation/programs and tutorial : 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. 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

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)"

University of Mumbai						
Course Code	Course Name	Teaching Scheme(Contact Hours)		Credits assigned		
EEC703	Electrical Machine Design (abbreviated as EMD)	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					
EEC703	Electrical Machine Design (abbreviated as EMD)	20	20	20	80	03	25	25	150

Course Code	Course Name	Credits
EEC703	**Electrical Machine Design**	**5**
Course Objectives	• To impart knowledge of various aspects of Electrical Machine Design and make them aware of recent trends in design.	
Course outcomes	• Students will be able to relate the physical dimensions of different parts of the machine to the rating • Students will be exposed to the optimization in design.	

Module	Contents	Hours
1	**Introduction**: Introduction to machine design, Magnetic, Electrical, Conducting and Insulating materials used in machines.	05
2	**Design of Single phase and Three phase transformers** Review on construction and parts of transformer, Output equation, Main Dimensions, Specific electric and magnetic loadings, Design of core, Selection of the type of winding, Design of LV and HV windings, Design of insulation,	10
3	**Performance measurement of Transformers:** Resistance and leakage reactance of the winding, Mechanical forces, No load current; Cooling of transformers – design of cooling tank and tubes/ radiators, IS: 1180, IS: 2026.	08
4	**Design of Three phase Induction motors:**	10

	Output equation, Choice of specific electric and magnetic loadings, Standard frames, Main dimensions, Design of stator and rotor windings, Stator and rotor slots, Design of stator core, air gap, Design of squirrel cage rotor, end rings, Design of wound rotor, Types of enclosures.	
5	**Performance measurement of three phase Induction motors:** Calculation of leakage reactance for parallel sided slot, Carter's coefficients, Concept of B_{60}, Calculation of No load current, Short circuit current, Calculation of maximum output from Circle diagram, Dispersion coefficient, IS325, IS1231, IEC 60034. Design criteria of Energy efficient Induction motor.	09
6	**Design examples of Transformers and Induction Motors.**	06

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 following:

1. The complete design of one Three phase transformer and one Three phase induction motor with standard frame size; Minimum four sheets (full imperial size) covering the diagrams of individual parts and the assembled views. At least one sheet should be using AUTOCAD. Design should be based on the Indian Standard Specifications.
2. A combined report (group of maximum four students) on recent trends in transformer and induction machine manufacturing should be submitted.
3. Minimum three assignment covering complete 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. A.K. Sawhney, "Electrical Machine Design", Dhanpat Rai & Co
2. M.V.Deshpande, "Design and Testing of Electrical Machines", PHI Learning.
3. M.G.Say, "Performance & Design of AC Machines", Pitman

4. Indrajit Dasgupta, “Design of Transformers”, TMH

Reference Book:

1. K.L.Narang, “Electrical engineering Drawing”, Satya Prakashan, New Delhi
2. K.G. Upadhyay, “Design of Electrical Machines “, New age publication.

University of Mumbai						
Course Code	**Course Name**	**Teaching Scheme(Contact Hours)**		**Credits assigned**		
EEC704	Control System _ II (abbreviated as CS - II)	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					
EEC704	Control System – II (abbreviated as CS - II)	20	20	20	80	03	25	25*	150

Course Code	Course Name	Credits
EEC704	**Control System – II**	**5**
Course Objectives	• Learning how to improve performance of any system using various techniques like state space , Bode plot, and Digital control • Learning the automation of systems using PLC.	
Course outcomes	• Students will have knowledge of different compensating methods and the automation of basic systems using PLC	

Module	Contents	Hours
1	**Introduction to controllers and controllers Design**: Lag, lead and lead-lag network, cascade and feedback compensation and concept of Proportional, Integral and derivative controllers (all these with no numerical), design of gain compensation, lag, lead, lag-lead compensators through frequency response technique (simple design problems).	06
2	**PID controllers**: Introduction to different form of PID controllers, textbook and industrial form, issues in implementation of industrial PID, and modifications in the form of PID controllers, reverse acting controller.	04
3	**Design Via state Space**: Introduction to controller design via gain adjustment, controllability, alternative approach to controller design, introduction to observer(estimator), observability, alternative approach to observer design, steady state error design via integral control.	12
4	**Digital control System:** introduction to digital control system, Modeling the digital computer, Pulse transfer function, Block diagram reduction, concept of stability in digital control system, Digital system stability via the s-plane (using Routh-Hurwitz) Steady state error, Transient response on Z	10

