Kerala Technological University

Cluster 4: Kottayam

M. Tech Program in Electrical Engineering (Energy Systems)

Scheme of Instruction and Syllabus: 2015 Admissions

Compiled By

Rajiv Gandhi Institute of Technology, Kottayam

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Kerala Technological University

(Kottayam/Idukki Cluster)

M. Tech Program in Energy Systems

Scheme of Instruction

Credit requirements **:** 67 credits (22+19+14+12)
Normal Duration : Regular: 4 semesters; External Registration: 6 semesters;
Maximum duration : Regular: 6 semesters; External Registration: 7 semesters.
Courses: Core Courses: Either 4 or 3 credit courses; Elective courses: All of 3 credits
Allotment of credits and examination scheme:-

Semester 1 (Credits: 22)

Exam Slot	Course No:	Name	L- T - P	Internal Marks	End Semester Exam		Credits
					Marks	Duration (hrs)	
A	04 EE 6001	Optimization Techniques for Engineering Applications	3-0-0	40	60	3	3
B	04 EE 6501	Non Conventional Energy Sources	3-1-0	40	60	3	4
C	04 EE 6503	Energy Resources Economics and Environment	4-0-0	40	60	3	4
D	04 EE 6303	Power Electronic Circuits	3-0-0	40	60	3	3
E	04 EE 6XXX*	Elective – I	3-0-0	40	60	3	3
	04 GN 6001	Research Methodology	0-2-0	100	0	0	2
	04 EE 6591	Seminar – I	0-0-2	100	0	0	2
	04 EE 6593	Energy Systems Lab	0-0-2	100	0	0	1
		Total	23				22

**See List of Electives-I for slot E*

List of Elective - I Courses

Exam Slot	COURSE NO.	COURSE TITLE
E	04 EE 6505	Industrial Thermal Systems
E	04 EE 6507	Chemical Process Technology
E	04 EE 6509	Integrated Lighting System
E	04 EE 6511	Energy System Modelling and Analysis

M. Tech (Energy Systems)

Semester 2 (Credits: 19)

Exam Slot	Course No:	Name	L- T - P	Internal Marks	End Semester Exam		Credits
					Marks	Duration (hrs)	
A	04 EE 6502	Energy Management and Audit	3-1-0	40	60	3	4
B	04 EE 6304	Grid Integration of Solar PV System	3-0-0	40	60	3	3
C	04 EE 6504	Wind and Hybrid Energy Systems	3-0-0	40	60	3	3
D	04 EE 6XXX*	Elective - II	3-0-0	40	60	3	3
E	04 EE 6XXX^	Elective - III	3-0-0	40	60	3	3
	04 EE 6592	Mini Project	0-0-4	100	0	0	2
	04 EE 6594	Advanced Renewable Energy Lab	0-0-2	100	0	0	1
		Total	22				19

**See List of Electives -II for slot D* *^See List of Electives -III for slot E*

List of Elective - II Courses

Exam Slot	COURSE NO.	COURSE TITLE
D	04 EE 6508	Utilization of Solar Thermal Energy
D	04 EE 6512	Fuel Cells and Hydrogen
D	04 EE 6514	Bio-Energy Engineering
D	04 EE 6516	Nuclear Reactor Theory

List of Elective - III Courses

Exam Slot	COURSE NO.	COURSE TITLE
E	04 EE 6200	Electric Drive Systems
E	04 EE 6434	Computer Aided Power System Analysis
E	04 EE 6444	FACTS and Power Quality
E	04 EE 6604	Digital Controllers for Power Applications

Summer Break

Exam Slot	Course No:	Name	L- T - P	Internal Marks	End Semester Exam		Credits (0)
					Marks	Duration (hrs)	
NA	04 EE 7590	Industrial Training	0-0-4	NA	NA	NA	Pass /Fail
		Total	4				0

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Semester 3 (Credits: 14)

Exam Slot	Course No:	Name	L- T - P	Internal Marks	End Semester Exam		Credits
					Marks	Duration (hrs)	
A	04 EE 7XXX*	Elective - IV	3-0-0	40	60	3	3
B	04 EE 7XXX^	Elective - V	3-0-0	40	60	3	3
	04 EE 7591	Seminar - II	0-0-2	100	0	0	2
	04 EE 7593	Project (Phase - I)	0-0-12	50	0	0	6
		Total	20				14

**See List of Electives-IV for slot A* *^See List of Electives-V for slot B*

List of Elective - IV Courses

Exam Slot	COURSE NO.	COURSE TITLE
A	04 EE 7501	Energy and Climate
A	04 EE 7505	Energy Efficient Buildings
A	04 EE 7507	Waste Management and Energy Generation Technologies
A	04 EE 7509	Energy Efficiency in Thermal Utilities

List of Elective - V Courses

Exam Slot	COURSE NO.	COURSE TITLE
B	04 EE 7001	Bio-inspired Algorithms
B	04 EE 7113	Data Acquisition and Signal Conditioning
B	04 EE 7421	Electricity Deregulation
B	04 EE 7423	Power Generation and System Planning

Semester 4 (Credits: 12)

Exam Slot	Course No:	Name	L- T - P	Internal Marks	External Evaluation Marks		Credits
NA	04 EE 7594	Project (Phase -II)	0-0-21	70	30	NA	12
		Total	21				12

Total: 67

COURSE NO.	COURSE TITLE	CREDITS	YEAR
04 EE 6001	**OPTIMIZATION TECHNIQUES FOR ENGINEERING**	**3-0-0:3**	**2015**

	APPLICATIONS		

Pre-requisites: NIL

Course Objectives:

To give the Student:-

- A foundation in the theory of optimization methods
- An awareness of the usefulness and limitation of optimization and the framework through which further studies/application in the area can be conducted.
- Practice in some of the well-known optimization techniques and their applicability in a real setting.

Syllabus

Fundamental concepts and overview of Optimization Theory; Linear Programming; Unconstrained Optimization Techniques; Constrained Optimization; Recent Developments in Optimization

Course Outcome:

Upon successful completion of this course, the student will be able to

- Understand the basic principles in Optimization Theory
- Formulate Optimization Problems
- Use appropriate Optimization algorithms for solving Engineering Problems
- Be familiar with Recent Developments in Optimization

Text Books:

1. Rao S. S., Engineering Optimization: Theory and Practice, Wiley, New York, 1996.
2. Pierre, D. A., Optimization Theory with Applications, Dover Publications, INC., New York,1969.

References:

1. Fox, R. L., Optimization method for Engineering Design, Addison –Wesley Pub. Co., 1971
2. Hadley, G., Linear Programming, Addison- Wesley Pub. Co., 1963
3. Bazaara M. S., Sherali H.D., Shetty C.M., Non-linear Programming, John Wiley and Sons, 2006.
4. D.E. Goldberg, Genetic Algorithm in Search, Optimization, and Machine Learning, Addison-Wesly, 1989.
5. Glover F., Laguna M., Tabu Search, Kluwer Academic Publishers, 1997.
6. Marco Dorigo, Vittorio Miniezza and Alberto Colorni, “Ant System:Optimization by a colony of Cooperation Agent”, IEEE transaction on system man and Cybernetics-Part B:cybernetics, Volume 26, No 1, pp. 29-41,1996.
7. Shi, Y. Eberhart, R. C., “A Modified Particle Swarm Optimizer”, Proceedings of the IEEE International conference on Evolutionary Computation, Anchorage, AK, pp. 69-73, May 1998.

