JSS Mahavidyapeetha

JSS Science and Technology University

Scheme of Teaching, Examination and Syllabus
for I to IV Semesters of M.Tech. Program
Energy Systems and Management

Applicable to 2016 and 2017 Batches

Approved by B.o.S on May 30, 2017

Department of Electrical & Electronics Engineering

JSS MAHAVIDYAPEETHA
JSS SCIENCE AND TECHNLOGY UNIVERSITY
JSS TECHNICAL INSITUTIONS' CAMPUS, MYSURU

Scheme of Teaching and Examination for M.Tech. Program in Energy Systems and Management

SEMESTER I											
Sl. No.	Subject Code	Subject	Teaching Department	Credits				Contact Hours/Wk	% Weightage		SEE Duration in Hours
				Lecture	Tutorial	Practicals	Total		CIE	SEE	
1	ESM110	Quantitative Methods for Energy Management and Planning	Maths	4	1	0	5	6	50	50	3
2	ESM120	General Aspects of Energy Management and Energy Audit	EE	4	1	0	5	6	50	50	3
3	ESM130	Solar and Wind Energy Systems	EE	4	1	0	5	6	50	50	3
4	ESM14x	Elective-A (One from Group-A)	EE/ME	4	1	0	5	6	50	50	3
5	ESM15x	Elective-B (One from Group-B)	EE/ME	4	1	0	5	6	50	50	3
6	ESM160	Computational Techniques Lab	Maths/EE	0	0	1.5	1.5	3	50	--	--
7	ESM170	Seminar-I *	EE	0	0	1.5	1.5	3	50	--	--
				Total			28	36			15

CIE: Continuous Internal Evaluation; SEE: Semester End Examination. * Each student should give one seminar in a semester. Student should cultivate standard practices of technical and professional writing and communication and learn to use software tools like LaTeX while preparing for seminars.

Elective Group – A		Elective Group – B	
Subject Code	Course Title	Subject Code	Course Title
ESM141	Power Electronics in Renewable Energy Systems	ESM151	Power System Modeling and Studies
ESM142	Biomass Energy Systems	ESM152	Hydrogen-based Energy Systems
ESM143	Electrical Power and Distribution Transformers	ESM153	Electrical Power Generating Stations
ESM144	Geothermal Technology	ESM154	Acts and Regulations Governing Electric Power Systems

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SEMESTER II												
Sl. No.	Subject Code	Subject	Teaching Department	Credits				Contact Hours/Wk	% Weightage		SEE Duration in Hours
				Lecture	Tutorial	Practicals	Total		CIE	SEE	
1	ESM210	Energy Efficiency in Thermal Systems	EE/ME	4	1	0	5	6	50	50	3
2	ESM220	Energy Efficiency in Electrical Utilities	EE/ME	4	1	0	5	6	50	50	3
3	ESM230	Energy Storage Systems	EE/ME	4	1	0	5	6	50	50	3
4	ESM24x	Elective-C (One from Group-C)	EE/ME	4	1	0	5	6	50	50	3
5	ESM25x	Elective-D (One from Group-D)	EE/ME	4	1	0	5	6	50	50	3
6	ESM260	Energy Systems Lab	EE/ME	0	0	1.5	1.5	3	50	--	--
7	ESM270	Seminar-II *	EE	0	0	1.5	1.5	3	50	--	--
				Total			28	36			15

CIE: Continuous Internal Evaluation; SEE: Semester End Examination. * Each student should give one seminar in a semester. Student should cultivate standard practices of technical and professional writing and communication and learn to use software tools like LaTeX while preparing for seminars.

Elective Group – C		Elective Group – D	
Subject Code	Course Title	Subject Code	Course Title
ESM241	Power Systems Operation and Security	ESM251	Advanced Fluid Mechanics
ESM242	Electrical Power Transmission and Distribution	ESM252	Safety, Environmental Issues and Disaster Management
ESM243	Advanced Heat and Mass Transfer	ESM253	SCADA and Automation in Energy Systems
ESM244	Material Procurement and Management	ESM254	H.V.D.C. Transmission
ESM245	Peak-load Power Plants	ESM255	Power System Instrumentation and Protection
ESM246	Flexible A.C.Transmisison Systems	ESM256	Electric Substation Practice and Recent Trends
ESM247	IoT and Data Analytics in Electrical Engineering		

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SEMESTER III											
Sl. No.	Subject Code	Subject	Conducting and Evaluating Agency	Credits				Contact Hours/Wk	% Weightage		SEE Duration in Hours
				Lecture	Tutorial	Practicals	Total		CIE	SEE	
1	ESM31T	Industrial Training/Internship (for 8 Weeks)*	Industry and EE Dept. Committee	0	0	4	4	--	100	--	--
2	ESM32P	Project Work (Phase-I)**	EE Dept. Committee	0	0	4	14	--	100	--	--
				Total			18	--			--

* Evaluation of Report on Industrial Training shall be in the 2nd Week of September with 25% weightage given to the external valuation done by the industry and 75 % weightage given to the valuation done by the Department Committee.

** CIE-I of Project Work for 4 credits to be done during the 1st week of October should focus on the project synopsis presentation which should contain the objectives, scope and literature survey. CIE-II of Project Work for 6 credits to be done during the 1st week of December should review the progress made in the project work. CIE-III of Project Work for 4 credits to be done during the 2nd week of January should focus on the compliance of issues raised during CIE-II of Project Work done earlier.

Marks obtained in ESM310 and ESM320 shall be finalized and sent to the Controller of Examinations by the 3rd week of January.

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Scheme of Teaching and Examination for M.Tech. Program in Energy Systems and Management

SEMESTER IV											
Sl. No.	Subject Code	Subject	Conducting Agency	Credits				Contact Hours/Wk	% Weightage		SEE Duration in Hours
				Lecture	Tutorial	Practicals	Total		CIE	SEE	
1	ESM41P	Project Work (Phase-II)*	EE Dept. Committee with External Examiner	--	--	26	26	--	100	200	3
				Total			26	--			--

* CIE-IV of Project Work for 8 credits to be done during the 2nd week of April should be a comprehensive review of the progress of the Project Work. CIE-V of Project Work for 8 credits to be done during the 2nd week of June should focus on discussion with final results, conclusions and review of the draft copy of the thesis.

Marks awarded for CIE-IV and CIE-V put together shall be sent to the controller of examination by the end of June.

The student is expected to submit the final version of the thesis in bound form during the 2nd week of July after incorporating all corrections and modifications suggested during CIE-V of the Project Work done earlier in June.

Viva-Voce for 10 credits in respect of the Project Work shall be completed on or before 30th of August and result shall be announced on 31st August.

Scheme of Study and Syllabi for M.Tech. Program in Energy Systems and Management

Approved by BoS in E&EE on 30-May-2017
Applicable to 2016 and 2017 Batches

Department of Electrical and Electronics Engineering

JSS Mahavidyapeetha
JSS Science and Technology University
JSS Technical Institutions' Campus
Mysuru 570 006

Contents

I Semester

Scheme of Study and Examination for I Semester of M.Tech. Program in ESM

Sl. No.	Sub. Code.	Course Title	Teaching Dept.	Credits L	Credits T	Credits P	Credits Total	Contact h/Wk	% Weightage CIE	% Weightage SEE	Exam Hours
1	ESM110	Quantitative Methods for Energy Management and Planning	EE/Maths	4	1	0	5	6	50	50	3
2	ESM120	General Aspects of Energy Management and Energy Audit	EE/ME	4	1	0	5	6	50	50	3
3	ESM130	Solar and Wind Energy Systems	EE/ME	4	1	0	5	6	50	50	3
4	ESM14x	Elective-I (one from Group-A)	EE/ME	4	1	0	5	6	50	50	3
5	ESM15x	Elective-II (one from Group-B)	EE/ME	4	1	0	5	6	50	50	3
6	ESM160	Computational Techniques Lab	EE	0	0	1.5	1.5	3	50	–	–
7	ESM170	Seminar-I	*	0	0	1.5	1.5	3	50	–	–
				Total			28	36	Total		15

- One hour/week of lecture is equal to 1 credit. Two hours/week of practicals is equal to 1 credit.
- Two hours/week of tutorial is equal to 1 credit.
- CIE : Continuous Internal Evaluation. SEE: Semester End Examination.

Electives Group-A

One of the following subjects has to be chosen as Elective-I during Semester-I:

ESM141 Power Electronics in Renewable Energy Systems

ESM142 Biomass Energy Systems

ESM143 Electrical Power and Distribution Transformers

ESM144 Geothermal Technology

Electives Group-B

One of the following subjects has to be chosen as Elective-II during Semester-I:

ESM151 Power System Modeling and Studies

ESM152 Hydrogen-based Energy Systems

ESM153 Electrical Power Generating Stations

ESM154 Acts and Regulations Governing Electric Power Systems

ESM170 Seminar-I

Each student should give one seminar on current technology topics in a semester. Student should cultivate standard practices of technical and professional writing and communication and learn to use software tools like LaTeX while preparing for seminars.

ESM110 Quantitative Methods for Energy Management and Planning

Total Lecture Hours	:	56	Credit Pattern L:T:P	:	4:1:0
Total Tutorial Hours	:	28	CIE, SEE Weightage	:	50%, 50%
Lecture Hours/Week	:	4	Prerequisite/s	:	Nil
Tutorial Hours/Week	:	2	Teaching Faculty	:	
Nature of Subject	:	Core			

Course Outcomes

After completing this course the student should be able to

CO-1 Apply appropriate method of curve fitting to a given set of data.

CO-2 Find optimal solution to a given problem.

CO-3 Apply appropriate methods for forecasting energy demand.

CO-4 Apply methods of time series analysis.

CO-5 Apply quality monitoring tools for power quality assessment.

1 Curve Fitting

Interpolation techniques, difference formulas, bezier curves, method of least squares. 11 Hours

2 Optimization Techniques

Local and global minima. Linear programming problems, Feasibility regions and solutions. Graphical solution, Simplex method, Duality and post-optimality analysis, Integer programming, Optimal technology mix in micro and macro level energy planning exercises. 15 Hours

3 Statistical Methods and Probability

Review of probability concepts. Probability distribution functions. Forecasting and decision making in view of multi-variant techniques, Sequencing, Quening theory, Networks, Decision theory, Markov analysis, Non linear programming, Decision making with uncertainty, decision making with multiple objectives, Deterministic and probabilistic dynamic programming, Regression analysis. CUSUM Techniques. 15 Hours

4 Econometrics, Time Series Analysis and Quality Monitoring

Introduction to econometrics and time series analysis. Prediction techniques based on time series data. Quality monitoring tools – Pareto Charts, Cause-Effect Diagram, Six-Sigma Techniques. 15 Hours

References

1. Course Materials.
2. Robert J. Schilling and Sandra L. Harris, “Applied Numerical Methods for Engineers using MATLAB and C”, C1-Engineering, 1999.
3. G. S. Maddala, “Introduction to Econometrics”, Wiley India Pvt. Ltd., 3rd Edition, 2007.
4. Chris Chatfield, “The Analysis of Time Series – An Introduction”, 6th Edition, Chapman and Hall/CRC, 2003.

ESM 120 General Aspects of Energy Management and Energy Audit

Total Lecture Hours	: 56		Credit Pattern L:T:P	:	4:1:0
Total Tutorial Hours	: 28		CIE, SEE Weightage	:	50%, 50%
Lecture Hours/Week	: 4		Prerequisite/s	:	Nil
Tutorial Hours/Week	: 2		Teaching Faculty	:	
Nature of Subject	: Core				

Course Outcomes

After completing this course the student should be able to

CO-1 Describe global and national energy scenario, acts and regulations, and international conventions related to energy systems.

CO-2 Perform financial assessment of energy projects.