	plane (no numerical), cascade compensation via s-plane, implementation of digital compensator.	
5	**Programmable Logic Controllers**: Introduction to PLC, Input output field devices, block diagram of PLC, input output module, power supply, programming unit, processing unit, rack assembly, memory unit, relay ladder logic circuit , addressing modes in PLC, relationship of data file to I/O module.	06
6	**Fundamentals of PLC programming**: PLC program execution, ladder diagram programming language, instructions set of PLC, simple programs using these instructions, jump and loop instruction, shift instruction, troubleshooting PLC.	10

***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 should consist of four practical on PLC, four programs / simulation on rest of the syllabus 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. Control system engineering by Norman Nise 2nd to latest edition
2. Control Engineering: An Introductory course by Wilkie J., Johnson M., Katebi R., Palgrave MacMillan, Ist to latest edition
3. Industrial Control Electronics: Devices, Systems and Applications by Bartelt, Delmar Thomson Learning, 1st edition

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

Reference books:

1. Modern control Engineering by Richard C Dorf, SH Bishop, Wesley edition eighth Edition
2. Linear Control system Analysis and design with MATLAB, by J.J. Azzo, C. H. Houpis, S.N. Sheldon, Marcel Dekkar, ISBN 0824740386
3. Control System Engineering, Shivanagraju s. Devi L., New age International latest edition
4. Control System engineering by Nagrath and Gopal, 5th to latest edition , Wiley Eastern
5. Modern control system engineering by K. Ogata, printice Hall.
6. Automatic control systems, Basic analysis and Design, William A. Wolovich, Oxford
7. Process Control principles and applications, Surekha Bharot, Oxford Higher education

University Of Mumbai						
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**		**Credits assigned**		
EEE701	High Voltage Engineering (Abbreviated as HVE)	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					
EEE701	High Voltage Engineering (Abbreviated as HVE)	20	20	20	80	03	25	-	125

Course Code	Course Name	Credits
EEE701	**High Voltage Engineering**	**5**
Course Objectives	• To provide an understanding of high-voltage phenomena and to present the basic of high-voltage insulation design and testing • To understand the modern numerical tools available in high-voltage equipment design.	
Course outcomes	• Able to know the fundamentals properties of the materials and their failure mechanisms to get appropriate and optimal design. • Students will be aware 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 electrical field intensity in Homogenous Isotropic Single dielectric and multi dielectric system, Numerical methods-Finite difference, Finite Element and Charge simulation methods for the estimation of Electric Field Intensity, Surge voltage, their distribution and control	06
2	**Conduction and breakdown in air and other gaseous dielectrics in electric fields:** Collision Processes, Ionization processes, Townsend's current growth equation-Primary and secondary processes, Townsend's criterion for	09

	breakdown in electronegative gases. Limitation of Townsend's theory, Paschen's law, Breakdown in non-uniform fields and corona discharges, Post-breakdown phenomenon and application, Practical considerations in using gas for insulation purposes.(Numerical on Townsend's theory, Paschen's law)	
3	**Breakdown in liquid and solid dielectrics** Liquid Dielectrics, Conduction and breakdown in pure liquids, Conduction and breakdown in commercial liquids. Solid dielectrics, Intrinsic, Electro-mechanical and Thermal breakdown, Breakdown of solid dielectrics in practice**,** Breakdown of composite insulation, Properties of composite dielectrics**,** Solid dielectrics used in practice, Application of insulating materials in electrical power apparatus, electronic equipments.	8
4	**Generation & Measurement of High voltage and Currents:** Generation of HV DC, HV AC and Impulse voltage, Generation of impulse currents, Tripping and control of impulse generators, Measurement of HVDC-High ohmic series resistance with micro-ammeter, HVAC and impulse voltage-Resistance and capacitance voltage dividers, Spark gap for measurement of High DC, AC and impulse voltages. Measurement of High DC, AC and impulse currents (Numerical based on impulse generation, high DC voltage generation, optimum number of stages).	11
5	**Testing and evaluation of dielectric materials and power apparatus:** Non-destructive testing of dielectric materials, DC resistivity measurement, Dielectric and loss factor measurement, Partial discharge measurement, Testing of insulators, bushing, isolators, circuit breakers, cable, transformers, high voltage motors , surge diverters, Radio interference measurement.	10
6	**High Voltage laboratory–design, planning and layout:** Size and dimensions of the equipment and their layout, Classification of HV laboratory, Earthing and its importance.	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 would consists of at least 02 practical/02 simulations/ a report on visit to any HV lab and 06 assignments