COURSE PLAN

Course No:	Course Title:	CREDITS
04 EE 6001	OPTIMIZATION TECHNIQUES FOR ENGINEERING APPLICATIONS	3-0-0:3

MODULES	Contact hours	Sem. Exam Marks;%
MODULE : 1 Statement and Classification of Optimization Problems , Overview of Optimization Techniques, Standard Form of Linear Programming Problems-Definitions and Theorems	5	15
MODULE : 2 Simplex Method-Revised Simplex Method-Duality and Dual Simplex Method-Sensitivity Analysis	8	15
FIRST INTERNAL TEST		
MODULE 3 Necessary and Sufficient Conditions-Search Methods(Unrestricted Fibonacci and Golden)-Interpolation Methods(Quadratic, Cubic and Direct Root Method)	6	15
MODULE 4 Direct Search Methods-Random Search-Pattern Search and Rosen Brock's Hill Climbing Method Descent Methods-Steepest Descent, Conjugate Gradient, Quasi Newton and DFE Method	7	15
SECOND INTERNAL TEST		
MODULE 5 Necessary and Sufficient Conditions-Equality and Inequality Constraints-Kuhn-Tucker Conditions. Gradient Projection Method-Cutting Plane Method-Penalty Function Method (Interior and Exterior). Principle of Optimality-Recurrence Relation-Computation Procedure-Continuous Dynamic Programming	9	20
MODULE 6	7	20

Rosenbrocks Rotating Coordinate Method-Tabu Search-Simulated Annealing. Genetic Algorithm-Particle Swarm Optimization –Ant Colony Optimization-Bees Algorithm		
END SEMESTER EXAM		

COURSE NO.	COURSE TITLE	Credits	YEAR
04 EE 6501	NON – CONVENTIONAL ENERGY SOURCES	3-1-0:4	2015

Pre-requisites: Nil

Course Objectives:

- To introduce concepts of solar energy conversion and the various ways of storing the solar energy
- To understand the principles of wind energy conversion devices, types of wind turbines and generators.
- To study about Geothermal energy, ocean energy, wave energy, tidal energy, fuel cell, hydrogen energy, biomass and its conversion technologies

Syllabus

Solar radiation outside the Earth's atmosphere and at the Earth's surface – Instruments for Solar radiation measurement– Solar radiation geometry – Solar Photovoltaic Systems - Solar thermal energy collectors – types and applications, Wind Energy: Basic principles of wind energy conversion – wind speed measurement - classification of wind turbine – types of rotors – aerodynamic operation of wind turbine – wind power equation – Betz limit – Wind characteristics, Small Hydro power system, Geothermal resources – power generation – Vapour/liquid dominating systems, Methods of ocean thermal electric power generation – open cycle and closed cycle OTEC system, Power in Waves – wave energy technology, Tidal Energy- tidal energy conversion scheme, Principles of operation of fuel cell – classification, Hydrogen energy – hydrogen production and utilization, Biomass conversion technologies - Biogas production.

Course Outcome:

- Student will be able to explain concepts behind various type of new and renewable energy resources.

Text Books:

1. J. Twidell and T. Weir, Renewable Energy Resources, E&FN Spon Ltd, London, 1986.

2. S. P. Sukatme, Solar Energy – Principles of thermal collection and storage, second edition, Tata McGraw Hill, 1991.

References:

1. G. D. Rai, Non Conventional Energy Sources, Khanna Publishers, 2010.

2. J. A. Duffie and W. A. Beckman, Solar Engineering of Thermal Processes, second edition, John Wiley, New York, 1991.

3. D. Y. Goswami, F. Kreith and J. F. Kreider, Principles of Solar Engineering, Taylor and Francis, Philadelphia, 2000.

4. L. L. Freris, Wind Energy Conversion Systems, Prentice Hall, 1990.

5. L. Monition, M. Lenir and J. Roux, Micro Hydro Electric Power Station,John Wiley and Sons,England, 1984.

6. K. M. Mittal, Non-conventional Energy Systems – Principles, Progress and Prospects, Wheeler Publications, 1997.

7. D. D. Hall and R. P. Grover, Bio-Mass Regenerable Energy, John Wiley, New York, 1987.

8. B. H. Khan, Non Conventional Energy Resources, 2nd edition, TMH 2013.

9. D. P. Kothari, K. C. Singhal, Rakesh Rajan, Renewable energy sources and emerging technologies, 2nd edition, 2013.

10. C. S. Solanki, Solar Photovoltaic Fundamentals, Technologies and Applications, PHI Learning, New Delhi, 2012.

COURSE PLAN

COURSE NO.	COURSE TITLE	CREDITS	
04 EE 6501	NON – CONVENTIONAL ENERGY SOURCES	3-1-0: 4	
MODULES		Contact Hours	Sem. Exam Marks (%)
MODULE: 1 **Solar Radiation:** Solar radiation outside the Earth's atmosphere and at the Earth's surface – Instruments for Solar radiation measurement, Solar radiation data – Solar radiation geometry – Empirical equations – Solar radiation on a tilted surface – Problems.		8	15
MODULE: 2 Solar Photovoltaic Systems – PV Cell fundamentals – equivalent circuit – cell characteristics – classification of solar cell. Solar thermal energy collectors – types - Liquid flat plate collector - concentrating collectors –parabolic collector - central receiver collector– applications – solar water heating systems.		9	15
FIRST INTERNAL TEST			
MODULE: 3 Wind Energy: Basic principles of wind energy conversion – wind speed measurement - classification of wind turbine – types of rotors – aerodynamic operation of wind turbine – wind power equation – Betz limit – Wind characteristics – Problems – types of generators – site selection		10	15
MODULE: 4 Small Hydro: Basic concepts – site selection – types of turbines. Geothermal energy: Geothermal resources – power generation – Vapour/liquid dominating systems – block diagram – hot dry rock and hydrothermal resources – applications – Environmental considerations Energy from biomass: Biomass conversion technologies - Biogas production – classification of biogas plants		10	15
SECOND INTERNAL TEST			
MODULE: 5 Ocean Energy: Methods of ocean thermal electric power generation – open cycle and closed cycle OTEC system - Environmental impacts. Wave Energy: Power in Waves – wave energy technology – Heaving float		9	20

type – pitching type – Heaving and pitching type – oscillating water column type – surge devices - Environmental impacts - Tidal Energy: Limitations of tidal energy – tidal range powers – problems – tidal energy conversion scheme – single basin and double basin types		
MODULE: 6 Hydrogen energy: Introduction – hydrogen production – electrolysis – thermo chemical methods – hydrogen storage – utilization of hydrogen gas. Fuel cell: Principles of operation of fuel cell – classification – conversion efficiency and losses – types of electrodes – work output and emf – applications	10	20
END SEMESTER EXAM		

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 6503	ENERGY RESOURCES, ECONOMICS AND ENVIRONMENT	4-0-0-4	2015

Pre-requisites: Nil

Course Objectives:

- To understand the World and Indian energy reserves, energy usage patterns and to study and develop various future energy scenarios
- To understand the concepts of Energy conservation and related energy economics by using various tools
- To study about various pollutants to the eco system, its production, harmful effects, methods of reduction relevant into the areas of air and water pollution and to understand the concepts of Global warming caused by Green house Gases, , and the mitigation and adaptation concepts.