CO-3 Describe types and methods of different types of energy audit.

CO-4 Describe methods of energy monitoring and targeting.

CO-5 Apply project management techniques to energy related projects.

1 Energy Scenario and Global Energy Concerns

Global and Indian energy Scenario. Energy production, consumption and pricing. Long-term energy scenario. Salient features of Electricity Act 2003. Energy Conservation Act – 2001 and its features. Central Electricity Regulator Commission (CERC) and State Electricity Regulatory Commission (SERC). Global warming, air pollution. Convention on Climate Change (UNFCC). Kyoto Protocol. Conference of Parties (COP). Clean Development Mechanism (CDM). Prototype Carbon Fund (PCF). 11 Hours

2 Financial Aspects of Energy Management

Time value of money and financial feasibility. Simple interest. Compound interest. Uniform series payment. Methods for evaluation of tangible alternatives – present worth, future worth, and annual equivalent method, benefit to cost ratio, rate of return on method and payback calculation. 11 Hours

3 Energy Audit

Energy audit – definition, need, types of energy audit. Energy audit report format. Plant energy performance. Energy audit instruments. Case studies and analysis. 11 Hours

4 Energy Monitoring and Targeting

Material and energy balance – Facility as an energy system. Methods for preparing Process Flow Diagram, Sankey Diagram. (c) Energy Action Planning – Roles and responsibilities of energy manager, motivation of employees. TQM, TPM, and 5S Principles. Energy certification. Definition of energy monitoring and targeting. Elements of energy monitoring and targeting. Data and information — analysis techniques, energy consumption, production. Cumulative sum of differences (CUSUM). 12 Hours

5 Demand Side Management and Tariffs

Concept of DSM. DSM techniques. Load management. Objectives of tariffs. Costing in electricity, pricing approach. Allocation of annual costs between classes. Tariff classfication. Features of ABT, bulk, multi-year tariffs. Recent trends in smart meters and billing. Open access. 6 Hours

6 Project Planning, Market and Demand Analysis

Concept of project planning. Phases of project planning and budgeting. Network techniques – PERT and CPM. Conduct of market survey. Characteristics of market. Demand forecasting. Market analysis and risk analysis. 5 Hours

References

1. Course Materials.

2. Book I, "General Aspect of Energy Management and Energy Audit", available at the website: http://www.energymanagertraining.com/new_course.php

3. A. Pabla, "Electric Power Distribution", TMH, 2003.

4. D. P. Sengupta, K. R. Padiyar, and Indranil Sen, "Recent Advances in Control and Management of Energy Systems", Interline Publications, Bangalore.

5. TERI, "Demand Side Management from Sustainable Development Perspective – Experiences from Quebec (Canada) and India".

6. Information available at http://www.powermin.ac.in.

7. Information available at http://www.kerc.org.

8. J. L. Riggs *et. al.*, "Engineering Economics", 4th Edition, Jan 2004, Tata McGraw-Hill Publishing Company Limited.

9. Prasanna Chandra, "Projects: Planning, Analysis, Financing, Implementation, and Review", 7th Edition Tata McGraw-Hill Publishing Company Limited, 2009.

10. R. Paneerselvam, "Engineering Economics", 1st Edition, Prentice-Hall of India Private Limited, 2008.

ESM130 Solar and Wind Energy Systems

Total Lecture Hours	:	56	Credit Pattern L:T:P	:	4:1:0
Total Tutorial Hours	:	28	CIE, SEE Weightage	:	50%, 50%
Lecture Hours/Week	:	4	Prerequisite/s	:	Nil
Tutorial Hours/Week	:	2	Teaching Faculty	:	
Nature of Subject	:	Core			

Course Outcomes

After completing this course the student should be able to

CO-1 Describe various characteristics of conventional and non-conventional energy resources.

CO-2 Estimate solar radiation received on a surface at a place.

CO-3 Describe types and various design aspects of solar thermal systems.

CO-4 Describe types and various design aspects of solar PV systems.

CO-5 Describe types and various design aspects of wind energy systems.

1 Energy Resources and Their Utilization

Definition of energy. Review of energy resources – thermal, hydro, nuclear. New technologies – hydrogen energy systems, fuel cells, biofuels. Distributed energy generation. Importance of solar and wind energy systems. 6 Hours

2 Solar Radiation and Its Measurement

Solar constant. Spectral distribution of extraterrestrial radiation. Terrestrial radiation. Solar radiation geometry. Computation of angle of incidence of solar radiation on a surface at any location and orientation. Sun rise, sunset and day length. Empirical formulas for estimating the availability of solar radiation. Solar radiation measurement. Solar radiation data for India.

10 Hours

3 Solar Thermal Energy Systems

Introduction to solar thermal energy systems. Flat-plate collector, effect of design parameters on performance. Laws of thermal radiation. Radiation heat transfer between real bodies. Radiation optics. Transmittivity of the cover system. Performance analysis of a liquid flat-plate collector. Total loss coefficient and heat losses. Solar concentrating collectors – types. Thermodynamic limits of concentration. Performance analysis of cylindrical parabolic collector. Compound parabolic concentrator (CPC). Performance analysis of CPC. Applications of solar thermal energy systems — water heating, distillation, liquid bath solar wax melter, heating of swimming pool by solar energy. Thermodynamic cycles and solar plants. Combined cycle power plant. Solar thermal power plants. Central receiver power plants. Solar ponds. Solar air heaters. Solar crop drying. Solar kilns. Solar cookers. Solar air-conditioning and refrigeration. 10 Hours

4 Solar Photovoltaic Energy Systems

Introduction to semiconductor physics. Photon energy. Energy bands in semiconductors. Theory of P-N junction, photovoltaic effect – operation of P-N junction as a solar cell, equivalent circuit of solar cell, V-I characteristics of a solar cell, parameters of solar cells, limits of cell efficiency, maximum power point tracking, solar cell materials and technologies, fabrication of crystalline Si solar cells, solar PV modules and arrays, PV module output as function of temperature and solar radiation. Aspects of practical design of solar PV systems – case studies, battery charging, pumping, lighting, Peltier cooling. Grid connected solar PV systems, aspects of Universal Intelligent Transformers (UIT). Standards for power conditioning unit. Power quality aspects. Feedin tariffs. Status of solar photovoltaics in India. Solar PV-based power generation plants in India. 10 Hours

5 Wind Energy Systems

Introduction. Classification of wind turbines. Types of rotors. Terms used in wind energy systems. Wind energy extraction. Extraction of wind turbine power. Wind characteristics. Mean wind speed and energy estimation. Power density duration curve. Weibull Probability Density Function and Wind Turbine Capacity Factor (WTCF). Field wind data analysis. Annual percentage frequency distribution of wind speed. Direction of wind and windrose data. Air density calculation. Variation of wind speed with elevation. Energy pattern factor in wind power studies. Beaufort Wind Scale. Land for wind energy. Factors affecting design of wind turbine rotor. Regulating system for rotor. Wind power generation curve. Sub-systems of a horizontal axis wind turbine generator. Modes of wind power generation. Advantages and disadvantages of wind energy systems. Wind energy farms. Wind resource surveys. Assessment of wind availability from meteorological data. Estimation of wind energy potential. Wind resource assessment in India. Status of wind energy systems in India. Methods of grid connection.

Doubly-fed and full-converter based wind electric generators. Pooling of wind farms and grid interconnection. Economics of wind farms. Hybrid energy systems. 20 Hours

References

1. Course Materials.
2. D. P. Kothari, K. C. Singal and Rakesh Ranjan, “Renewable Energy Sources and Emerging Technologies”, 2nd Edition, Prentice-Hall of India Pvt. Ltd., New Delhi, 2012.
3. Chethan S. Solanki, “Solar Photovoltaics: Fundamentals, Technologies and Applications”, PHI, 2009, New Delhi.
4. Sukhatme S. P., “Solar Energy : Principles of Thermal Collection And Storage”, 3rd Edition, Tata McGraw-Hill, 2008.
5. Information available at http://mnes.nic.in.
6. Information available at http://pveducation.org/NOTE: Hourly lesson plan for covering this syllabus and topic-wise allocation of marks in the SEE will be provided by the teacher..
7. Manfred Stiebler, “Wind Energy Systems for Electric Power Generation”, Springer, 2008.
8. European Wind Energy Association, “Wind Energy – The Facts: A Guide To The Technology, Economics and Future of Wind Power”, 2009, Earthscan Publications Limited.

ESM141 Power Electronics in Renewable Energy Systems

Total Lecture Hours	: 56		Credit Pattern L:T:P	:	4:1:0
Total Tutorial Hours	: 28		CIE, SEE Weightage	:	50%, 50%
Lecture Hours/Week	: 4		Prerequisite/s	:	Nil
Tutorial Hours/Week	: 2		Teaching Faculty	:	
Nature of Subject	: Elective				

Course Outcomes

After completing this course the student should be able to

CO-1 Describe the features and characteristics of recently developed power switching semiconductor devices and select an appropriate device for a given application in a renewable energy system to build a power converter.

CO-2 Analyze the working of A.C. link universal power converters and design their power circuit and describe their applications.

CO-3 Describe the converters used in modern wind energy systems and their control issues.

CO-4 Describe MPPT in stand-alone PV systems and control issues in grid-connected solar PV systems.

CO-5 Describe multi-level converter/inverter topologies and their applications in renewable energy systems.

1 Recent Developments in Power Semiconductor Devices

Importance of power electronics in renewable energy systems. Introduction to power switching semiconductor devices. Power MOSFETs, IGBTs and high power devices. Overview of Silicon Carbide (SiC) transistor designs. SiC JFET, SiC MOSFET, SiC Bipolar Transistor, SiC IGBT and SiC power modules. Gate and base drives for SiC devices. Parallel connection of transistors. Overview of applications in solar PV systems, A.C. drives, hybrid and plugin vehicles, high-power applications. Gallium Nitride transistors. 11 Hours

2 A.C.-Link Universal Power Converters

Introduction. Hard-switching A.C.-link universal power converter. Soft-switching A.C.-link universal power converter. Principle of operation of soft-switching A.C.-link universal power converter. Design procedure and analysis. Applications – A.C.-A.C. conversion in wind power generation systems, D.C.-A.C. and A.C.-D.C. power conversion, multi-port conversion.

11 Hours

3 Power Converters for Wind Turbines

Introduction. Development of wind power generation. Wind power conversion – basic control variables for wind turbines, wind turbine concepts. Power converters for wind turbines – two level, multi-level, and multi-cell types. Power semiconductors for wind power converters. Control and grid requirements for modern wind turbines – active power control, reactive power control, total harmonic distortion, fault-ride-through capability. Emerging reliability issues for wind power systems. 12 Hours

4 Power Converters for Photovoltaic Energy Systems

Introduction. Power curves and maximum power point of PV systems. Converters for stand-alone PV systems. Maximum Power Point Tracking (MPPT). Grid-connected PV system configurations. Control of grid-connected PV systems. Recent developments in multi-level inverter-based PV systems. 11 Hours

5 Multi-level Converters/Inverters Topologies and Applications

Fundamentals of multi-level converters/inverters. Cascaded multi-level inverters and their applications. Emerging applications — magnetic-less D.C./D.C. conversion, multi-level modular capacitor clamped D.C./D.C. converters (MMCCC), nX D.C./D.C. converter. Zero-current switching MMCCC. Fault tolerance and reliability of multi-level converters. 11 Hours

References

NOTE: Specific text book/s to be followed will be prescribed by the teacher.

1. Course Materials.

2. Haithum Abu-Rub, Mariusz Malinowski, and Kamal Al-Haddad, “Power Electronics for Renewable Energy Systems”, Wiley-Blackwell, ISBN-13: 978-1118634035, 2014.