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. Naidu M. S. and Kamraju V., high voltage engg. TMH publications second ed.,1995
2. Wadhwa C. L. ,High voltage engg ,Wiley Eastern ltd., first ed., 1994
3. Kuffel E. and Abdullah M. 'Introduction to High voltage engg, Pergamon, 1970.
4. Kuffel E. 'High voltage engg, Pergamon, 1984.

Reference Books:

1. E. Kuffel, W. S. Zaengl and J. Kuffel High Voltage Engineering Fundamentals Second Edition Elsevier Publication
2. Dieter Kind and Kurt Feser High Voltage Test Techniques (SBA Electrical Engineering Series) by Shankars Book Agency Pvt. Ltd.

University of Mumbai						
Course Code	Course Name	Teaching Scheme(Contact Hours)		Credits assigned		
EEE702	Analysis and Design of Power Switching Converters (abbreviated ADPSC)	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					
EEE702	Analysis and Design of Power Switching Converters (abbreviated ADPSC)	20	20	20	80	03	25	-	125

Course Code	Course Name	Credits
EEE702	**Analysis and Design of Power Switching Converters**	**5**
Course Objectives	• To make students understand the concepts and basic operation of efficient switched-mode power conversion, including basic circuit operation, analysis of different conduction modes and magnetics design.	
Course outcomes	• Gain knowledge in design of converters including selection of various components and fabrication converters for specific applications	

Module	Contents	Hours
1	**Basic DC to DC converters:** Buck Converter, Boost Converter, Buck – Boost , Continuous (CCM) and Discontinuous mode(DCM) of operation, boundary between CCM and DCM, CUK converter, introduction to SEPIC converter, Calculation of output voltage ripple, Numericals	10
2	**Switching Power Supplies:** Overview of switching power supplies, Isolated dc/dc converters, Transformer core utilization, - Fly back and Forward Converters– duty	08

	cycle derivation, waveforms, Comparison of converters, Numericals	
3	**Control Aspects:** Voltage mode control- PWM and feed forward control, Current mode control, Slope compensation, comparison of voltage and current mode control, Power supply protection, Electrical isolation in the feedback loop, Designing to meet power supply specifications, PI and Type III controllers	04
4	**Converter Design:** Selection of output filter capacitor, Selection and design of high frequency Inductor and high frequency transformer, Selection of switches, Snubber circuit design, PWM ICs, Design of driver circuits, Necessity of EMI filter, Thermal resistance , Selection of Heat sinks , Simple heat sink calculations	12
5	**Switched mode inverters:** Review of single phase and three phase bridge inverters, PWM techniques, Detailed analysis of sinusoidal PWM- Effect of m_a and m_f, Analysis of harmonic spectrum, Space vector modulation- switching sequence, duration of zero and active vectors, Introduction to multilevel inverters	08
6	**Applications:** DC/DC converter as Power factor Corrector (active shaping of the line current), in Renewable energy systems , Applications of inverters in power systems, renewable energy systems, drives etc.	06

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: Mini project on "Design, Implementation and Testing of a dc to dc converter for specific application"

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) Mohan N. Undeland . T & Robbins W., “Power Electronics Converters , Application and Design” John Wiley, 3rd edition
2) Umanand L., Bhat S.R., “Design of magnetic components for switched Mode Power converters” , Wiley Eastern Ltd.
3) “Power Electronics: Devices, Circuits and Matlab Simulations” by Alok Jain, Penram International publishing (India Pvt, Ltd)
4) “Power Electronics”, Joseph Vithayathil, Tata McGrawhill
5) “Power Electronics” M.H.Rashid, Prentice-Hall of India

Reference Books:

1. Robert. W. Erickson, D. Maksimovic “Fundamentals of Power Electronics”, Springer International Edition,
2. Philip T Krein, “Elements of power electronics”, Oxford University Press
3. Billings K.H., “Handbook of Switched Mode Power Supplies”, McGraw Hill
4. IEEE Transactions on Power Electronics