Syllabus

Overview of World and India's energy scenario – energy reserves and security - country annual energy balances –trends in energy use patterns, Energy chain - primary energy analysis – life cycle energy assessment – energy and development linkage – Energy Scenarios –need of scenarios, Energy Economics:- Need for economic analysis - Simple payback period - Time value of money - Return on Investment – Internal Rate of Return – Capital Recovery Factor - Net Present Value, Life cycle costing – cost of saved energy – cost of energy generated – simple problems about economics of renewable energy systems and energy conservation systems, Environmental impacts of energy use – Air pollution - Indoor air quality – SOx – NOx – CO –Volatile Organic Compounds – Particulate matter, Sources of emissions - Motor vehicle emissions - exhaust emission test – control of automobile emissions, Stationery sources of emissions – Coal power plants – control of emissions from coal power plants, Environmental impact assessment - environmental audit, Climate change from green house gases – CO_2 emissions – Global warming - Green house gases and Global warming potential, Radiative forcing of Climate change - mitigation and adaptation measures - IPCC Assessment –Stabilizing Greenhouse gases, Kyoto Protocol – Carbon credits

Course Outcome:

- Ability to understand energy reserves, various energy scenarios, impacts of energy usage on environment and energy economics.

Text Books:

1. G. M. Masters, W.P. Ela, Introduction to Environmental Engineering and Science, Third Edition, PHI, 2008.

2. Frank Kreith, Jan F. Kreider, Principles of Sustainable Energy, CRC Press, 2011.

References:

1. Energy and the Challenge of Sustainability, World energy assessment, UNDP, United Nations Publications, New York, 2000.
2. General Aspects of Energy Management and Energy Audit (Book -1of Guide books), Revision II, Bureau of Energy Efficiency, India.
4. A. K. N. Reddy, R. H. Williams, T. B. Johansson, Energy after Rio – Prospects and challenges, UNDP, United Nations Publications, New York, 1997.
5. Nebojsa Nakicenovic, Arnulf Grubler, Alan McDonald, Global energy perspectives, Cambridge University Press, 1998.
6. J. M. Fowler, Energy and the environment, 2nd Edition, McGraw Hill, New York, 1984.

COURSE PLAN

COURSE NO.:	COURSE TITLE	L-T-P: 4-0-0	
04 EE 6503	ENERGY RESOURCES, ECONOMICS AND ENVIRONMENT	CREDITS: 4	
MODULES		Contact Hours	Sem. Exam Marks (%)
MODULE: 1 Overview of World and India's energy scenario – energy reserves and security - Disaggregation by end-use and supply – country annual energy balances – examples – trends in energy use patterns – annual electrical energy usage pattern in India.		8	15
MODULE: 2 Energy chain - primary energy analysis – life cycle energy assessment – energy and development linkage – Energy Scenarios –need of scenarios - simple problems with development of energy use scenarios.		8	15
FIRST INTERNAL TEST			
MODULE: 3 Energy Economics: Need for economic analysis - Simple payback period - advantages and limitations - Time value of money - Return on Investment – Internal Rate of Return – Capital Recovery Factor - Net Present Value.		10	15
MODULE: 4 Life cycle costing – cost of saved energy – cost of energy generated – simple problems about economics of renewable energy systems and energy conservation systems.		10	15
SECOND INTERNAL TEST			
MODULE: 5 Environmental impacts of energy use – Air pollution - Indoor air quality – SOx – NOx – CO –Volatile Organic Compounds – Particulate matter, Sources of emissions - Motor vehicle emissions - exhaust emission test – control of automobile emissions, Stationery sources of emissions – Coal power plants – control of emissions from coal power plants, Environmental impact assessment - environmental audit		10	20
MODULE: 6 Climate change from green house gases – CO_2 emissions – Global warming - Green house gases and Global warming potential,		10	20

Radiative forcing of Climate change - mitigation and adaptation measures - IPCC Assessment –Stabilizing Greenhouse gases, Kyoto Protocol – Carbon credits.		
END SEMESTER EXAM		

COURSE NO.	COURSE TITLE	CREDITS	YEAR
04 EE 6303	POWER ELECTRONIC CIRCUITS	3-0-0:3	2015

Pre-requisites: Nil

Course Objectives:

- To provide in-depth knowledge about important power electronic devices and their protection.
- To provide insight into design operation of different power converters.
- To impart knowledge about different DC to DC converters.
- To develop the student's ability to design and control inverters with high efficiency

Syllabus

Ideal and Real switches; static and dynamic performance; Power diodes; Power Transistors; Power MOSFET; IGBTs; Thyristor; GTO; Static and Dynamic Performance; Uncontrolled rectifiers; Single phase and Three phase; Controlled Rectifiers; Analysis with RL, RLE loads; AC Voltage Controllers; DC to DC Converters; Isolated DC to DC Converters; Inverter; Half Bridge and Full Bridge; Six Step and Two Level PWM; Introduction to Multilevel Invertors

Course Outcome:

The students will be

- Able to describe the characteristics, operational features and control of important power electronic devices.
- Able to design basic inverter circuitries that are useful in applications demanding high energy efficiency & compact power conversion stages.

TEXT BOOKS:

1. Ned Mohan, Tore M. Undeland, William P. Robbins, Power Electronics: Converters, Applications and Design, 3rd Edition, John Wiley, 2003.
2. M H Rashid, Power Electronics: Circuits, Devices and Applications, Pearson Education India.

References:

1. William Shepherd, Li Zhang, Power Converter Circuits, Marcel Dekker Inc, 2004.
2. Joseph Vithayathil, Power Electronics: Principles and Applications, McGraw Hill,1994.
3. Philip T. Krein, Elements of Power Electronics, Oxford, 1998.

COURSE PLAN

COURSE NO:	COURSE TITLE	CREDITS	
04 EE 6303	POWER ELECTRONIC CIRCUITS	3-0-0: 3	
MODULES		**Contact hours**	**Sem. Exam Marks;%**
MODULE : 1 Ideal and Real switches – static and dynamic performance – Power diodes – Power Transistors – Power MOSFET- IGBTs – Thyristor – GTO – Static and Dynamic Performance – Snubbers for switching devices – Turn on, Turn off and Over voltage.		8	15
MODULE : 2 Uncontrolled rectifiers – Single phase and Three phase. Controlled Rectifiers – Single phase and Three phase-fully controlled and semi-controlled- Analysis with RL, RLE loads – Inversion mode of operation.		8	15
FIRST INTERNAL TEST			
MODULE : 3 Rectifiers - Performance -Effect of source inductance – Dual converters – Circulating and Non circulating type AC Voltage Controllers – Single Phase and Three phase, Principle of operation.		6	15
MODULE : 4 DC to DC Converters - Buck, Boost, Buck-Boost- Cuk Converters. Basic Operation-Waveforms-modes of operation –Output voltage ripple-State space modeling- Multi output Boost Converter.		6	15
SECOND INTERNAL TEST			
MODULE : 5 Isolated DC to DC Converters - Push-Pull, Forward, fly back, Bridge type converter topologies - Basic Operation only.		6	20
MODULE : 6		8	20

Inverter – Half Bridge and Full Bridge – Six Step and Two Level PWM – Harmonics and Voltage control in inverters – Current source inverter – Single phase and Three phase – Introduction to Multilevel Inverters – Different types.		
END SEMESTER EXAM		

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 6505	INDUSTRIAL THERMAL SYSTEMS	3-0-0-3	2015

Pre-requisites: Nil

Course Objectives:

- To understand the basic principles and applications of heat transfer, properties of steam and Rankine cycle.
- To give an awareness about combustion of Fuels, operation of Boilers and heat exchangers.
- To use heat transfer principles to understand the refrigeration and air conditioning systems.