3. M. H. Rashid, “Power Electronics”, P.H.I.NOTE: Hourly lesson plan for covering this syllabus and topic-wise allocation of marks in the SEE will be provided by the teacher.

4. Ned Mohan, Tore M. Undeland, and Willium P. Robbins, “Power Electronics: Converters, Applications, and Design”, John Wiley, 3rd Edition.

5. Robert Warren Erickson, “Fundamentals of Power Electronics”, Springer, 2nd Edition.

6. Relevant course materials available at http://nptel.iitm.ac.in/index.php

ESM142 Biomass Energy Systems

Total Lecture Hours	:	56	Credit Pattern L:T:P	:	4:1:0
Total Tutorial Hours	:	28	CIE, SEE Weightage	:	50%, 50%
Lecture Hours/Week	:	4	Prerequisite/s	:	Nil
Tutorial Hours/Week	:	2	Teaching Faculty	:	
Nature of Subject	:	Elective			

Course Outcomes

After completing this course the student should be able to

CO-1 Describe the meaning of bioenergy and its production by photosynthesis.

CO-2 Describe the working principle, construction aspects, and problems related to biogas plants.

CO-3 Describe various bioenergy conversion technologies.

CO-4 Perform cost analysis of biomass energy systems.

CO-5 Describe recent trends in biomass energy systems.

1 Introduction

Bioenergy – why it is worth while? Photosynthesis and fuel production in a nutshell. 4 Hours

2 Solar Energy and Photosynthesis

Solar energy – down to earth. The mechanisms of photosynthesis. 4 Hours

3 Energy from Bio Masses

Biogas generation. Factors affecting biodigestioin or generation of gas. Types of biogas plants. Constructional details of some main digesters. Biogas from plant wasters, Digester design considerations. Methods for maintaining biogas production, Problems related to biogas plant.
14 Hours

4 The Bioenergy Conversion Technology

An overview. Anaerobic digestion. Alcoholic fermentation. Chemical reduction. Gasification. Pyrolysis. Direct combustion. 6 Hours

5 The Economics of Biomass Systems

General considerations. Net present valve Energy payback time. Some conventional economic costings. Costs of biomass fuels Relative prices of biological and other fuels. 12 Hours

6 Present Developments and Future Prospects

The state of the art – an over view Hydrogen and electricity via bio photolysis – hope for the future. Petrol pump plants. Improving plant productivity I and II, Conservation through integration – a system approach. Biomass potential for national energy autonomy. The biological path to self reliance. 16 Hours

References

1. Course Materials.
2. D. P. Kothari, K. C. Singal and Rakesh Ranjan, “Renewable Energy Sources and Emerging Technologies”, 2nd Edition, Prentice-Hall of India Pvt. Ltd., New Delhi, 2012.
3. Philippe Chartier, Willeke Palz, P. Chartier, “Energy From Biomass”, Commission Of European Communities, 1981.
4. G. D. Rai, “Non Conventional Energy Sources”, 1st Edition, Khanna Publishers, New Delhi, 2010.

ESM143 Electrial Power and Distribution Transformers

Total Lecture Hours	:	56	Credit Pattern L:T:P	:	4:1:0
Total Tutorial Hours	:	28	CIE, SEE Weightage	:	50%, 50%
Lecture Hours/Week	:	4	Prerequisite/s	:	Nil
Tutorial Hours/Week	:	2	Teaching Faculty	:	
Nature of Subject	:	Elective			

Course Outcomes

After completing this course the student should be able to

CO-1 Describe construction aspects of power transformers.

CO-2 Describe standards and methods of erection and testing of power transformers.

CO-3 Describe present practises in respect of protection, maintenance and troubleshooting of transformers.

CO-4 Describe standards and methods of erection and testing of distribution transformers.

CO-5 Describe recent trends in the construction of distribution transformers.

1 Construction of Power Transformers

Properties and characteristics of materials used in power transformers. Magnetic circuit, optimum design of core. Oil ducts. Joints and assembly. Winding types. Voltage distribution. Heat transfer. Surge voltage. Vector group of transformers and parallel operation. Voltage regulation. Tap changers. Control of tap changers. Diverter etc. Transformer auxiliaries. Gas operated relay, temperature Indicators, pressure relief valves. Oil level indicators. Gas sealing of conservators. Assembly and drying of transformers (at factory). 15 Hours

2 Erection and Testing of Transformers

Testing — preliminary, routine, and type tests. Special tests on transformers. Specifications and standards related transformers. Erection, pre-commission tests on transformers, drying at site. 11 Hours

3 Protection, Maintenance and Troubleshooting

Hotline maintenance and filtration techniques, fire hazards and care. Transformer protection. Protection against short circuit, high voltage surges and internal faults. Condition monitoring, residual life assessment, thermography, partial discharge measurements, refurbishing of transformers. 15 Hours

4 Distribution Transformers

Distribution transformers — rating, standardization, specification, maintenance. Earthing of transformer centers, Failure of distribution transformers. Capitalization of losses. Intelligent distribution transformers. Amorphous core Transformers. Dry type and SF6 cooled transformers. Star rating of transformers and transformers suitable for HVDS system. Pad mounted, vault and under-ground transformer centres, transformer fitted compact R.M.U.'s. 15 Hours

References

1. Course Materials.
2. BHEL, "Transformers", 2nd Edition, T.M.H., 2003.
3. Say M. G., "Performance and Design of A.C. Machines", C.B.S. Publishers, New Delhi.
4. Martin J. Heathcote, "The J & P Transformer Book: A Practical Technology Of The Power Transformer", 13th Edition, Butterworth-heinemann, 2007.
5. Hand Book of Power Utility Companies — TNEB, KSEB, APSEB, Latest Editions.
6. Relevant reports of CIGRE, IEEE papers.

ESM144 Geothermal Technology

Total Lecture Hours	:	56	Credit Pattern L:T:P	:	4:1:0
Total Tutorial Hours	:	28	CIE, SEE Weightage	:	50%, 50%
Lecture Hours/Week	:	4	Prerequisite/s	:	Nil
Tutorial Hours/Week	:	2	Teaching Faculty	:	
Nature of Subject	:	Elective			

Course Outcomes

After completing this course the student should be able to

CO-1 Describe the structure of earth's interior, plate tectonic theory and geothermal sites.

CO-2 Describe the basics of geothermal energy generation and its technology status.

CO-3 Describe the principle of working of geothermal HVAC systems.

CO-4 Describe the practical aspects of design of geothermal heat pumps, their types and characteristics.

CO-5 Describe recent trends in drilling technologies, their environmental aspects, economics and life cycle management.

1 Geothermal Energy Systems

Introduction. Structure of the earth's interior. Plate tectonic theory. Geothermal sites, earthquakes and volcanoes. Geothermal field. Geothermal gradients. Geothermal resources. Geothermal power generation (basics), technology status in India and in the developed countries.

16 Hours

2 Geothermal HVAC Systems

Usage of geo thermal technology for heating, ventilation, and air conditioning applications of houses, industries, green house cultivation etc. Application of the said technology for cooling towers. Methods, efficiency, economics, environmental implications. Geo thermal heat pumps:

Classification, working of low grade heat pumps. Practical aspects of design, comparison of compressor systems. Requirement of building envelops conservation methodologies. Drilling technologies, environmental aspects of drilling. Status of technology, economics, life cycle assessment. 40 Hours

References

1. Course Materials.
2. D. P. Kothari, K. C. Singal and Rakesh Ranjan, "Renewable Energy Sources and Emerging Technologies", 2nd Edition, Prentice-Hall of India Pvt. Ltd., New Delhi, 2012.
3. Jay Egg, Greg Cunnif, and Carl Orio, "Modern Geothermal HVAC Engineering and Control Applications", 1st Edition, McGraw-Hill Professional, 2013.
4. Lucas Hyman, "Sustainable Thermal Storage Systems", ISBN-13 : 978-0071752978, McGraw-Hill Professional, 2011, 2011.
5. Alberto Piatti, Carlo Piemonte, and Edoardo Szego, "Planning of Geothermal District Heating Systems", ISBN-13 : 978-0792319689, Springer, 1992.

ESM151 Power System Modeling and Studies

Total Lecture Hours	:	56	Credit Pattern L:T:P	:	4:1:0
Total Tutorial Hours	:	28	CIE, SEE Weightage	:	50%, 50%
Lecture Hours/Week	:	4	Prerequisite/s	:	Nil
Tutorial Hours/Week	:	2	Teaching Faculty	:	
Nature of Subject	:	Elective			

Course Outcomes

After completing this course the student should be able to

CO-1 Obtain three-phase model of transmission lines, transformers and form the bus admittance matrix.

CO-2 Perform N-R method of load flow, Decoupled Newton Raphson load flow method.

CO-3 Perform Decoupled Newton Raphson method of load flow.

CO-4 Perform Fast Decoupled method of load flow.

CO-5 Perform A.C.-D.C. load flow.

1 Introduction

Introduction. Linear transformation techniques. Basic single phase modeling. Three phase system analysis. Three phase models of transmission lines. Three phase models of transformers. Formation of the system admittance matrix. 16 Hours

2 Load Flow

Introduction. Basic nodal method. Conditioning of Y-matrix. The case where one voltage is known. Analytical definition of the problem. Newton Raphson method of solving load flow problem. Techniques that make Newton-Raphson Method competitive in load flow. Characteristics of the Newton Raphson load flow method. Decoupled Newton Raphson load flow method. Fast Decoupled load flow. Convergence criteria and tests. Numerical examples. 20 Hours

3 A.C.-D.C. Load Flow

Introduction. Formulation of the problem. D.C. system model. Solution techniques. Control of converter A.C. terminal voltage. Extension to multiple and or multi-terminal D.C. systems. D.C. convergence tolerance. Test system and results. Numerical examples. 20 Hours

References

1. Course Materials.
2. J. Arrillaga and C. P. Arnold and B. J. Harker, "Computer Modeling of Electrical Power Systems", Wiley Inter-science Publication, John Wiley & Sons.
3. E. Clarke, "Circuit Analysis of A.C. Power Systems" Vol. 1, John Wiley & Sons Ltd, New York
4. Glenn W. Stagg and E. L. Abiad, "Computer Methods in Power System Analysis", McGraw-Hill Publishers
5. E. W. Kimbark, "Direct Current Transmission", Vol. 1, Wiley Inter-science, London.

ESM152 Hydrogen-based Energy Systems

Total Lecture Hours	:	56	Credit Pattern L:T:P	:	4:1:0
Total Tutorial Hours	:	28	CIE, SEE Weightage	:	50%, 50%
Lecture Hours/Week	:	4	Prerequisite/s	:	Nil
Tutorial Hours/Week	:	2	Teaching Faculty	:	
Nature of Subject	:	Elective			

Course Outcomes

After completing this course the student should be able to

CO-1 Describe emergence of hydrogen as an energy source.

CO-2 Describe different techniques of hydrogen production, and applications.

CO-3 Describe methods, economics and safety aspects of hydrogen storage.

CO-4 Describe the construction, working principle, equivalent circuit and operating characteristics of hydrogen fuel cells.

CO-5 Describe recent trends in fuel cell technology.