University of Mumbai						
Course Code	Course Name	Teaching Scheme(Contact Hours)		Credits assigned		
EEE703	Power System Modelling (abbreviated PSM)	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					
EEE703	Power System Modelling (abbreviated PSM)	20	20	20	80	03	25	-	125

Course Code	Course Name	Credits
EEE703	**Power System Modelling**	**5**
Course Objectives	• To impart the knowledge of mathematical modeling of electrical power system • To study the steady state and dynamic behavior of power system	
Course outcomes	• Students will be familiar with modeling of different elements of power system • They will be able to do the system planning and expansion for future demand in power system	

Module	Contents	Hours
1	**Introduction:** Components of power system, Need for power system modeling, dqo transformation, α-β transformation.	4
2	**Synchronous machine modeling:** Physical description, Mathematical description of synchronous machine in abc frame of reference, synchronous machine model in dq0 frame of reference (rotating frame) and pu representation.	12
3	**Excitation system modeling:** Excitation system requirements, Elements of excitation system, Types of excitation system and modeling of excitation systems.	6

4	**Transmission line and Transformer modeling:** Transmission line, d-q transformation using α-β variables. Transformer modeling such as auto-transformer, tap-changing & phase-shifting transformer.	10
5	**SVC and Load modeling:** Static VAR compensators, Basic concept of load modeling, modeling of induction motor.	8
6	**Modeling of non-electrical component:** Simplified models of non-electrical components like boiler, steam & hydro-turbine & governor system.	8

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 following minimum **Eight** experiments, Assignments (minimum **Two**).

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:

Reference Books:

1. Power System Dynamics & Control – Kundur, IEEE Press , New York
2. Power System Operation & Control – P.S.R. Murthy
3. "Electrical Energy System Theory – an introduction" by Olle Elgerd. TMH Publishing Company 2nd Edition, New Delhi
4. "Power System Analysis" – John J. Granier and W.D. Stevenson Jr, 4th Edition, McGraw Hill International student edition.
5. "Power System Modeling and Fault Analysis" – Nasser Tleis, Elsevier publication.

University Of Mumbai						
Course Code	Course Name	Teaching Scheme(Contact Hours)		Credits assigned		
EEE704	Digital Signal Controllers and its Application (abbreviated DSCA)	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					
EEE704	Digital Signal Controllers and its Application (abbreviated DSCA)	20	20	20	80	03	25	-	125

Course Code	Course Name	Credits
EEE704	**Digital Signal Controllers and its Application**	**5**
Course Objectives	• To impart knowledge of digital signal controllers along with their applications in power system and power electronics fields. • To realize real time system in digital domain through programming of DSC	
Course outcomes	• Students will understand the basics of design and implementation of DSC based systems	

Module	Contents	Hours
1	**Introduction** Review of microprocessor, microcontroller and digital signal processors architecture, Fixed and floating-point processors Number formats and operations: Fixed point 16 bit numbers representations of signed integers and fraction, Floating Point Numbers. Review of commonly used DSP processors and their applications, introduction to TMS320C2000 digital signal controller (DSC)	06
2	**DSC Architecture and Peripherals** Overview of TMS320C2000 Digital signal controller family – Features, Architecture, Interrupt and Reset, Memory map - On-chip memories: Flash, RAM, and Boot ROM, Clock system- Digital I/O -CPU Timers – Analog to Digital Converter (ADC), Pulse Width Modulator (PWM), High Resolution PWM, Capture Module, Quadrature Encoder Pulse (QEP) Module Communication Interface and protocols.	10

3	**DSC Programming** Code development process, Assembly language programming, Linker, C Compiler, Code Composer Studio (CCS) and online debugging tools	06
4	**Mathematical tools for Real Time DSC implementation:** Review of numerical integration: Euler's implicit and explicit method, Heun's Method, Trapezoidal Method. Implementation of digital filters and transformations	6
5	**DSC Applications in Power Electronics:** Speed control of Induction motor, BLDC motor, Digital control of DC/DC converter, LED Lighting.	8
6	**DSP Applications in Power Systems** Implementation of Active filters in DSP under balanced and unbalanced condition, harmonic oscillator and 3ϕ phase lock loop, Static VAR Compensator, Hardware in Loop simulations. Design of a DSP controlled Converter/Inverter system:	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 would consists of minimum 08 practicals / simulations and 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:

Reference Book:

1. Digital Signal Processing in Power Electronics Control Circuits By Krzysztof Sozanski, Springer
2. Digital Signal Processing in Power System Protection and Control By Waldemar Rebizant, Janusz Szafran, and Andrzej Wiszniewski, Springer.
3. Digital Power Electronics and Applications By *Fang Lin Luo , Hong Ye and Muhammad Rashid,* Elsevier Academic Press.