Syllabus

Conduction: Fourier's law of heat conduction – one dimensional steady state conduction– concept of thermal resistance – critical thickness of insulation and its application – overall heat transfer coefficient - Basic concepts in transient heat conduction – Qualitative analysis only, Convection: Newton's law of cooling and application areas – Forced convection: flow over a flat plate - hydrodynamic and thermal boundary layer – Basic concepts about free convection – Qualitative analysis only, Radiation: Nature of thermal radiation-definitions and concepts-monochromatic and total emissive power - absorptivity, reflectivity and transmissivity - definition of black, grey and real surfaces -concept of a black body - Plank's law, Kirchoff's law, Wein's displacement law and Stefan-Boltzmann law - geometric factor (shape factor or configuration factor) of simple geometries – Qualitative analysis only, Heat exchangers-Types – Specifications, Steam System-Properties of steam - Rankine cycle - reheat cycle-regenerative cycle-Assessment of steam distribution losses - Boiler Types, Combustion in boilers, Performances evaluation, Analysis of losses, feed water treatment, Blow down– basic concepts only, Fuels and Combustion: Properties of Fuel oil, Coal and Gas - Storage, handling and preparation of fuels - Fuel Analysis, Combustion Stoichiometry, theoretical & actual combustion processes – Air fuel ratio - Combustion Thermodynamics - Bomb calorimeter, Principles of refrigeration - Thermodynamics of refrigeration – Carnot, reversed carrot cycle, heat pump, and refrigerating machine- coefficient of performance -unit of refrigeration - conventional refrigeration systems, Vapour compression system-simple cycle - comparison with Carnot cycle, theoretical and actual cycles- COP, Principles of air conditioning - Psychrometry and psychrometric chart - human comfort - sensible heat factor- psychometric process – basic problems only - winter air conditioning - summer air conditioning - year round air conditioning - unitary and central systems.

Course Outcome:

- The student will understand the fundamentals of industrial thermal systems.

Text Books:

1. Guide Books for energy managers and Auditors, Book 2 and 4, Revision 2, Bureau of Energy Efficiency, India, 2005.
2. Yunua A. Cengel, Afshin Ghajar, Heat and mass transfer: fundamentals and applications, Mc Graw Hill higher Education, 5th ed., 2014.
3. R. S. Khurmi, J. K. Gupta, A text book of refrigeration and air conditioning, S. Chand, 2006.

References:

1. V.S. Arpaci, Conduction Heat Transfer, Addison Wesly, 1996.
2. A. Bejan, Convection Heat Transfer, J. Wiley, 2007.
3. M.F. Modest, Radiative Heat Transfer, McGraw Hill, 1993.
4. A. P. Fraas, Heat Exchanger Design, Second Edition, John Wiley & Sons, 1989.
5. R. K. Rajput, Thermal Engineering, Laxmi Publications, 9th ed., 2013.

COURSE PLAN

COURSE NO.:	COURSE TITLE	L-T-P: 3-0-0	
04 EE 6505	INDUSTRIAL THERMAL SYSTEMS	CREDITS: 3	
MODULES		Contact Hours	Sem. Exam Marks (%)
MODULE: 1 Conduction: Fourier's law of heat conduction – one dimensional steady state conduction– concept of thermal resistance – critical thickness of insulation and its application – overall heat transfer coefficient - Basic concepts in transient heat conduction – Qualitative analysis only. Convection: Newton's law of cooling and application areas – Forced convection: flow over a flat plate - hydrodynamic and thermal boundary layer – Basic concepts about free convection – Qualitative analysis only		11	15
MODULE: 2 Radiation: Nature of thermal radiation-definitions and concepts-monochromatic and total emissive power - absorptivity, reflectivity and transmissivity - definition of black, grey and real surfaces -concept of a black body - Plank's law, Kirchoff's law, Wein's displacement law and Stefan-Boltzmann law - geometric factor (shape factor or configuration factor) of simple geometries – Qualitative analysis only Heat exchangers: Types – Specifications - Study of different methods used for design of heat exchangers, classification – LMTD method – Effectiveness NTU method (No derivations required)		8	15
FIRST INTERNAL TEST			
MODULE: 3 Steam System: Properties of steam - Simple steam power cycle- Rankine cycle -comparison of Rankine & Carnot Cycle- reheat cycle-regenerative cycle- Assessment of steam distribution losses - Steam leakages - Steam trapping - Condensate and flash steam recovery system – Qualitative analysis only Boilers: Types, Combustion in boilers, Performances evaluation, Analysis of losses, feed water treatment, Blow down– basic concepts only		9	15
MODULE: 4 Fuels and Combustion: Introduction to Fuels - Properties of Fuel oil, Coal and Gas - Storage, handling and preparation of fuels - Fuel Analysis Combustion Stoichiometry, theoretical & actual combustion processes – Air fuel ratio - Combustion Thermodynamics - calculation of heat of		10	15

formation & heat of combustion - Bomb calorimeter		
SECOND INTERNAL TEST		
MODULE: 5 Refrigeration: Principles of refrigeration - Thermodynamics of refrigeration – Carnot, reversed carrot cycle, heat pump, and refrigerating machine- coefficient of performance -unit of refrigeration - conventional refrigeration systems. Vapour compression system: simple cycle -comparison with Carnot cycle, theoretical and actual cycles- COP - actual cycle representation on T-S and pH diagrams- Basic problems only.	8	20
MODULE: 6 Air Conditioning: Principles of air conditioning - Psychrometry and psychrometric chart - human comfort - sensible heat factor- psychometric process – basic problems only - winter air conditioning - summer air conditioning - year round air conditioning -unitary and central systems	5	20
END SEMESTER EXAM		

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 6507	CHEMICAL PROCESS TECHNOLOGY	3-0-0-3	2015

Pre-requisites: Nil

Course Objectives:

- To understand various chemical processes in industries

Syllabus

Raw Materials and Energy Supply for Chemical Process Industries - Principal Chemical Conversion Processes and General Characteristics, Units Operations, Flow Charts, PlantLayout, Mass and Energy Balances, Process Industry: Chlor - Alkali Industries, Electro Chemical Industries & Cement Industries, Fertilizer industry: Feed stocks for the production of ammonia, nitrogenous fertilizers, Phosphatic Fertilizers, Potassium Fertilizers, NPK Fertilizer, Organic Industry: Phosphoric & Phosphoric Acid, Ammonia & Nitric Acid, Sulphuric and Hydrochlonic Acid Industries, Food Processing, Oil and Fats, Sugar ans Starch, Alcohol, Pulp & Paper Industries, Paints and Varnishes, Petroleum Technology: Key Petroleum Products, Crude Oil Fractionations, Destructive Petroleum Processing Purification of Petroleum Products, Environmental Abatement in Petroleum Refining.