1 Introduction

Introduction. Emergence of hydrogen as an energy source. 2 Hours

2 Hydrogen Production and Applications

Steam reformation. Electrolysis. Thermal decomposition of water. Thermo-chemical method of producing hydrogen. Biological method of producing hydrogen. Production of hydrogen from sunflower oil. Solar electrolytic hydrogen production. Cost analysis of hydrogen production. Characteristics and Applications of Hydrogen. 18 Hours

3 Hydrogen Storage

Compressed gas storage. Liquid storage. Solid state storage. Hydrogen storage using nano-crystalline magnesium-based Nickel-Hydride. Development of hydrogen cartridge. National Hydrogen Energy Board. Economics of hydrogen fuel and its use. Gas hydrate – occurance, Indian resources of hydrates. Importance of gas hydrates. 14 Hours

4 Fuel Cells

Introduction. Principle of operation of an acidic fuel cell. Technical parameters of a fuel cell. Fuel processor. Hydrogen for fuel cells from renewable resources. Methyl alcohol fuel cell. Fuel cell types. Advantages of fuel cell power plants. Fuel cell battery-powered bus system. Comparison between acidic and alkaline, hydrogen-oxygen fuel cells. State-of-art fuel cells. Energy output of a fuel cell. Efficiency and EMF of a fuel cell. Gibbs-Helholtz equation. Hydrogen fuel cell analysis with thermodynamic potentials. Comparison of electrolysis and fuel cell process. Operating characteristics of fuel cells. Thermal efficiency of a fuel cell. Future potential of fuel cells. 22 Hours

References

1. Course Materials.
2. D. P. Kothari, K. C. Singal and Rakesh Ranjan, “Renewable Energy Sources and Emerging Technologies”, 2nd Edition, Prentice-Hall of India Pvt. Ltd., New Delhi, 2012.
3. B. Viswanathan and M. Aulice Scibioh, “Fuel Cells: Principles and Applications”, 1st Edition, University Press, 2006, ISBN-13: 9788173715570.

ESM153 Electric Power Generating Station Practices

Total Lecture Hours	:	56	Credit Pattern L:T:P	:	4:1:0
Total Tutorial Hours	:	28	CIE, SEE Weightage	:	50%, 50%
Lecture Hours/Week	:	4	Prerequisite/s	:	Nil
Tutorial Hours/Week	:	2	Teaching Faculty	:	
Nature of Subject	:	Elective			

Course Outcomes

After completing this course the student should be able to

CO-1 Describe different types of power stations, their economics with respect to location, and types of machinery used in them.

CO-2 Describe hydro, thermal, and gas turbine power plants.

CO-3 Describe nuclear power plants.

CO-4 Describe various essential requirements and cooling arrangements in generating stations.

CO-5 Describe instrumentation, communication and safety aspects in respect of generating stations.

1. Economics of power generation, Load duration curves, categorization of power plants, power plant economics, fixed cost and depreciation, fuel cost, effect of load factor on cost per kwh, operational capabilities, future requirements. 8 Hours

2. Types of power stations, choice of generation location, choice of generator units & number of units, selection of alternate places, capacity and economic consideration. 8 Hours

3. Hydro power stations, Advantages and disadvantages, Classification on – load cycle, run of the river, head etc., Types of turbines, Hydro generator - stator, rotor, braking & lifting of rotor, type of Bearing, governors, controllers, valves, penstocks, layout of power house, location, classification and dimensions. 8 Hours

4. Thermal stations, concepts, major systems of power plants, electrical systems, turbo generators, coal & ash handling equipments. 8 Hours

5. Gas turbine plants, advantages, operating principles, fuels, combined cycle integrated coal gasification, combined cycle feed water heating and treatment. 8 Hours

6. Nuclear power plant, pressurized water reactors, gas cooled reactors, heavy water reactors, general arrangement, coolant system, contaminant, auxiliary systems, emergency cooling systems, fuel handling, storage and disposal of wastes. 8 Hours

7. Essential requirements of generating stations - Earthing, Bus ducts and power cables, Excitation system, Auxiliary power supply – station and unit, Cooling arrangements – Generators, Exciter, Transformers etc., Lubrication and oil handling systems., D.C. supply and emergency supplies, general instrumentation, controls and control cablings, communication, telecommunication and other essential requirements, maintenance management, safety measures and management. 8 Hours

References

1. Course Materials.
2. P. K. Nag, “Power Plant Engineering”, 3rd Edition, T.M.H., 2008.
3. Relevant IS specifications.
4. Hand book of utilities – TNEB, KSEB, APSEB, ABB, SIEMENS etc., Latest Editions.
5. Relevant reports of CIGRE, IEEE papers.

ESM154 Acts and Regulations Governing Electric Power Systems

Total Lecture Hours	:	56	Credit Pattern L:T:P	:	4:1:0
Total Tutorial Hours	:	28	CIE, SEE Weightage	:	50%, 50%
Lecture Hours/Week	:	4	Prerequisite/s	:	Nil
Tutorial Hours/Week	:	2	Teaching Faculty	:	
Nature of Subject	:	Elective			

Course Outcomes

After completing this course the student should be able to

CO-1 Describe the power sector scenario before and after the enactment of Electricity Act of 2003.

CO-2 Describe various reforms made in the power sector at the national level and at the state level.

CO-3 Describe various acts, regulations and their important clauses related to the power and energy sector.

CO-4 Describe the salient features of Energy Conservation Act of 2001, various international bodies and protocols related to environmental protection which are relevant to the energy sector.

CO-5 Describe various measures adopted to encourage independent power producers.

1. Power sector scenario before the enactment of Electricity Act 2003. Enactment of Electricity Act 2003, power trading, open access, Regulatory commission, appellate tribunals, liberating generation plants, from permits (except hydro). 12 Hours

2. Electricity reforms envisaged in the country, necessity of forming electricity regulatory commission at the centre and states, enactment of regulatory commission act 1998, Karnataka electricity reforms act 1998, necessity of reducing T&D loss, formulation of uniform structure of tariff, de-linking of generation, transmission and distribution activities. 13 Hours

3. Relevant acts, rules, related, important clauses and subjects there on, - in respect of Consumer Protection Act, Factories Act, Workmen Compensation Act, Indian Telegraphic Act Pertaining to Power sector, Companies act, Boiler Safety Act, Right to Information Act and KTPP Act. 12 Hours

4. Energy Conservation Act 2001. Necessity and formation of BEE, Green power/green building concepts, carbon trading and formation of international bodies for protection of environment, CDM technologies. 13 Hours

5. Introduction of friendly measures to encourage independent power producers. 6 Hours

Reference

1. Anita Abraham, "Electricity Rules Cited – Electricity Law Manual".

2. Various acts and rules as cited.

3. KERC ES&D Code.

4. Condition of Supply of Electricity of Distribution Licenses in various states.

ESM160 Computational Techniques Lab

Total Practical Hours	:	42	Credit Pattern L:T:P	:	0:0:1.5
Lecture Hours/Week	:	0	CIE, SEE Weightage	:	100%, 0%
Practical Hours/Week	:	3	Corequisite	:	ESM110
Nature of Subject	:	Core	Teaching Faculty	:	

Course Outcomes

After completing this course the student should be able to

CO-1 Use the GNU Linux machine for general applications and for academic purposes.

CO-2 Use spreadsheets and other software tools for energy system or power system studies and design.

CO-3 Use simulation tools like MATLAB or equivalent for system simulation and data visualization.

CO-4 Write programs for energy forecasting.

CO-5 Use graphic tools required for preparing documents.

List of Experiments

In this lab students are expected to solve problems related to the topics taught in theory using any higher level language like MATLAB (or its equivalents like Scilab, or GNU Octave, or SciPy). Problems to be solved will be suggested by the faculty teaching the theory. The following are some possible activities:

1. Familiarizing with GNU Linux environment, installation, and usage.
2. Using spread sheets to prepare PERT/CPM chart for a given project activity.
3. Preparing Pareto charts using any appropriate software for a given data.
4. Exercises on MATLAB or equivalent to solve problems, on simulation of physical systems and data visualization using different types of plots.

5. Using software tools like PC1D to simulate solar cells.
6. Solving problems on load forecasting using given historical data.
7. Using RETScreen or similar software for designing solar energy systems.
8. Learning to use graphics tools like Inkscape and LibreCAD to prepare drawings.

II Semester

Scheme of Study and Examination for II Semester of B.E. Program in ESM

Sl. No.	Sub. Code.	Course Title	Teaching Dept.	Credits L	Credits T	Credits P	Credits Total	Contact h/Wk	% Weightage CIE	% Weightage SEE	Exam Hours
1	ESM210	Energy Efficiency in Thermal Systems	ME/EE	4	1	0	5	6	50	50	3
2	ESM220	Energy Efficiency in Electrical Utilities	E&EE	4	1	0	5	6	50	50	3
3	ESM230	Energy Storage Systems	E&EE	4	1	0	5	6	50	50	3
4	ESM24x	Elective-III (One from Group-C)	*	4	1	0	5	6	50	50	3
5	ESM25x	Elective-IV (One from Group-D)	*	4	1	0	5	6	50	50	3
6	ESM260	Energy Systems Lab	E&EE	0	0	1.5	1.5	3	50	–	–
7	ESM270	Seminar-II	*	0	0	1.5	1.5	3	50	–	–
				Total			28	31	Total		15

- One hour/week of lecture is equal to 1 credit.
- Two hours/week of practicals is equal to 1 credit.
- Two hours/week of tutorial is equal to 1 credit.

Electives Group-C

ESM241	Computer Aided Power Systems Analysis and Operation
ESM242	Electrical Power Transmission and Distribution
ESM243	Advanced Heat and Mass Transfer
ESM244	Material Procurement and Management
ESM245	Peak-load Power Plants
ESM246	Flexible A.C. Transmission Systems
ESM247	IOT and Data Analytics in Electrical Engineering

Electives Group-D

ESM251	Advanced Fluid Mechanics
ESM252	Safety, Environmental Issues and Disaster Management
ESM253	SCADA and Automation in Electric Energy Systems
ESM254	H.V.D.C. Transmission
ESM255	Power System Instrumentation and Protection

ESM270 Seminar-II

Each student should give one seminar on current technology topics in a semester. Student should cultivate standard practices of technical and professional writing and communication and learn to use software tools like LaTeX while preparing for seminars.

ESM210 Energy Efficiency in Thermal Systems

Total Lecture Hours	:	56	Credit Pattern L:T:P	:	4:1:0
Total Tutorial Hours	:	28	CIE, SEE Weightage	:	50%, 50%
Lecture Hours/Week	:	4	Prerequisite/s	:	Nil
Tutorial Hours/Week	:	2	Teaching Faculty	:	
Nature of Subject	:	Core			

Course Outcomes

After completing this course the student should be able to

CO-1 Describe properties of fuels and methods of combustion control.

CO-2 Compute energy efficiency of boilers and suggest methods of improving their efficiency.

CO-3 Compute energy efficiency of steam systems and methods of improving their efficiency.

CO-4 Describe different types of insulation, furnaces and refractories and choose them to improve heat loss.

CO-5 Describe methods of cogeneration and waste heat recovery in order to improve energy efficiency of thermal systems.

1 Fuels and Combustion

Introduction to fuels. Properties of liquid fuels. Properties of coal. Properties of gaseous fuels. Properties of agro residues. Combustion. Combustion of oil. Combustion of coal. Combustion of gas. Draft system. Combustion controls. 7 Hours

2 Boilers

Types. Combustion in boilers. Performances evaluation. Analysis of losses. Feed water treatment. Blow down. Energy conservation opportunities. 7 Hours

3 Steam System

Properties of steam. Assessment of steam distribution losses. Steam leakages. Steam trapping. Condensate and flash steam recovery system. Identifying opportunities for energy savings.
7 Hours

4 Furnaces

Classification. General fuel economy measures in furnaces. Excess air. Heat distribution. Temperature control. Draft control. Waste heat recovery. 7 Hours

5 Insulation and Refractories

Insulation – types and application. Economic thickness of insulation. Heat savings and application criteria. Refractory – types, selection and application of refractories. Heat loss. 7 Hours

6 FBC Boilers

Introduction. Mechanism of fluidised bed combustion. Advantages. Types of FBC boilers. Operational features. Retrofitting FBC system to conventional boilers. Saving potential.
7 Hours

7 Cogeneration

Definition. Need. Application. Advantages. Classification. Saving potentials. 7 Hours

8 Waste Heat Recovery

Classification. Advantages and applications. Commercially viable waste heat recovery devices. Saving potential. Checklists and tips for energy efficiency in thermal utilities. 7 Hours

References

1. Course Materials.
2. Book II - Energy Efficiency in Thermal Utilities, available at the website: http://www.energymanagertraining.com/
3. A. K. Shaha, "Combustion Engineering and Fuel Technology", Oxford & IBH Publishing Company
4. Book-IV : Energy Performance Assessment for Equipment and Utility Systems available at www.energymanagertraining.com.
5. Energy audit Reports of National Productivity Council.
6. Robert L.Loftness, "Energy Hand Book", Second edition, Von Nostrand Reinhold Company.
7. "Industrial Boilers", Longman Scientific Technical, 1999.
8. Relevant information available at www.boiler.com , www.eng-tips.com, www.worldenergy.org.
9. Handbook of Energy Conservation for Industrial Furnaces, Japan Industrial Furnace Association.
10. Energy audit reports of National Productivity Council.
11. Trinks, "Industrial Furnace", Volume 1 and Volume 2, John Wiley & Sons.
12. Improving Furnace Efficiency, Energy Management Journal.