4. Digital Signal Processing in Power Electronics Control Circuits By Krzysztof Sozanski, Springer
5. Power Electronics, Converters, Applications & Design by N.Mohan, T.M.Undeland, W.P Robbins, Wiley India Pvt. Ltd.
6. Modern Power Electronics and AC Drives by B. K Bose, Pearson Education
7. DSP Based Electromechanical Motion Control by Hamid Toliyat and Steven Campbell, CRC Press

List of recommended experiments:

The experiments to be performed using CCS with TMS320F280xx family controllers.
Write program for DSC (Any four**)**

- Generation of sine wave
- Sense a non-sinusoidal voltage/current and find out harmonic content in it
- Generation of Sine-PWM signals
- Implementation of dq reference transformations
- Implementation of Harmonic Oscillator
- PLL implementation

DSP Controlled Applications (Any two)

- Closed loop control of DC-DC converter
- Power factor correction in converters
- LED lamp intensity control
- Solar PV based converter / inverter system
- Speed control of BLDC / PMSM motor
- Communication System protocol implementation

University Of Mumbai						
Course Code	Course Name	Teaching Scheme(Contact Hours)		Credits assigned		
		Theory	Pract./Tut.	Theory	Pract.tut.	Total
EEE705	**Advanced Lighting Systems** (abbreviated ADLS)	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					
EEE705	Advanced Lighting Systems (abbreviated ADLS)	20	20	20	80	03	25	-	125

Course Code	Course Name	Credits
EEE705	**Advanced Lighting Systems**	**5**
Course Objectives	• To learn the various design philosophies used in lighting system. • To understand the state of the art of lighting control and solid state lighting.	
Course Outcomes	Students will be able to: • Design the lighting system for various applications. • Understand and design lighting control system for achieving the energy efficiency. • Grasp the basic and details of futuristic solid state lighting.	

Module	Contents	Hours
1	**Introduction**: Review of Light, Color and Photometry: Laws of illumination, illumination entities. Radiometric and photometric standards, Photometric measurement procedure- assessment of lamp efficacy, Color temperature, Colorimetry-Measurement of CRI, Glare	03
2	**Lamps and Luminaries:** Lamp: Review of development, construction and characteristics: Incandescent lamp, Discharge lamps: fluorescent lamps, CFL, mercury vapor, sodium vapor, metal halide, induction lamp, and LED lamp. Luminaire: optical control, Control gear: ballast, standard and electronic, Luminaries photometry, Luminaire testing procedures.	07

3	**Interior Lighting Design & Calculation:** Objectives, quality and quantity of lighting. Lamp /Luminaire selection and placement, design considerations and calculation. Glare Consideration and control. Indoor lighting design by lumen method, by point by point method. Applications: residential, educational institute, industries, sports centers, commercial premises: retail stores, offices etc. Applicable standards.	12
4	**Exterior Lighting Design & Calculation:** Exterior lighting system- Road lighting system, Utility area lighting, Sports lighting, Decorative flood lighting. Applicable standards.	06
5	**Lighting Control:** Introduction to Lighting Control, Controls, Selection of Lighting Controls, Design of Lighting Control Scheme, Lighting and LEED, Lighting Controls and the ASHRAE/IES 90.1-1999, Personal Lighting Control, Day-lighting control, Lighting control for Fluorescent Lamps and Electronic Ballasts in Frequently Switched Applications, Linear Fluorescent Dimming Ballasts, Dimming of High-Intensity Discharge Lamps, Controlling LED Lighting Systems, Smart Lighting Fixtures Digital Lighting Networks, DMX control, BACnet: Building Automation Standard Protocol,:	10
6	**Solid-State Lighting:** LED as a light source, color quality of Light, efficacy evaluation, thermal Management, drivers for LED lamps, Lighting Control, Protocol, standards and regulations, LED luminaries, Indoor Lighting Applications, Street & Roadway Lighting, Outdoor Utility Area, and Solar Powered LED Lighting.	10