Course Outcome:

- The student will have a better understanding of industrial chemical processes

Text Books:

1. Austin GT and Shrerve Chemical Process Industries V - Edition, McGraw Hill (1984)
2. Hand Book of Fertilizer Technology - Rantumen Associates of India New Delhi - 1997

References:

1. CE Dryden and GN Pandey - Outlines of Chemical Technology for the 21 st Century, Afffiliated East West Process, New Delhi (1973)
2. Van Den Berg, Introduction to Chemical Process Technology, Univ Press, Delft, 1980
3. James G, Chemistry & Technology of Petroleum, Marcel Dekker, New York, 1999

COURSE PLAN

COURSE NO.:	COURSE TITLE	L-T-P: 3-0-0	
04 EE 6507	CHEMICAL PROCESS TECHNOLOGY	CREDITS: 3	
MODULES		Contact Hours	Sem. Exam Marks (%)
MODULE: 1 Raw Materials and Energy Supply for Chemical Process Industries - Principal Chemical Conversion Processes and General Characteristics, Units Operations, Flow Charts, Plant Layout, Mass and Energy Balances		10	15
MODULE: 2 Process Industry: Chlor - Alkali Industries, Electro Chemical Industries & Cement Industries		6	15
FIRST INTERNAL TEST			
MODULE: 3 Fertilizer industry: Feed stocks for the production of ammonia, nitrogenous fertilizers, Phosphatic Fertilizers, Potassium Fertilizers, NPK Fertilizer		6	15
MODULE: 4 Organic Industry: Phosphoric & Phosphoric Acid, Ammonia & Nitric Acid, Sulphuric and Hydrochlonic Acid Industries.		6	15
SECOND INTERNAL TEST			
MODULE: 5 Food Processing, Oil and Fats, Sugar and Starch, Alcohol, Pulp & Paper Industries, Paints and Varnishes		6	20
MODULE: 6 Petroleum Technology: Key Petroleum Products, Crude Oil Fractionations, Destructive Petroleum Processing Purification of Petroleum Products, Environmental Abatement in Petroleum Refining		8	20
END SEMESTER EXAM			

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 6509	INTEGRATED LIGHTING SYSTEM	3-0-0-3	2015

Pre-requisites: Nil

Course Objectives:

- To understand the various mathematical methods for energy system modelling
- To study the various economic models and convergence solution

Syllabus

Light & Vision : Electromagnetic spectrum - visible spectrum, visual process, Structure of the eye and function of each part, Rods and Cones - their distribution and importance, Photopic Scotopic & Mesopic visions, colour vision, Propagation of light :Light propagation - Reflection – specular, diffuse, spread, compound, scattered & selective reflections, Photometric quantities &Units: Basic quantities – Definition with examples – Laws of illumination - Inter relation between the various photometric quantities, Luminous efficacy, Spectral eye sensitivity curve - Light watt, Color Theory : Specification and measurement of Colour – C.I.E. system –Chromaticity diagram, Principles and general requirements of interior lighting for different applications - Quantity and Quality determination methods of interior lighting design - Design calculations, Design issues for Specific areas in office lighting, Lighting systems for educational facilities- special applications, Flood lighting of large working areas, buildings and monuments - General design considerations - Positioning and aiming of flood lights, Flood lighting for indoor and outdoor sports-Simple Design, Road lighting Criteria - recommendations – Road Surface reflection properties, Conventional road lighting arrangements – Road lighting Calculations, Tunnel Lighting Design Considerations in Road lighting, Lighting Consideration In health care facility- retail lighting, Role of economic analysis in Lighting- Lighting cost comparisons- Cost of light- simple pay back, Life Cycle cost benefit analysis

Course Outcome:

- The student will be able to design the lighting system for indoor and outdoor applications

Text Books:

1. J.B.de Boer and D. Fischer, "*Interior Lighting*" 2nd Edition, Philips Technical Library, 1981.
2. W. J. M. Van Bommel and J. B. De Boer, "*Road Lighting*", Deventer: Kluwer Technical Library, Eindhoven, 1980

References:

1. Philips Lighting Division, Eindhoven, "*Lighting Manual*", 5th Edition, 1993
2. D.W. Durrant, "*Interior Lighting Design*" 5th Edition, Lighting Industry Federation Ltd., London, 1977
3. I.E.S.N.A., New York, "*Lighting Hand Book*" 10th Edition, 2011

COURSE PLAN

COURSE NO.:	COURSE TITLE	L-T-P: 3-0-0	
04 EE 6509	INTEGRATED LIGHTING SYSTEM	CREDITS: 3	
MODULES		Contact Hours	Sem. Exam Marks (%)
MODULE: 1 Light & Vision : Electromagnetic spectrum - visible spectrum, visual process Structure of the eye and function of each part, Rods and Cones - their distribution and importance, Photopic Scotopic & Mesopic visions, colour vision Propagation of light :Light propagation - Reflection – specular, diffuse, spread, compound, scattered & selective reflections		7	15
MODULE: 2 Photometric quantities &Units: Basic quantities – Definition with examples – Laws of illumination - Inter relation between the various photometric quantities Luminous efficacy, Spectral eye sensitivity curve - Light watt Color Theory : Specification and measurement of Colour – C.I.E. system – Chromaticity diagram		7	15
FIRST INTERNAL TEST			
MODULE: 3 Principles and general requirements of interior lighting for different applications - Quantity and Quality determination methods of interior lighting design - Design calculations, Design issues for Specific areas in office lighting, Lighting systems for educational facilities- special applications		7	15
MODULE: 4 Flood lighting of large working areas, buildings and monuments - General design considerations - Positioning and aiming of flood lights - Flood lighting for indoor and outdoor sports-Simple Design			15
SECOND INTERNAL TEST			
MODULE: 5 Road lighting Criteria - recommendations – Road Surface reflection properties, Conventional road lighting arrangements – Road lighting		8	20

Calculations, Tunnel Lighting Design Considerations in Road lighting		
MODULE: 6 Lighting Consideration In health care facility- retail lighting, Role of economic analysis in Lighting- Lighting cost comparisons- Cost of light- simple pay back, Life Cycle cost benefit analysis	6	20
END SEMESTER EXAM		

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 6511	ENERGY SYSTEM MODELLING AND ANALYSIS	3-0-0-3	2015

Pre-requisites: Nil

Course Objectives:

- To understand the various mathematical methods for energy system modelling
- To study the various economic models and convergence solution

Syllabus

Modelling Overview: Levels of analysis – steps in model development - examples of models – quantitative techniques – interpolation – polynomial– Lagrangian – curve fitting – regression analysis – solution of transcendental equations, Systems Simulation: Information flow diagram – solution of set of nonlinear algebraic equations – successive substitution – Newton Raphson – examples of energy systems simulation, Optimization: Objectives/constraints – problem formulation – unconstrained problems – necessary and sufficiency conditions, Constrained optimization, Lagrange multipliers – constrained variations – Kuhn-Tucker conditions – linear programming – simplex tableau – pivoting – sensitivity analysis, Dynamic Programming: Search Techniques – univariate / multivariate – case studies of optimization in energy systems, Dealing with uncertainty- probabilistic techniques – Trade-offs between capital and energy using Pinch analysis, Energy- Economy Models: Scenario generation – input output model, Numerical solution of differential equations – overview – convergence – accuracy – transient analysis – application examples.

Course Outcome:

- The student will be able to mathematically model and optimize an energy system

Text Books:

1. W. F. Stoecker, Design of Thermal Systems, McGraw Hill, 1981.
2. S. S. Rao, Optimization theory and applications, Wiley Eastern, 1990.

References:

1. S. S. Sastry, Introductory methods of numerical analysis, Prentice Hall 1988.
2. S. C. Chapra, R. P. Canale, Numerical methods for Engineers, Tata McGraw Hill, New Delhi, 2007.