ESM220 Energy Efficiency in Electrical Utilities

Total Lecture Hours	:	56	Credit Pattern L:T:P	:	4:1:0
Total Tutorial Hours	:	28	CIE, SEE Weightage	:	50%, 50%
Lecture Hours/Week	:	4	Prerequisite/s	:	Nil
Tutorial Hours/Week	:	2	Teaching Faculty	:	
Nature of Subject	:	Core			

Course Outcomes

After completing this course the student should be able to

CO-1 Describe power supply links, tariff structure, concept of metering, assessment of losses, efficiency improvement techniques in electrical systems including power quality, labelling of lines and transfomers.

CO-2 Describe electrical motors and its characteristics. Determination of efficiency speed control and related aspects including rewinding.

CO-3 Description of compressed air systems HVAC, their performance improvisation techniques and related energy saving aspects.

CO-4 Assess energy efficiency of fans, blowers, pumps, cooling towers, lighting systems and diesel generator sets and suggest energy saving opportunities in them.

CO-5 Describe energy saving technologies of lighting systems and energy conservation techniques in buildings.

1 Electrical System

Electricity billing, electrical load management and maximum demand control, power factor improvement and its benefit, selection and location of capacitors, performance assessment of PF capacitors, distribution and transformer losses. 5 Hours

2 Electric Motors

Types, losses in induction motors, motor efficiency, factors affecting motor performance, rewinding and motor replacement issues, energy saving opportunities with energy efficient motors.
5 Hours

3 Compressed Air System

Types of air compressors, compressor efficiency, efficient compressor operation, Compressed air system components, capacity assessment, leakage test, factors affecting the performance and savings opportunities. 6 Hours

4 HVAC and Refrigeration System

Vapor compression refrigeration cycle, refrigerants, coefficient of performance, capacity, and factors affecting Refrigeration and Air conditioning system performance and savings opportunities. Vapor absorption refrigeration system: Working principle, types and comparison with vapor compression system, saving potential. 7 Hours

5 Fans and Blowers

Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities. 3 Hours

6 Pumps and Pumping System

Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities. 4 Hours

7 Cooling Towers

Types and performance evaluation, efficient system operation, flow control strategies and energy saving opportunities assessment of cooling towers. Dry cooling towers – applications, types and necessity. 8 Hours

8 Lighting System

Light source, choice of lighting, luminance requirements, and energy conservation avenues.
8 Hours

9 Diesel Generating system

Factors affecting selection, energy performance assessment of diesel conservation avenues.

3 Hours

10 Energy Efficient Technologies in Electrical Systems

Maximum demand controllers, automatic power factor controllers, energy efficient motors, soft starters with energy saver, variable speed drives, energy efficient transformers, electronic ballast, occupancy sensors, energy efficient lighting controls, energy saving potential of each technology.

7 Hours

References

1. Course Materials.
2. Book III - Energy Efficiency in Electrical Utilities, available at the website: http://www.energymanagertraining.com/
3. Book-IV : Energy Performance Assessment for Equipment and Utility Systems available at www.energymanagertraining.com.

ESM230 Energy Storage Systems

Total Lecture Hours	:	56	Credit Pattern L:T:P	:	4:1:0
Total Tutorial Hours	:	28	CIE, SEE Weightage	:	50%, 50%
Lecture Hours/Week	:	4	Prerequisite/s	:	Nil
Tutorial Hours/Week	:	2	Teaching Faculty	:	
Nature of Subject	:	Core			

Course Outcomes

After completing this course the student should be able to

CO-1 Describe the need for energy storage and list methods of storage.

CO-2 Describe the general aspects of energy storage and methods of storing thermal energy and mechanical energy.

CO-3 Describe various methods of electromagnetic energy storage.

CO-4 Describe various methods of electrochemical storage.

CO-5 Describe various methods of energy storage systems for medium to large scale applications.

1 Need for Energy Storage

Introduction. Storage in the fuel distribution system – periodic storage, long-term or seasonal storage, daily and weekly storage. Energy security. Strategic crude oil storage – Indian Strategic Petroleum Reserves Limited (ISPRL). The problem of load leveling. Methods that can be used to reduce the magnitude of the variations in energy demand. Short-term transients. Portable applications that require energy storage. Hydrogen propulsion of vehicles. Temperature regulation in buildings. Improved lighting technologies. 8 Hours

2 General Concepts Related to Energy Storage

Introduction. The mechanical equivalent of heat. The First Law of Thermodynamics – Conservation of Energy. Enthalpy (H). Entropy (S) – thermal entropy, configurational entropy. The energy available to do work – Gibb's Free Energy or exergy (G). Temperature dependence of G, H, and S. Irreversible and reversible storage modes. The Carnot limitation. Energy quality.

8 Hours

3 Thermal Energy Storage

Introduction. Sensible heat. Latent heat – inorganic phase change materials, organic phase change materials. Solar thermal energy storage. Heat pumps. 8 Hours

4 Mechanical Energy Storage

Introduction. Potential energy storage. Energy storage in presurrised gas. Potential energy storage using gravity. Hydroelectric power, pumped-hydro storage. Pumped-hydro storage power plants in India. Global status of pumped-hydro storage power plants. Kinetic energy in mechanical systems – linear kinetic energy, rotational kinetic energy. Flywheel energy storage systems. Global status of flywheel energy storage systems. Internal structural energy storage. 8 Hours

5 Electromagnetic Energy Storage

Introduction. Energy storage in capacitors. Electrochemical charge storage mechanism. Ultracapacitors and supercapacitors. Comparative magnitudes of energy storage. Importance of quality of stored energy. Transient behaviour of a capacitor. Energy storage in magnetic systems. Supercondutive materials. Energy storage in superconducting magnetic systems.

8 Hours

6 Electrochemical Energy Storage

Electro-chemical storage — electro-chemical cell, fuel cells. Construction, working principle, ratings and performance characteristics of leads acid, sealed lead-acid, alkaline electrolyte, hydride-nickel batteries, high temperature type batteries. Chemical reaction storage. Phase transition. Heat capacity. Nuclear fuel. 8 Hours

7 Energy Storage Systems for Medium to Large Scale Applications

Introduction. Utility load leveling, peak shaving and mitigating instability by energy storage. Lead-acid batteries for large-scale storage. Sodium-sulfur batteries. Flow batteries. All-liquid batteries. Storage of energy for vehicle propulsion. ZEBRA batteries. Total energy system — hybrid, combined, integrated. Storage for peaking applications. 8 Hours

References

1. Course Materials.
2. Robert A. Huggins, "Energy Storage", Springer,
3. Frank S. Barnes & Jonah G. Levine, "Large Energy Storage Systems Handbook", 1st Edition, CRC Press, 2011.
4. Johannes Jensen Bent Squrensen, "Fundamentals of Energy Storage", Wiley Inter-science, 1984.
5. M. Barak, "Electro-chemical Power Sources – Primary and Secondary Batteries", IEE Energy Series, The Institution of Engineering and Technology, 1980.
6. Dieter Deublein & Angelika Steinhauser, "Biogas From Waste And Renewable Resources: An Introduction", 2nd Edition, Wiley-vch Verlag Gmbh, 2010.
7. Winston (win) Stothert, "Renewable Energies With Energy Storage", Xlibris Corporation, 2011.
8. Information available at Internet Resources:
   a) http://www.electricitystorage.org/
   b) http://www.sandia.gov/ess/Technology/technology.html

ESM241 Power System Operation and Security

Total Lecture Hours	: 56		Credit Pattern L:T:P	:	4:1:0
Total Tutorial Hours	: 28		CIE, SEE Weightage	:	50%, 50%
Lecture Hours/Week	: 4		Prerequisite/s	:	Nil
Tutorial Hours/Week	: 2		Teaching Faculty	:	
Nature of Subject	: Elective				

Course Outcomes

After completing this course the student should be able to

CO-1 Describe different models of power and energy interchange in a power system and calculate the cost of interchange as per different models.

CO-2 Describe methods of determining and improving the security of a power system.

CO-3 Describe various actions taken to improve the reliability of power systems.

CO-4 Describe the working of governor, AVR, power system stabilizers, and control of bus voltage at grid substations and generating substations.

CO-5 Describe the organizational structure, regulations, and different aspects of the present power market.

1 Interchange of Power and Energy in Power Systems

Introduction. Economy interchange. Economy interchange evaluation. Interchange evaluation with unit commitment. Multiple interchange contracts. After the fact production costing. Transmission losses in transaction evaluation. Other types of interchange. Capacity interchange. Diversity interchange. Energy banking. Emergency power interchange. Inadvertent power interchange. Power pools. The energy broker system. Centralized economic dispatch of a power pool. Allocating pool saving. Problems and further reading. 14 Hours

2 Power System Security

Introduction. Factors affecting power system security. Contingency analysis. Detection of network problems. Network sensitivity methods. A.C. load flow methods. Correcting the generation dispatch. Correcting the generation dispatch by sensitivity methods. Compensated factors. Correcting the generation dispatch using linear programming. 14 Hours

3 Power System Reliability

Demand estimation, monitoring and control. Actions to be taken during load crash and load changeover. Measures to ensure network security and reliability. Measures during high frequency conditions. Measures during low frequency conditions. Governor operation. Automatic voltage regulators and power system stabilisers. Control of voltage at grid substations and generating stations. Transformer tap optimisation. Synchronous condenser mode of operation. Operational planning in different time horizons. Scheduling and despatch. Hydro-thermal cordination. 14 Hours

4 Power Markets

Fundamentals of Electricity markets: restructuring, corporatization, privatization, competitive markets – pricing mechanisms, regulated markets, impact of transmission and system operation on electricity markets. Day-ahead resource scheduling: load forecasting, preparation of daily schedules, shortages, base load stations, peaking stations, must – run stations, generation location and effect on losses, open access: bilateral contracts and power exchange transactions. Whole sale market design: bilateral contracts, organized trading, market abuse and its mitigation: Market power and its evaluation, implications of market abuse, detection and avoidance of market abuse. Metering and settlement: measurement principles, meter placement, meter data collection, validation and processing, preparation of energy accounts billing, regional energy account, unscheduled interchange account, reactive energy account, congestion rent. Settlement system – ABT and UI, modalities for access to transmission: Long Term, Medium Term, Short Term. 14 Hours

References

1. Course Materials.
2. Allen J. Wood Brie and F. Wollengerg, “Power Generation Operation and Control”.
3. George L. Kusic, “Computer Aided Power System Analysis”, Prentice-Hall of India, Pvt. Ltd.