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:

1. Four lab experiments based on study of lamps and luminaries operation and construction parameters measurements
2. Group study report on observation and analysis of existing lighting installation (at least 4) at following areas: commercial/ non commercial, industries/offices, indoor/outdoor, sports center etc.
3. Minimum two designs on interior and exterior lighting based on specific applications. Design calculation and computer aided design

Term work shall consist of lab experiments / group study and CAD design as described above.
The distribution of marks for the term work shall be as follows:

Laboratory work (Experiments, Group studies and Journal)	: 10 marks.
Group Case Studies	: 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. "Designing with light: Lighting Handbook", by Anil Valia, International Lighting Academy 2002
2. "Lamps and Lighting", by M.A. Cayless and A.M. Marsden; Edward Arnold
3. "Interior Lighting for Designers", by Gary Gorden, John Wiley & Sons Inc.
4. "Advanced Lighting Controls: Energy Savings, Productivity, Technology and Applications", by Craig DiLouie, The Fairmount Press, 2006
5. "Automated Lighting", by Richard Cadena, Second Edition, Focal Press, 2010
6. "Solid State Lighting Reliability: Components to Systems", by W.D. van Driel l X.J. Fan, Springer, 2013
7. "LED Lighting Systems: All you need to know", by Anil Valia, International Lighting Academy, 2012
8. "LEDs for Lighting Applications", by Patrick Mottier, ISTE Ltd and John Wiley & Sons, Inc. 2009
9. "LED Lighting", by Sal Cangeloso, Published by O'Reilly Media, Inc., 2012

Reference Book:

1. "IESNA lighting Handbook", by D.L. Dilaura, K. W. Houser, R.G.Mistrick and G. Steffy, Illuminating Engineering Society of North America, 10th edition 2011
2. "Simplified Design for Building Lighting", by M.Schiler, John Wiley & Sons Inc
3. IS 3646- Part I: 1992, Code of practice for interior illumination, BIS publication

University Of Mumbai						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits assigned		
EEE706	Renewable Energy and Energy Storage Systems (abbreviated REESS)	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					
EEE706	Renewable Energy and Energy Storage Systems (abbreviated REESS)	20	20	20	80	03	25	-	125

Course Code	Course Name	Credits
EEE706	Renewable Energy and Energy Storage Systems	**5**
Course Objectives	• To introduce the new paradigm of power generation in the form of renewable energy and the various means used for power processing and optimization. • To relate and study the various energy storage technology and their significance in the context of renewable energy based applications.	
Course outcomes	• Students will understand the basics of utilization of renewable energy sources, related power systems configurations and basis for futuristic power grid scenario.	

Module	Contents	Hours
1	**Introduction**: Review of worlds production and reserves of commercial energy sources, India's Production and reserves, energy alternatives, Review of conventional and non conventional energy sources. Distributed generation, Future trends in power generation and distribution.	04
2	**Solar Energy:** Review of solar thermal applications-solar thermal conversion devices and storage applications. Review of solar photovoltaic (PV) cells, principle of power generation using solar PV; Solar PV cell model, emerging solar cell technologies; Solar PV modules from solar cells, Mismatch in module , hot spots in the module , Bypass diode, Design and structure of PV modules , PV module power output , I-V and power curve of module;	14

	BOS of PV system**,** battery charge controllers, MPPT, and different algorithms for MPPT, distributed MPPT, Types of PV systems; Design methodology of standalone PV system. Solar PV Micro-inverters. Power quality and protection issues, review of regulatory standards.	
3	**Wind Energy**: Review of wind energy system and its components, types of wind turbines, characteristics; Power generation and control in wind energy systems, performance calculations of wind energy systems. Topologies of WES, WES with rectifier / inverter system, Power Converters for Doubly Fed Induction Generators (DFIG) in Wind Turbines.	08
4	**Fuel Cell**: Review of fuel cells and their principle of operation, Review of types of fuel cell and their performance comparison. Topologies of fuel cell power systems, applications.	05
5	**Other Sources:** Review of other nonconventional sources, their features and applications; Biomass, Tidal, Ocean Thermal Electric Conversion, geothermal, and Micro-hydro.	03
6	**Energy Storage** Forms of energy storage, importance of storage system in new power generation scenario; Types, characteristics and performance evaluation of: batteries, ultra-capacitors, flywheels, SME, pumped hydro storage system; Applications of Energy storage in distributed generation, smart grid systems, Electric and Hybrid electric vehicles. Hybrid power system based on renewable energy and energy storage.	14