COURSE PLAN

COURSE NO.:	COURSE TITLE	L-T-P: 3-0-0	
04 EE 6511	ENERGY SYSTEM MODELLING AND ANALYSIS	CREDITS: 3	
MODULES		Contact Hours	Sem. Exam Marks (%)
MODULE: 1 Modelling Overview: Levels of analysis – steps in model development - examples of models – quantitative techniques – interpolation – polynomial– Lagrangian – curve fitting – regression analysis – solution of transcendental equations.		7	15
MODULE: 2 Systems Simulation: Information flow diagram – solution of set of nonlinear algebraic equations – successive substitution – Newton Raphson – examples of energy systems simulation.		6	15
FIRST INTERNAL TEST			
MODULE: 3 Optimization: Objectives/constraints – problem formulation – unconstrained problems – necessary and sufficiency conditions, Constrained optimization		6	15
MODULE: 4 Lagrange multipliers – constrained variations – Kuhn-Tucker conditions – linear programming – simplex tableau – pivoting – sensitivity analysis		6	15
SECOND INTERNAL TEST			
MODULE: 5 Dynamic Programming: Search Techniques – univariate / multivariate – case studies of optimization in energy systems Dealing with uncertainty- probabilistic techniques – Trade-offs between capital and energy using Pinch analysis		8	20
MODULE: 6 Energy- Economy Models: Scenario generation – input output model, Numerical solution of differential equations – overview – convergence – accuracy – transient analysis – application examples		9	20
END SEMESTER EXAM			

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 GN 6001	RESEARCH METHODOLOGY	0-2-0:2	2015

Pre-requisites:

Course Objectives:

To enable the students:

- To get introduced to research philosophy and processes in general.
- To formulate the research problem and prepare research plan
- To apply various numerical /quantitative techniques for data analysis
- To communicate the research findings effectively

Syllabus

Introduction to the Concepts of Research Methodology, Research Proposals, Research Design, Data Collection and Analysis, Quantitative Techniques and Mathematical Modelling, Report Writing.

Course Outcome:

Students who successfully complete this course would learn the fundamental concepts of Research Methodology, apply the basic aspects of the Research methodology to formulate a research problem and its plan. They would also be able to deploy numerical/quantitative techniques for data analysis. They would be equipped with good technical writing and presentation skills.

Text Books:

1. Research Methodology: Methods and Techniques', by Dr. C. R. Kothari, New Age International Publisher, 2004
2. Research Methodology: A Step by Step Guide for Beginners' by Ranjit Kumar, SAGE Publications Ltd; Third Edition

References:

1. Research Methodology: An Introduction for Science & Engineering Students', by Stuart Melville and Wayne Goddard, Juta and Company Ltd, 2004
2. Research Methodology: An Introduction' by Wayne Goddard and Stuart Melville, Juta and Company Ltd, 2004
3. Research Methodology, G.C. Ramamurthy, Dream Tech Press, New Delhi
4. Management Research Methodology' by K. N. Krishnaswamy et al, Pearson Education

COURSE NO.:	COURSE TITLE	CREDITS
04 GN 6001	RESEARCH METHODOLOGY	0-2-0: 2

MODULES	Contact Hours	
MODULE : 1 Introduction to Research Methodology: Concepts of Research, Meaning and 2 Objectives of Research, Research Process, Types of Research, Type of research: Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, and Conceptual vs. Empirical	5	
MODULE :2 Criteria of Good Research, Research Problem, Selection of a problem, Techniques involved in definition of a problem, Research Proposals – Types, contents, Ethical aspects, IPR issues like patenting, copyrights.	4	
INTERNAL TEST 1 (MODULE 1 & 2)		
MODULE: 3 **Research Design :** Meaning, Need and Types of research design, Literature Survey and Review, Identifying gap areas from literature review, Research Design Process, Sampling fundamentals, Measurement and scaling techniques, Data Collection – concept, types and methods, Design of Experiments.	5	
MODULE 4: **Quantitative Techniques:** Probability distributions, Fundamentals of Statistical analysis, Data Analysis with Statistical Packages, Multivariate methods, Concepts of correlation and regression - Fundamentals of time series analysis and spectral analysis.	5	
INTERNAL TEST 2 (MODULE 3 & 4)		
MODULE: 5 **Report Writing:** Principles of Thesis Writing, Guidelines for writing reports & papers, Methods of giving references and appendices, Reproduction of published material, Plagiarism, Citation and acknowledgement.	5	
MODULE: 6 Documentation and presentation tools – LaTeX, Office with basic presentations skills, Use of Internet and advanced search techniques.	4	

COURSE NO.	COURSE TITLE	L-T-P:C	YEAR
04 EE 6593	ENERGY SYSTEMS LABORATORY	0-0-2:1	2015

Pre-requisites: Nil

Course Objectives:

- To understand the energy efficiency improvement in pumping systems, fan systems, lighting systems and thermal systems
- To familiarise with the simulation of basic power conversion systems required in renewable power systems such as Solar PV and Wind.
- To familiarize with the various energy auditing instruments

Syllabus

Energy Efficiency

1. Pump & motor efficiency testing using various flow control methods
2. Efficiency and performance of axial fan
3. Testing of wind turbine with Pitch control
4. Performance characteristics of Solar PV Panel
5. Series parallel connection and MPP of Solar PV Panel
6. Efficacy and performance of various Light sources

Power System

7. Study of harmonic pollution by power electronics loads
8. Analysis of current waveform for linear and non-linear loads in a Solar PV Grid system
9. Impact of transmission line inductance on voltage quality in a Solar PV Grid system

Power Electronics

10. Microcontroller based control of dc-dc converters (Buck,Boost and Buck-Boost)
11. Single phase Full Converter with RL load
12. Three phase Full Converter with RL load
13. Performance analysis of Single phase Inverter

Simulation

14. Simulation of Single phase rectifier with RL load using Matlab
15. Simulation of Three phase rectifier with RL load using Matlab
16. Simulation of Buck, Boost and Buck-Boost Converters using Matlab
17. Simulation of Single phase PWM inverter using Matlab

Heat Engines

18. Performance analysis of Heat Exchanger
19. Performance testing of Refrigeration
20. Performance testing of AC

Optional Experiments

1. Pollutant level measurement in exhaust gas using exhaust emission measurement
2. Estimation of properties of various liquid fuels and biomass using Bomb Calorimeter
3. Boiler load test, loss and Efficiency estimation
4. Speed control of DC Motor using open loop and closed loop system
5. Speed control of Induction Motor using open loop and closed loop system
6. Performance analysis of Three phase Inverter
7. Simulation of Single phase and three phase PWM inverter using Matlab
8. Simulation based design of a typical indoor/outdoor lighting system using Dialux

Note:
At least 15 experiments need to be completed by students in a lab. Also, the additional advanced experiments can be offered as Demo experiments to students. In addition to the above, the Department can offer newly developed experiments which are relevant to the course.

Course Outcome:

- The student will be in a position to use various energy audit instruments for an energy audit and will familiarize with simulation of power conversion systems.

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 6502	ENERGY MANAGEMENT AND AUDIT	3-1-0-4	2015

Pre-requisites: Nil

Course Objectives:

- To understand the need for industrial Energy Audit, methodology and various tools and instruments used.
- To understand the concepts of electrical load management and energy efficiency in electrical systems such as lighting, induction motors, transformers etc.
- To understand the concepts of energy efficiency in industrial systems such as boiler, pumping system, compressor and fan systems, steam distribution systems, AC systems etc.