4. Stevenson, “Power System Analysis”, McGraw-Hill.

ESM242 Electrical Power Transmission and Distribution Practices

Total Lecture Hours	:	56	Credit Pattern L:T:P	:	4:1:0
Total Tutorial Hours	:	28	CIE, SEE Weightage	:	50%, 50%
Lecture Hours/Week	:	4	Prerequisite/s	:	Nil
Tutorial Hours/Week	:	2	Teaching Faculty	:	
Nature of Subject	:	Elective			

Course Outcomes

After completing this course the student should be able to

CO-1 Describe general aspects of transmission and distribution engineering.

CO-2 Calculate transmission line parameters and voltage gradients in conductors.

CO-3 Describe the corona effect.

CO-4 Compute standing waves, traveling waves in transmission lines. Describe methods of protecting lines against lightning and over voltages.

CO-5 Describe the EHV testing of transmission lines and design of EHV lines.

1 Distribution Engineering

Distribution planning and automation, load characteristics, application of distribution transformers, design of sub-transmission lines, design of distribution sub-stations, design consideration of primary and secondary systems, voltage drop and loss evaluations, application of capacitors, voltage regulation, HVDS system, protection, reliability, commercial aspects – AT&C loss, feeder indices. 7 Hours

2 Transmission Engineering

Introduction to EHV transmission, Transmission line trends, standard transmission voltages, average values of line parameters, power handling capacity and line losses, cost of transmission line and equipments, mechanical consideration in line performance. 3 Hours

3 Line Engineering

Resistance of conductors, temperature raise of conductor and current carrying capacity, properties of conductors and bundled conductors, inductance of EHV line configurations, line capacitance calculations, sequence inductance and capacitances, line parameters for modes of propagation resistance and inductance of ground returns. 6 Hours

4 Voltage Gradients of Conductors

Electrostatics, field of sphere gap, field of line charge and properties, charge potential relations for multi-conductor lines, surface voltage gradient on conductors, electric shock and threshold currents, calculation of electrostatic field of AC lines, effect of high electrostatic field on humans, animals and plants, meters and measurement of electrostatic field, electrostatic field induction in un-energized circuit of double circuit line, electromagnetic interference. 7 Hours

5 Corona Effect

Power loss and audible noise, radio interference corona pulses, generation and properties, limits of radio interference tests, lateral profile of radio interference and modes of propagation, measurement of radio interference. 3 Hours

6. Theory of Traveling Wave and Standing Wave

Open ended line response to sinusoidal excitation, line energizing with trapped charge voltage, reflection and refraction of traveling waves, transient response of system with series and shunt lumped parameters and distributed line. 3 Hours

7 Lightning and Lightning Protection

Lightning stroke to line, stroke to mechanism, general properties of lightning, protection problem, tower footing resistance, insulator flash over, and withstand voltage, probability of occurrence of lightning stroke currents, lightning arresters and their characteristics. 5 Hours

8 Over Voltages in EHV Lines

Origin and types of over voltages. Short-circuit current and the breakers. Recovery voltage, interruption of low inductive and capacitive currents, Ferro resonance over voltages, calculation of switching surges, reduction of switching surges on EHV systems, experimental and calculated results of switching surge studies. 5 Hours

9 Power Frequency and Voltage Control

Over voltage problems at power frequency, generalized constants, no load voltage conditions and charging current, power circle diagram and its use, voltage control using synchronous condensers, cascade connections of components, shunt and series compensation, sub-synchronous resonance in series compensated lines, static hybrid systems reactive compensating system, high phase order transmission. 7 Hours

10 EHV Testing and Lab Equipment

Standard specifications, standard wave shapes for testing, properties of double exponential wave shapes, procedure to evaluate α, β, γ. Wave shaping circuits, theory and principle, generation of switching surges for transformer, testing, impulse voltage generator, generation of impulse currents and high alternating current voltages, measurements of high voltages, general layout of EHV laboratories. 7 Hours

11 Design of EHV Lines

Design based on steady state limits and transient over voltages. 3 Hours

References

1. Course Materials.
2. Turan Gonen, “Electric Power Distribution Engineering”, Taylor & Francis /b S Publication, 2007.
3. Anthony Pansini, “Electrical Distribution Engineering”, 3rd Edition, Fairmont Press, 2006.
4. W. D. Stevenson, “Elements of Power System Analysis”, 4th Edition, McGraw-Hill, 1982.
5. A. S. Pabla, “Electric Power Distribution”, 5th Edition, McGraw-Hill, 2003.
6. Westinghouse, “T&D Handbook”.
7. Edison Electric Institute, “EHV Transmission Reference Book”.
8. Begamudre, “EHV Transmission Lines”,
9. Handbooks of SEBs.

ESM243 Advanced Heat and Mass Transfer

Total Lecture Hours	:	56	Credit Pattern L:T:P	:	4:1:0
Total Tutorial Hours	:	28	CIE, SEE Weightage	:	50%, 50%
Lecture Hours/Week	:	4	Prerequisite/s	:	Nil
Tutorial Hours/Week	:	2	Teaching Faculty	:	
Nature of Subject	:	Elective			

Course Outcomes

After completing this course the student should be able to

CO-1 Calculate heat transferred by conduction and convection.

CO-2 Calculate heat transferred by radiation.

CO-3 Describe phase change heat transfer.

CO-4 Describe heat transfer in porous media.

CO-5 Determine mass transfer in solids, liquids and gases.

1 Conduction Heat Transfer

Energy equations and boundary conditions. Multi-dimensional steady and unsteady heat conduction equations. Extended surface heat transfer. Conduction with moving boundaries. 8 Hours

2 Convective Heat Transfer

Boundary layer heat transfer, mixing length concept, analogy between heat and momentum transfer, Reynolds, Colburn, Von Karman, Turbulent flow in a tube, high speed flows. 8 Hours

3 Radiation Heat Transfer

Radiation heat transfer in enclosures, gases and vapor radiation. 8 Hours

4 Phase Change Heat Transfer

Condensation with shear edge on bank of tubes, boiling, pool and flow boiling. 8 Hours

5 Heat Transfer in Porous Media

Analysis of fluid flow and heat transfer in porous media based on conservation principles, local volume averaging, augmented conservation equations for porous media, applications to conduction, convection, mass transfer, radiation and two phase flows, introduction to numerical solutions for porous media. 8 Hours

6 Special Applications

Introduction to liquid metal heat transfer and micro heat transfer ablation heat transfer. 8 Hours

7 Mass Transfer

Introduction. Fick's law. Diffusion in solids, liquids, and gases. Mass transfer coefficient. Unsteady-state molecular diffusion, convective mass transfer, interface mass transfer, mass transfer equipment: absorption, stripping, extraction. 8 Hours

References

1. Course Materials.
2. Holman, J. P., "Heat Transfer", McGraw-Hill, 2002.
3. Nag P. K., "Heat Transfer", Tata McGraw-Hill, 2002.
4. Welty J. R., Wicks C. E., "Fundamentals of Momentum, Heat and Mass Transfer", John Wiley and Sons, 2001.
5. Kern D. Q., "Process Heat Transfer", Tata McGraw-Hill, 1997.
6. Kaviany M., "Principles of Heat Transfer in Porous Media", Springer Verlag, 1995.
7. Bennett C. O. and Myers J. E., "Momentum Heat and Mass Transfer", McGraw-Hill, 1983.

ESM244 Material Procurement and Management

Total Lecture Hours	: 56		Credit Pattern L:T:P	:	4:1:0
Total Tutorial Hours	: 28		CIE, SEE Weightage	:	50%, 50%
Lecture Hours/Week	: 4		Prerequisite/s	:	Nil
Tutorial Hours/Week	: 2		Teaching Faculty	:	
Nature of Subject	: Elective				

Course Outcomes

After completing this course the student should be able to

CO-1 Describe conventional and modern approaches to organizing materials management in organizations.

CO-2 Describe standards related to inventory control.

CO-3 Describe procurement methods, tendering, E-tendering, global tendering, two-part tendering and salient features of Karnataka Transparency in Public Procurement Act (1999) (KTPP).

CO-4 Describe purchase procedures followed in power sector organizations and standard procedures followed in the management of stores, and standard procedures to be followed for waste materials management.

CO-5 Describe the standard procedures for supply chain management.

1 Introduction

Introduction. Scope of materials management, primary and secondary objectives. Integrated materials management – relation with other functional areas of organization. Organizing for materials management, basis for forming organizations – conventional and modern approaches to organizing materials management. 12 Hours

2 Inventory Control

Materials identification, classification, and codification, standardization, simplification, and variety reduction, spares and minimum inventory levels. Inventory control techniques — FSN-VED, ABC – working capital management with reference to inventory. Technical specification guidelines (BIS, ISS etc, and relevant standards). Procedures for procurement of innovative materials for improvement of system operation. Procurement methods, tendering, E-tendering, global tendering, two-part tendering. Karnataka Transparency in Public Procurement Act (1999) (KTPP). Right to information Act. 16 Hours

3 Management of Stores

Management of stores, location, different types of stores, methods of storing, safety and security of materials, stores equipment, materials handling equipment, factors affecting materials handling, spares and inventory level, accounting. Management of surplus, obsolete and scrap materials. Reasons for accumulation of surplus, obsolete and scrap materials. Methods of disposal, regulations and procedures. Waste materials management. 12 Hours

4 Materials Procurement

Purchasing — planning purchase of materials, derivation of special benefits and concessions given by government and other organizations for the power sector at the time of purchase of services and goods. Norms of vendor rating pre-qualification of bidders – CEI methodology, Japanese industry — purchase procedures and methods. Legal aspects — insurance of materials. Supply management – sources of supply, direct procurement from OEM's. Out sourcing. Turnkey projects, service contracts, BOOT, BOO methods. 16 Hours

References

1. Course Materials.
2. Acts and Codes of Practices published by Government of Karnataka.
3. A. K. Datta, "Integrated Materials Management", PHI
4. Dobbler, Burt D.N, "Purchasing and Supply Management", TMI,7/e, 2004.
5. P. Gopalakrishnan, "Materials Management", PHI, 2002.
6. Leenders Fearon, "Purchasing and Materials Management", Universal Book Stall
7. K. S. Menon, "Purchasing and Inventory Control", Wheeler Publishers

8. Varma M. M., "Materials Management", Sultan Chand & Sons.

ESM245 Peak-load Power Plants

Total Lecture Hours	: 56		Credit Pattern L:T:P	:	4:1:0
Total Tutorial Hours	: 28		CIE, SEE Weightage	:	50%, 50%
Lecture Hours/Week	: 4		Prerequisite/s	:	Nil
Tutorial Hours/Week	: 2		Teaching Faculty	:	
Nature of Subject	: Elective				

Course Outcomes

After completing this course the student should be able to

CO-1 Describe merits of small hydro power plants and classify them.

CO-2 Describe the national scenario in respect of small hydro power plants.

CO-3 Describe design aspects of small hydro power plants.

CO-4 Describe the features of pumped storage plants and their national scenario.

CO-5 Describe the features of IC engine power plants.

1 Small Hydro Power Plants

Introduction. Power equation for a hydropower plant. Classification of small hydropower stations. Classification of water turbines. Impulse turbines. Specific speed of turbine. Range of application of various types of turbines for a small hydro project. Civil works needed for small hydropower facilities. Major components of small hydropower projects. Low-head small hydro projects. Choice of electric generators for small hydropower stations. Examples of small hydro power projects – Micro Hydro-electric Project at Shansha, Himachal Pradesh, Micro Hydroelectric Power Project, Kakroi (Sonepat), Haryana, Western Yamuna Canal Small Hydroelectric Project, Haryana. Global scenario of small hydropower systems. Indian scenario of small hydropower systems. Economic viability of small hydropower systems. 25 Hours

2 Pumped Storage Power Plants

Working principle, advantages, justification, classification, site selection, machinery, pumps, reversible pumps, storages, typical power house, salient features of hydraulic systems, flood detection, control and safety, starting methods. 16 Hours

3 IC Engine Power Plant

Introduction to oil and gas engines, diesel engine power plants, effluents, conventional and alternate fuels. Energy storage systems for electrical utilities. Importance of non-conventional energy systems. 15 Hours

References

1. Muhammad Abid, Khasan Karimov, "Micro-Hydropower Systems", Vdm Verlag, 2010.
2. David Barker Rushmore, "Hydro-Electric Power Stations", Nabu Press, 2010.