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 would consists of minimum 08 practicals / simulations and 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:

Reference Book:

1. Chetan Singh Solanki , *Solar Photo Voltaics* , PHI Learning Pvt Ltd., New Delhi,2009
2. Hashem Nehrir and Caisheng Wang, Modeling *and control of fuel cells: Distributed Generation Applications,* IEEE Press, 2009
3. J.F. Manwell and J.G. McGowan, *Wind Energy Explained, theory design and applications*, Wiley publication
4. D. D. Hall and R. P. Grover, *Biomass Regenerable Energy,* John Wiley, New York, 1987.
5. Felix A. Farret and M. Godoy Simoes, *Integration of Alternative Sources of Energy*, 2006, John Wiley and Sons.
6. M. Ehsani, Y. Gao, and Ali Emadi, *Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design*, Second Edition, CRC Press.
7. S. Chakraborty, M. G. Simões and W. E. Kramer, *Power Electronics for Renewable and Distributed Energy System,* Springer 2013
8. Ahmed Faheem Zobaa, *Energy storage – Technologies and Applications,* InTech Publication 2013.
9. N. Femia • G. Petrone, G. Spagnuolo and M. Vitelli, *Power Electronics and Control Techniques for Maximum Energy Harvesting in Photovoltaic Systems,* CRC Press, 2013

University of Mumbai						
Course Code	Course Name	Teaching Scheme(Contact Hours)		Credits assigned		
		Theory	Pract./Tut.	Theory	Pract.tut.	Total
EEE707	Optimization Techniques and its Applications (abbreviated OTA)	4	2	4	1	5

Course Code	Course Name	Examination Scheme							
		Theory					Term work	Pract./ tut.	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
EEE707	Optimization Techniques and its Applications (abbreviated OTA)	20	20	20	80	03	25	-	125

Course Code	Course Name	Credits
EEE707	**Optimization Techniques and its Applications**	**05**
Course Objectives	• To teach Conventional and Evolutionary Techniques for obtaining optimal solutions in a numerical form.	
Course Outcomes	• Students will be capable of analyzing various techniques and choosing the best technique for any particular application.	

Module	Contents	Hours
1	**Introduction:** Optimization Techniques, Conventional Techniques, Evolutionary Techniques.	02
2	**Linear Programming:** Simplex method, Revised simplex method, Duality in linear programming	05
3	**Non-linear Programming**: Quadratic Programming with Kuhn-Tucker conditions and Wolfe's Modified simplex method , Geometric programming	05
4	**Dynamic Programming (DP):** Multistage decision processes, concept of sub-optimization and principle of optimality, conversion of final value problem into an initial value problem. Integer Programming: Gomory's cutting plane method, Branch and bound algorithm.	12
5	**Genetic Algorithm**: Definition and concept used in GA, coding of variables, fitness function.	12

	General algorithm of GA, Unconstrained and constrained optimization using Genetic Algorithm, global optimization using GA. Particle swarm Optimization Algorithm: Basic fundamentals, general PSO Algorithm.	
6	**Applications to power system**: Economic Load Dispatch and Unit commitment problem using dynamic Programming, GA and Particle swam optimization techniques.	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 consists of minimum five computer programs/simulations covering 80% of 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. Modern Optimization Techniques with Applications in Electric Power Systems. By Soliman Abdel-Hady Soliman, Abdel-Aal Hassan Mantawy, Springer LLC 2012
2. Operations Research Theory and applications, J.K.Sharma, Macmilan, third edition.
3. Engineering Optimization Theory and Practice, S. S. Rao, New Age International Publishers.
4. J.C. Pant: Introduction to Optimization, Jain Brothers, 2004
5. Optimization of Power System Operation, By Jizhong Zhu, August 2009, Wiley-IEEE Press

Reference Books:

1 David G Luenberger, "Linear and Non Linear Programming", 2nd Ed, Addison-Wesley Pub.Co.,Massachusetts, 1973

2 Kalyanmoy Deb, "Optimization for Engineering Design-Algorithms and Examples", Prentice Hall India- 1998.

3 Systems & Control , Stanislaw H. Zak, Oxford