Syllabus

Importance of energy management – overview of energy conservation act(2001), Energy auditing – objectives – methodology – steps in energy management– types of energy audit – preliminary energy audit – detailed energy audit, Energy audit report writing – analysis of past data –Identification of energy conservation opportunities - mass and energy balances – examples – Simple payback period calculation, Potential energy and cost savings from energy conservation measures – barriers to energy efficiency, Need for measurements during energy audit – various measuring instruments used for energy audit, Energy monitoring and targeting, Electrical Systems: Tariff systems – billing elements – load curve analysis – load management – power factor correction – electrical demand and load factor improvement – load scheduling/shifting, Demand side management (DSM) – case study, Energy efficiency in transformers – Case study, Electric motors: Motors efficiency, idle running – factors affecting induction motor performance, estimation of motor loading - efficiency at low loads – numerical problems – high efficiency induction motors, rewound motors, Variable speed drives for induction motors –advantages and applications – different types of VFD, Lighting: Components of lighting system –different lighting technologies – lighting calculation – optimum lux levels – efficiency options –lighting transformer – control of lighting – light meter audit – case study – methods to reduce operating cost of lighting systems– day lighting – timers, Steam Systems: Boiler –operation fundamentals and energy flow – losses and efficiency estimation–energy efficiency in steam distribution system –Basic principles only.

Energy conservation in industrial systems – pumping systems– fans (flow control) – compressed air systems – Refrigeration and air conditioning systems, Cogeneration – concept and advantages– options (steam/gas turbines/diesel engine based) – selection criteria, Heat exchanger networking –pinch analysis – basic concept only.

Course Outcome:

- The student will be able to attain the technical background required for an industrial Energy Audit

Text Books:

1. Guide Books for energy managers and Auditors, Book 1, 2, 3 and 4, Revision 2, Bureau of Energy Efficiency, India, 2005.
2. Y. P. Abbi, S. Jain, Handbook of Energy audit and environment Management, The Energy and Resourcr Institute, New Delhi, 2006.

References:

1. W. C. Turner, Energy Management Handbook, Wiley, New York, 1982.
2. Guide Books for energy managers and Auditors, Book 1, 2, 3 and 4, Revision 2, Bureau of Energy Efficiency, India, 2005.
3. L. C. Witte, P. S. Schmidt, D. R. Brown, Industrial Energy Management and Utilization, Hemisphere Publishers, Washington,1988.
4. Industrial Energy Conservation Manuals, MIT Press, Mass, 1982.
5. I. G. C. Dryden, The Efficient Use of Energy, Butterworths, London, 1982.
6. Larry C. Whit et al, Industrial Energy Management & Utilization.
7. T.D. Eastop, D.R. Croft, Energy Efficiency for Engineers and Technologists, Logman Scientific & Technical, ISBN-0-582-03184, 1990.
8. A. Chakrabarti, Energy Engineering and Management, PHI Learning, Delhi, 2013.

COURSE PLAN

COURSE NO.:	COURSE TITLE	L-T-P: 3-1-0	
04 EE 6502	ENERGY MANAGEMENT AND AUDIT	CREDITS: 4	
MODULES		Contact Hours	Sem. Exam Marks (%)
MODULE: 1 Importance of energy management – overview of energy conservation act(2001), Energy auditing – objectives – methodology – steps in energy management– types of energy audit – preliminary energy audit – detailed energy audit, Energy audit report writing – analysis of past data –Identification of energy conservation opportunities - mass and energy balances – examples - Simple payback period calculation		9	15
MODULE: 2 Potential energy and cost savings from energy conservation measures – barriers to energy efficiency, Need for measurements during energy audit - various measuring instruments used for energy audit, Energy monitoring and targeting		7	15
FIRST INTERNAL TEST			
MODULE: 3 Electrical Systems: Tariff systems – billing elements – load curve analysis – load management – power factor correction – electrical demand and load factor improvement – load scheduling/shifting - Demand side management (DSM) - case study - Energy efficiency in transformers - Case study.		10	15
MODULE: 4 Electric motors: Motors efficiency, idle running – factors affecting induction motor performance, estimation of motor loading - efficiency at low loads – numerical problems - high efficiency induction motors, rewound motors Variable speed drives for induction motors – advantages and applications - different types of VFD.		10	15
SECOND INTERNAL TEST			
MODULE: 5 Lighting: Components of lighting system -different lighting technologies - lighting calculation - optimum lux levels – efficiency options –lighting transformer - control of lighting – light meter audit – case study –		10	20

methods to reduce operating cost of lighting systems– day lighting – timers.		
MODULE: 6 Steam Systems: Boiler –operation fundamentals and energy flow - losses and efficiency estimation–energy efficiency in steam distribution system -Basic principles only. Energy conservation in industrial systems - pumping systems– fans (flow control) – compressed air systems – Refrigeration and air conditioning systems Cogeneration – concept and advantages– options (steam/gas turbines/diesel engine based) – selection criteria Heat exchanger networking –pinch analysis - basic concept only.	10	20
END SEMESTER EXAM		

COURSE NO.	COURSE TITLE	Credits	YEAR
04 EE 6304	GRID INTEGRATION OF SOLAR PV SYSTEM	3-0-0:3	2015

Pre-requisites: Nil

Course Objectives:

1. To enable the student to model, analyse and design Solar PV systems connected to the grid.

Syllabus

Solar Cells - Design of Solar Cells - Solar PV Modules from Solar Cells - Series and Parallel Connection of Cells – Design and Structure of PV Module - I- V Equation of PV Module - Ratings of PV Module - P-V Curve of Module - Effect of Variation of Solar Insolation and Temperature – Partial Shading of a Solar Cell and a Module- Batteries for PV systems- MPPT Algorithms: Perturb and Observe- Incremental Conductance- Mechanical Tracking- Standalone P V System Configurations- A Grid Interactive PV System - Phase , Frequency Matching and Voltage Consideration – Operation of a Grid Interactive Inverter – Protection Against Islanding and Reverse Power Flow- Grid Imposed Frequency VSC system : Control in αβ Frame - Structure of Grid Imposed Frequency VSC system- Selection of DC Bus Voltage Level- Model of Controlled DC Voltage Power Port - Grid Imposed Frequency VSC system : Control in dq Frame.

Course Outcome:

The students will be able to analyse, model and design various subsystems and controllers for grid-connected solar PV systems.