ESM246 Flexible A.C. Transmission Systems

Total Lecture Hours	: 56		Credit Pattern L:T:P	:	4:1:0
Total Tutorial Hours	: 28		CIE, SEE Weightage	:	50%, 50%
Lecture Hours/Week	: 4		Prerequisite/s	:	Nil
Tutorial Hours/Week	: 2		Teaching Faculty	:	
Nature of Subject	: Elective				

Course Outcomes

After completing this course the student should be able to

CO-1 Describe how power flow in an A.C. transmission line is controlled using FACTS controllers.

CO-2 Describe series and shunt compensation of A.C. transmission lines, and compensation by using STATCOM and SSSC.

CO-3 Describe the circuit configuration, modeling, performance, protection aspects, and applications of SVC, GCSC, TCSC.

CO-4 Describe the circuit configuration, modeling, performance, protection aspects, and applications of SPST and SSSC.

CO-5 Describe the circuit configuration, modeling, performance, protection aspects, and applications of UPFC.

1 Introduction

General. Basics of power transmission networks. Control of power flow in A.C. transmission line. Flexible A.C. transmission system controllers. Application of FACTS controllers in distribution systems. 5 Hours

2 A.C. Transmission Line and Reactive Power Compensation

Analysis of uncompensated A.C. line. Passive reactive power compensation. Compensation by a series capacitor connected at the mid-point of the line. Shunt compensation connected at the mid-point of the line. Comparison or series and shunt capacitors. Compensation by STATCOM and SSSC. Some representative examples. 8 Hours

3 Static VAR Compensator

Analysis of SVC. Configuration of SVC. SVC controller. Voltage regulator design — some issues. Harmonics and filtering. Protection aspects. Modeling of SVC. Applications of SVC. 8 Hours

4 Thyristor and GTO Controlled Series Capacitor

Introduction. Basic concepts of controlled series compensation. Operation of TCSC. Analysis of TCSC. Control of TCSC. Modeling of TCSC for stability studies. GTO tyristor controlled series capacitor(GCSC). Mitigation of subsynchronous resonance with TCSC and GCSC. Application of TCSC. 7 Hours

5 Static Phase Shifting Transformer

General. Basic principle of a PST. Configurations of SPST. Improvement of transient stability using SPST. Damping of low frequency power oscillations. Applications of SPST. 7 Hours

6 Static Synchronous Compensator (STATCOM)

Introduction. Principle of operation of STATCOM. A simplified analysis of a three phase six pulse STATCOM. Analysis of a six pulse VSC using switching functions. Multi-pulse converters. Control of Type 2 converters. Control of Type 1 converters. Multilevel voltage source converters. Harmonic transfer and resonance in VSC. Applications of STATCOM. 7 Hours

7 Static Synchronous Series Compensator

Introduction. Operation of SSSC and the control of power flow. Modeling and control of SSSC. SSSC with an Energy source. Analysis of SSR with a SSSC. Applications of SSSC. 7 Hours

8 Unified Power Flow Controller and other Multi-Converter Devices

Introduction. Operation of a UPFC. Control of UPFC. Protection of UPFC. Interline power flow controller. Convertible static compensator. Modeling of UPFC, IPFC and other Multi-converter FACTS. SSR characteristics of UPFC. Application of UPFC. 7 Hours

References

1. Course Materials.
2. K. R. Padiyar, "FACTS Controllers in Power Transmission and Distribution", New Age International Publishers, 2008.
3. R. Mohan Mathur and Rajiv K. Varma, "Thyristor-based FACTS Controllers for Electrical Transmission Systems", Wiley Interscience
4. FACTS Tutorials 1, 2, 3, and 4, Power Engineering Journal, 1995.
5. Latest papers from IEEE.

ESM247 IoT and Data Analytics in Electrical Engineering

Total Lecture Hours	: 56	Credit Pattern L:T:P	: 4:1:0
Total Tutorial Hours	: 28	CIE, SEE Weightage	: 50%, 50%
Lecture Hours/Week	: 4	Prerequisite/s	: Nil
Tutorial Hours/Week	: 2	Teaching Faculty	:
Nature of Subject	: Elective		

Course Outcomes

After completing this course the student should be able to

CO-1 Apply IoT technologies in electrical systems for monitoring and increasing efficiencies and for building new businesses.

CO-2 Implement a MQTT Subscriber/Broker in an IoT system.

CO-3 Describe the construction and working principle of different types of sensors and their industrial applications.

CO-4 Distinguish between real time, near real time and long time analytics, edge and cloud computing, and implement analytics for a system given the raw data in the domain of electrical engineering.

CO-5 Design an IoT system and implement it practically.

1 Overview of Internet of Things

Overview of Internet of Things. Device/cloud collaboration framework. Fog computing. Stream processing. Reliability and Security. Major drivers and trends in the industry.

2 Sensors

Sensors – types, target applications and trends; Sensors for – transformer, induction motor and generators, fuel cells, PV cells, batteries; air pollution - SOx, NOx, CO, CO2, particulates, solid and water pollution, boiler efficiency testing, steam distribution, air-conditioning systems, biogas, steam turbine, heat exchangers.

3 Data Analytics

Data Analytics – Introduction. Review of Probability distributions. Correlation analysis. Confidence Interval estimation. Hypothesis testing. Regression analysis. Machine learning.

References

1. Course Materials.
2. "Internet of Things: Principles and Paradigms", Edited by Rajkumar Buyya and Amir Vahid Dastjerdi, Elsevier, 2016.
3. Jacob Fraden, "Handbook of Modern Sensors - Physics, Designs, and Applications", 5th Ed., Springer, 2016.
4. S. Christian Albright and Wayne L. Winston, "Business Analytics: Data Analysis and Decision Making", 6th Ed, Cengage Learning, 2015.
5. Thomas A. Runkler, "Data Analytics – Models and Algorithms for Intelligent Data Analysis", 2nd Ed., Springer, 2016.

ESM251 Advanced Fluid Mechanics

Total Lecture Hours	: 56		Credit Pattern L:T:P	:	4:1:0
Total Tutorial Hours	: 28		CIE, SEE Weightage	:	50%, 50%
Lecture Hours/Week	: 4		Prerequisite/s	:	Nil
Tutorial Hours/Week	: 2		Teaching Faculty	:	
Nature of Subject	: Elective				

Course Outcomes

After completing this course the student should be able to

CO-1 Describe the basic principles of fluid mechanics.

CO-2 Apply Bernoulli's equation to determine fluid flow.

CO-3 Apply Control Volume Theorems to fluid flow problems.

CO-4 Apply Navier-Stokes Equation and Potential Flow Theory to fluid flow problems.

CO-5 Describe vorticity and circulation in fluid flow and the effect of surface tension on fluid flow.

1. Continuum Viewpoint and the Equation of Motion. The Material Derivative. Lagrangian and Eulerian Descriptions. Thermophysical Properties. Compressibility Effects in Gases. Forces Acting on a Continuum. The Inviscid Fluid.

2. Static fluids.

3. Mass Conservation. Mass Conservation in Flowing Media.

4. Inviscid Flow (Differential Approach): Euler's Equation, Bernoulli's Integral, and the Effects of Streamline Curvature. Steady Bernoulli Equation. Unsteady/Generalized Forms of the Bernoulli Equation.

5. Control Volume Theorems (Integral Approach): Linear Momentum Theorem, Angular Momentum Theorem, First and Second Laws of Thermodynamics. The Reynolds Transport Theorem. Conservation of Mass/Energy/Entropy.

6. Examples of Conservation of Linear Momentum. Conservation of Angular Momentum

7. Navier-Stokes Equation and Viscous Flow. Kinematics of Deformation. The Navier-Stokes Equation. Boundary Conditions for Navier-Stokes Equations. Fully Developed Flows, Stability of Viscous Flows. Start-up and Transient Flows Similarity Solution for a Flat Plate (The Rayleigh Problem). Quasi-Fully Developed Flows: Lubrication Theory.

8. Potential Flow Theory. The Velocity Potential and Streamfunction. Complex Variable Formulation. Examples of Potential Flow Solutions.

9. Similarity and Dimensional Analysis. The Buckingham Pi Theorem. Physical Significance of Dimensionless Variables. Asymptotic Limits of the Governing Equations and Scaling with Dimensionless Variables.

10. Boundary Layers, Separation and the Effect on Drag and Lift. The Velocity Potential and Stream function. Complex Variable Formulation. Examples of Potential Flow Solutions.

11. Vorticity and Circulation. Definition of Circulations Kelvin's Circulation Theorems. Lift, Induced Drag

12. Surface Tension and its Effect on Flows. Free Surface Force Balance. Scaling and Dimensional Analysis. Sample Flows.

References

1. Course Materials.

2. Kundu, Pijush K., and Ira M. Cohen, "Fluid Mechanics", 3rd Ed. Burlington, MA: Elsevier, 2004. ISBN: 9780121782535.

3. Fay, James A, "Introduction to Fluid Mechanics", Cambridge, MA: MIT Press, 1994. ISBN: 9780262061650.

4. M.I.T. Open Courseware available at: http://ocw.mit.edu/

5. Lectures available at NPTEL: http://nptel.iitm.ac.in/

ESM252 Safety, Environmental Issues, and Disaster Management

Total Lecture Hours	: 56		Credit Pattern L:T:P	:	4:1:0
Total Tutorial Hours	: 28		CIE, SEE Weightage	:	50%, 50%
Lecture Hours/Week	: 4		Prerequisite/s	:	Nil
Tutorial Hours/Week	: 2		Teaching Faculty	:	
Nature of Subject	: Elective				

Course Outcomes

After completing this course the student should be able to

CO-1 Describe various environmental legislation and regulations as applicable to energy systems.

CO-2 Describe recommended methods of minimizing water pollution in power plants.

CO-3 Describe recommended methods of minimizing air pollution in power plants.

CO-4 Describe standard methods of ensuring safety during the construction and running of power plants.

CO-5 Describe recommended practices to be followed for disaster management.

1 Environmental Issues

Overview of environmental system. Environmental legislation and regulation. Environmental ethics. Material balance approach to problem solving. Pollution types. Water, air, soil and noise pollution related to electrical equipment, installations and its effects. Environmental pollution due to dams and reservoirs of hydroelectric power stations. Pollutions caused by fossil fuels in thermal station and its control. Ash handling and its reuse. Definition and classification of hazardous waste. Hazardous waste management and treatment technologies. Land disposal. Ground water contamination and remedy. Handling and disposal of nuclear waste of a nuclear power plant. Standards and statutory requirements of pollution control related to power plants. Boiler feed water analysis and treatment. 15 Hours

Air pollution and standards. Effects of air pollution. Micro and macro air pollution. Air pollution metrology. Atmospheric dispersion. Air pollution control in thermal and nuclear power stations. Noise pollution and its effects. Rating systems. Protection. Noise control. 10 Hours

2 Safety Management

Safety management. Electrical safety. Prevention of injuries and damages. Protective aids and equipments. Safety in generating stations — hydro, thermal, nuclear. Civil engineering aspects of safety. Earth quakes, land slides, floods etc. Medical vigilance and requirements. Prevention of injuries and damages to personnel. Protective aids and equipment. Safety during construction and maintenance of plants and systems. Safety during maintenance and operating periods. Accidents — prevention and investigations. Safety in store houses in power plants. Handling emergency situations in power houses. Fire fighting in oil and coal store houses. Standby power supplies. Emergency power supplies. Loss prevention. 25 Hours

3 Disaster Management

Issues regarding risk, hazard and disaster. Monitoring and control. Mitigation. Preparedness, response and recovery. 6 Hours

References

1. Course Materials.
2. Mackenzie L. Davis and David. A Cornwell, "Introduction to Environmental Engineering", McGraw-Hill, 1991.
3. Noel De Nevers, "Air Pollution Control Engineering", McGraw-Hill, 1995.
4. C. Ray Asfahl, "Industrial Safety and Health Management", 5th Edition, Prentice-Hall, 2003.
5. Information available at the websites:
   a) http://www.nsc.org.in/
   b) http://www.nsc.org/

ESM253 SCADA and Automation in Electric Energy Systems

Total Lecture Hours	:	56	Credit Pattern L:T:P	:	4:1:0
Total Tutorial Hours	:	28	CIE, SEE Weightage	:	50%, 50%
Lecture Hours/Week	:	4	Prerequisite/s	:	Nil
Tutorial Hours/Week	:	2	Teaching Faculty	:	
Nature of Subject	:	Elective			

Course Outcomes

After completing this course the student should be able to

CO-1 Describe the basic components of Transmission and distribution systems and need for automation.

CO-2 Describe the various functions and the components used in SCADA communication systems and network.

CO-3 Describe the various components used for SCADA systems with reference to substation and feeder automation.

CO-4 Describe the components used in distribution automation system.

CO-5 Describe the desirable functionalities of distribution automation systems, and features of data bases used in such systems.

1 Supervisory Control and Data Acquisition (SCADA)

Basics of distribution systems, faults in distribution systems. Joint utility construction practices, economics of distribution, reliability aspects, distributed generation and coordination, power monitoring and dispatch, ABT. Feeder automation aspects. Equipments used for automation. Fault passage indicators, sectionlizers, auto reclosers, sensors, actuators etc. Pad mounted transformers and switchgears. R.M.U.'s. Basic concepts of smart grids. 7 Hours

Definition of SCADA. Evolution of SCADA. SCADA functions – data acquisition, monitoring and event processing, control, data storage archiving and analysis, application-specific decision support, and reporting. SCADA system components — RTU, IEDs, communication network, SCADA server. Configuration of a typical SCADA system. SCADA system polling principles. Communication technologies — wired, wireless. Standard communication protocols in SCADA. SCADA applications – utility applications, transmission and distribution sector operation, monitoring and analysis. 7 Hours

2 Distribution Automation

Definition of DA. Why distribution automation (DA)? Separate legal entities in deregulated power delivery systems. Key benefits of DA — capital deferred savings, operation and maintenance savings, interruption related savings, customer related savings, operational savings, improved operation. Software components in DA. Some abbreviations used in DA domain. Control hierarchy. Depth of control. Boundaries of control responsibility. Stages of automation. Automation Intensity Level (AIL). Components of Distribution Automation Systems — Consumer Information Service, GIS, Automatic Meter Reading, Energy and Revenue Management System. 14 Hours

3 Central Control and Management of Distribution Systems

Operating states of a power system. Power system operation function. Four key functional organizations in a distribution utility. Key distribution management systems (DMS) functions. Desirable functionality in a DMS. Outage management – trouble call based outage management, advanced application-based outage management. Decision support applications – load flow, fault calculation, loss minimization, VAR control, volt control, data dependency. Subsystems – substation automation, substation local automation. Extended control feeder automation. Performance measures and response times of DA systems. Database structures and interfaces. 14 Hours

4 Hardware for Distribution Automation

Introduction to switchgear. Primary switchgear – substation circuit breakers, substation disconnectors. Ground-mounted network substations – ring main unit (RMU), pad mounted switchgear. Pole mounted enclosed switches. Pole mounted reclosers. Pole mounted switch disconnectors. Operating mechanisms and actuators. Current and voltage measuring devices. Instrument transformers in extended control. Current and voltage sensors. 14 Hours

References

1. Course Materials.

2. James Northcote-Green and Robert G. Wilson, “Control and Automation of Electrical Power Distribution Systems”, CRC Press, 2006.

3. James A. Momoh, “Electric Power Distribution, Automation, Protection, and Control”, CRC Press, 2007.

4. A. S. Pabla, “Electric Power Distribution”, Tata McGraw-Hill Company Ltd.

5. Gordan Clark and Deem Reynders, “Practical Modern SCADA Protocols”

6. IEEE Tutorial on Distribution Automation.

7. Anthony J Pansini, “Electrical Distribution Engineering”, McGraw-Hill.

8. Dr M. K. Khedkar and Dr G M Dhole, “Electrical Power Distribution Automation”, University Press, New Delhi.

9. Stuart A. Boyer, “SCADA – Supervisory Control and Data Acquisition”, the Instrumentation, Systems and Automation Society (ISA), 2004.

ESM254 HVDC Transmission

Total Lecture Hours	: 56		Credit Pattern L:T:P	:	4:1:0
Total Tutorial Hours	: 28		CIE, SEE Weightage	:	50%, 50%
Lecture Hours/Week	: 4		Prerequisite/s	:	Nil
Tutorial Hours/Week	: 2		Teaching Faculty	:	
Nature of Subject	: Elective				

Course Outcomes

After completing this course the student should be able to

CO-1 State the modern trends and merits of D.C. transmission as compared to A.C. transmission.

CO-2 Define a valve and explain the various valve tests, analyze a Graetz circuit with and without overlap, analyze six-pulse and twelve-pulse converter bridge characteristic.

CO-3 Describe the general principles of D.C. link control and telecommunication requirements in H.V.D.C. transmission systems.

CO-4 Describe various faults in converters and methods of protecting against them.

CO-5 Describe protection schemes to be employed in H.V.D.C. links.

1 DC Power Transmission Technology

Introduction. Comparison of AC and DC transmission. Application of DC transmission. Description of DC transmission. Planning for HVDC transmission. Modern trends in DC transmission. 6 Hours

2 Thyristor Valve

Introduction. Thyristor device, Thyristor valve, Valve tests, Recent trends. 9 Hours

3 Analysis of HVDC Converters

Pulse number. Choice of converter configuration. Simplified analysis of Graetz circuits. Converters bridge characteristics. Characteristics of twelve pulse converter. Detailed analysis of converters. 9 Hours

4. Converters and HVDC System Control

General Principles of DC link control. Converter control characteristics. System control hierarchy. Firing angle control. Current and excitation angle control. Starting and stopping of DC link. Power control. Higher levels controllers. Telecommunication requirements. 12 Hours

5 Converter Faults and Protection

Introduction. Converter faults, Protection against over-currents. Over-voltages in a converter station. Surge arrestors, Protection against over-voltages. 10 Hours

6 Smoothing Reactor and Line

Introduction. Smoothing reactors, DC line, Transient over-voltages in DC line. Protection of a DC line, DC breakers, Mono-poplar operation. Effects of proximity of AC and DC transmission lines. 10 Hours

References

1. Course Materials.
2. Dr. K. R. Padiyar, “High Voltage D. C. Power Transmission Systems ”, New Age, 1990.
3. Arrilaga. J., “High Voltage Direct Current Transmission”, Peter Peregrinus Ltd., 1983.
4. Uhlmann, E. “Power Transmission by Direct Current”, Springer Verlag, 1975.

ESM255 Power System Instrumentation and Protection

Total Lecture Hours	:	56	Credit Pattern L:T:P	:	4:1:0
Total Tutorial Hours	:	28	CIE, SEE Weightage	:	50%, 50%
Lecture Hours/Week	:	4	Prerequisite/s	:	Nil
Tutorial Hours/Week	:	2	Teaching Faculty	:	
Nature of Subject	:	Elective			

Course Outcomes

After completing this course the student should be able to

CO-1 Describe standard specifications of instrument transformers, current sensors, VA meters.

CO-2 Describe the working of RTU, data acquisition system, trivector meter, event and disturbance recorders.

CO-3 Describe various types of comparators used in protective relays.

CO-4 Describe different protection schemes used in power systems for various power system apparatus.

CO-5 Describe the meaning of relay coordination, architecture of typical numeric protective relay.

1 Measurement of Voltages and Currents in Power Systems

Measurement of large current and voltage. Current and voltage transformers. Design equations and operational characteristics, error compensation schemes. Protection C.T.'s and P.T.'s. Metering and protection class. Standard specification of instrument transformers, design considerations. Types of C.T.'s. Testing of instrument transformers. D.C. current transformer, current sensors. Measurement of power and energy, torque equation of induction type energy meter, parasitic torques and their minimization. IS Specifications, analog and digital KVA meters. Telemetering. Remote terminal unit (RTU), Data Acquisition System, Trivector meter, event and disturbance recorders. 28 Hours

2 Relays and Protection Schemes

Role of protection in power system, concepts of protection chain, current and potential transducers, Solid state Relays, Static relay, coordination of current relays. Microprocessor based Protective relays, functions, block diagrams. Comparators, phase and amplitude comparators, duality between phase and amplitude comparator. Protection of generator, transformer, harmonic restrained relay, combined differential protection for generator and transformer, bus bar protection, frequency relay, Distance protection types, star delta switching, pilot wire protection, carrier protection, phase and directional compensation schemes. Testing of distance relays, relay co-ordination, nomenclature of relays, numeric relays. 28 Hours

References

1. Course Materials.
2. E. W Golding, F. C. Widdis, “Electrical Measurements And Measuring Instruments”, Reem Publications Pvt. Ltd.
3. B. C. Nakra, “Instrument Measurement and Analysis”, M.G.H., Publishers, 2009.
4. Selected topics from IEE, CIGRE Journals.
5. Ravindranath B. S. , Chander M. Phillips, “Power System Protection and Switchgear”, New Age International (p) Limited, Publishers, 2011.
6. T. S. Madhava Rao, “Static Relays and Microprocessor Application”, 2nd Edition, T.M.H., 2004.
7. Badri Ram, “Power System Protection and Switchgear”, T.M.H., 2005.
8. Singh, “Digital Power System Protection”, Prentice-Hall, 2007.
9. S. P. Patra and S. K. Basu, “Power System Protection”,

ESM260 Energy Systems Lab

Total Practical Hours	: 42	Credit Pattern L:T:P	:	0:0:1.5
Lecture Hours/Week	: 0	CIE, SEE Weightage	:	100%, 0%
Practical Hours/Week	: 3	Corequisite	:	ESM110
Nature of Subject	: Core	Teaching Faculty	:	

Course Outcomes

After completing this course the student should be able to

CO-1 Determine the properties of fuels and biomass.

CO-2 Determine the efficiency of boilers and pumps.

CO-3 Determine V-I characteristics of solar PV panel, efficiency of refrigeration systems and diesel generator sets. Track maximum power point in a solar PV system.

CO-4 Conduct tests on wind energy systems to determine their performance parameters.

CO-5 Program smart meters.

List of Experiments

1. Measurement of properties of fuels and biomass.
2. Determination of boiler and pump efficiency.
3. Testing of gasifier.
4. Determination of V-I characteristics of solar PV panel.
5. Evaluation of variable speed drives for induction motors.
6. Testing of refrigeration systems and diesel generator sets to determine their efficiency.
7. Measurement of pollutant level in exhausts coming from diesel engines.
8. Determination of performance characteristics of induction motors by conducting load test.

9. Battery charging and discharging characteristics.
10. Experiments on solar thermal systems to determine efficiency.
11. Maximum power point tracking (MPPT) in a solar PV system.
12. Experiments on wind energy systems to determine the performance characteristics.
13. Programming smart energy meters.
14. Using virtual instrumentation systems.