Text Books:

1. A K Mukerjee, Niveditha Thakur : Photovoltaic Systems Analysis and Design, PHI
2. Chetan Singh Solanki: Solar Photovoltaics Fundametals, Technologies and Applications, PHI
3. Amir Naser Yazdani and Reza Iravani: Voltage - Sourced Converters in Power Systems modelling, control and Applications, WILEY, IEEE Press

References:

1. Goetzberger V. U. Hoffmann : Photovoltaic Solar Energy Generation Springer Series in optical sciences
2. Antonio Luque and Steven Hegedus : Handbook of Photovoltaic Science and Engineering, WILEY

COURSE PLAN

COURSE NO.	COURSE TITLE	L-T-P: 3-0-0	
04 EE 6304	GRID INTEGRATION OF SOLAR PV SYSTEM	CREDITS: 3	
MODULES		Contact Hours	Sem. Exam Marks (%)
MODULE: 1 Solar Cells: Generation of Photo Voltage – Light Generated Current – I V Equation of Solar Cells- Solar Cell Characteristics. **Design of Solar Cells:** Upper Limit of Cell Parameters- Losses in Solar Cells - Diode Equivalent Model - Solar Cell Energy Conversion Efficiency - Effect of Variation of Solar Insolation and Temperature on Efficiency.		7	15
MODULE: 2 Solar PV Modules from Solar Cells - Series and Parallel Connection of Cells – Design and Structure of PV Module – Number of Solar Cells in a Module – Wattage of Modules- PV Module Power Output - I- V Equation of PV Module - Ratings of PV Module – I-V Curve and P-V Curve of Module - Effect of Variation of Solar Insolation and Temperature – Partial Shading of a Solar Cell and a Module.		8	15
FIRST INTERNAL TEST			
MODULE: 3 Batteries for PV systems – Factors affecting battery performance MPPT Algorithms: Perturb and Observe- Incremental Conductance Mechanical Tracking - Single Axis Tracking – Dual Axis Tracking		7	15
MODULE: 4 Standalone P V System Configurations – Design PV powered DC fan and pump without battery- Design of Standalone System with Battery and AC or DC Load.		6	15
SECOND INTERNAL TEST			
MODULE: 5 A Grid Interactive PV System - Phase , Frequency Matching and Voltage Consideration – Operation of a Grid Interactive Inverter – Protection Against Islanding and Reverse Power Flow. Design of EMI Filters.		8	20
MODULE: 6 Grid Imposed Frequency VSC system : Control in αβ Frame - Structure of Grid Imposed Frequency VSC system – Real-/ Reactive Power Controllers - Current Mode Versus Voltage Mode Control - Dynamic Model of Real-/		6	20

Reactive Power Controllers - Current Mode Control of Real/ Reactive Power Controllers - Selection of DC Bus Voltage Level -PWM with Third Harmonic Injection – Real-/Reactive Power Controller Based on Three Level NPC - Midpoint Current of Three Level NPC Based on Third Harmonic Injected PWM - Controlled DC Voltage Power Port - Model of Controlled DC Voltage Power Port - Grid Imposed Frequency VSC system : Control in d-q Frame.		
END SEMESTER EXAM		

COURSE NO.	COURSE TITLE	Credits	YEAR
04 EE 6504	WIND AND HYBRID ENERGY SYSTEMS	3-0-0:3	2015

Pre-requisites: Nil

Course Objectives:

1. To understand the working of wind turbine, hybrid energy systems

   To analyses the dynamics of grid integrated wind system

Syllabus

Fundamentals of wind turbine- power contained in wind-types- Aerodynamics of wind rotor- Grid connected and self exited induction generator characteristics- Variable voltage variable frequency generation: The self excitation process- Effect of wind generator on the network- Generation scheme with Variable speed turbines- induction generators- Hybrid energy systems: wind diesel hybrid system- system with no storage- system with battery backup- Wind - photovoltaic systems

Course Outcome:

Must able to explain the dynamics of grid integrated wind system

Text Books:

1. S N Bhadra, D Kastha, S Banerjee, Wind Electrical System, Oxford higher Education

2. L. L. Freris, Wind Energy Conversion Systems, Prentice Hall, 1990.

References:

1. D. A. Spera, Wind Turbine Technology: Fundamental concepts of Wind Turbine Engineering, ASME Press.
2. Paul Gipe, Wind Energy Comes of Age, John Wiley & Sons Inc.
3. T. Burton, D. Sharpe, N. Jenkins and E. Bossanyi, Wind energy Handbook, John Wiley & Sons, 2001.
4. Mathew Sathyajith, Wind Energy: Fundamentals, Resource Analysis and Economics, Springer, 2006.
5. Mathew Sathyajith, Geetha Susan Philip, Advances in Wind Energy Conversion Technology, Springer, 2011.
6. G. L. Johnson, Wind Energy Systems, Prentice Hall, 1985.
7. Anna Mani, Wind Energy Data for India, Department of Non-conventional Energy Sources, Govt. of India, New Delhi,1995.

COURSE PLAN

COURSE NO.	COURSE TITLE	CREDITS	
04 EE 6504	WIND AND HYBRID ENERGY SYSTEMS	3-0-0: 3	
MODULES		Contact Hours	Sem. Exam Marks (%)
MODULE: 1 Fundamentals of wind turbine- power contained in wind-types-tip speed ratio- power coefficient- specific rated capacity Aerodynamics of wind rotor- power speed characteristics and torque speed characteristics- wind turbine control system – pitch- stall- yaw and power electronic control		7	15
MODULE: 2 Grid connected and self exited induction generator characteristics: Constant voltage and constant frequency generation- single out- double output – with current converter- equivalent circuits- reactive power and harmonics- double output – with voltage source inverter - Reactive power compensation		8	15
FIRST INTERNAL TEST			
MODULE: 3 Variable voltage variable frequency generation: The self excitation process- Circuit model for the self excited induction generator		7	15
MODULE: 4 Analysis of the steady state operation - the steady -state characteristics. Effect of wind generator on the network		6	15
SECOND INTERNAL TEST			
MODULE: 5 Generation scheme with Variable speed turbines: classification of schemes – operating area- induction generators- doubly fed induction generators- wound field synchronous generators – permanent magnet generators		8	20
MODULE: 6 Hybrid energy systems: wind diesel hybrid system- system with no storage- system with battery backup. Wind - photovoltaic systems		6	20
END SEMESTER EXAM			

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 6508	UTILIZATION OF SOLAR THERMAL ENERGY	3-0-0:3	2015

Pre-requisites: INDUSTRIAL THERMAL SYSTEMS

Course Objectives:

- To introduce the basic concepts and novel technologies in solar thermal systems; to provide a balance between both frontier technology updates and existing solar thermal energy strategies, in both a quantitative and qualitative way.
- To develop skills to design, model, analyze and evaluate solar thermal systems and to develop creative thinking to deal with complex multidisciplinary solar thermal energy projects that involve the provision of effective and efficient solutions.
- To provide students for practical training in the design of different solar thermal systems, such as water heating and control, solar collection, solar energy storage and system design.

Syllabus

Solar Radiation – solar constant - availability – instruments for measuring solar radiation and sunshine

Solar radiation geometry - estimation of monthly average of daily global and diffuse radiation – Isotropic and anisotropic models – numerical, Solar radiation on tilted surfaces - empirical relations - numericals. Solar Collector: Liquid flat plate collector – performance analysis – transient analysis – testing procedures, Concentrating collectors – Design – Classification - flat plate collectors with plane reflectors – cylindrical parabolic collector – compound parabolic collector – paraboloid dish collector – central receiver collector - Concentrator mounting, Thermal storage: Sensible heat storage – analysis of liquid storage tank – thermal stratification– latent heat storage – thermo chemical heat storage – Basic concepts,

Power generation – Low/ Medium /High temperature systems, Solar heating Systems: Calculation of heating and hot water load in building – solar water heating system – liquid based solar heating system for buildings – solar air heating systems, Space heating and cooling of buildings – Passive methods and Active methods – Space cooling and refrigeration, Solar distillation – introduction – working principal of solar distillation – thermal efficiency of distiller unit, Solar drying – basic concepts – types, Solar pond – principle of working – types, Methods of modelling and design of solar heating systems – design of active systems by f-chart and utilizability methods, Introduction to simulation software – Transys.

Course Outcome:

- Students will be able to understand the principles and technologies for solar thermal energy collection, conversion and utilization.

Text Books:

1. S. P. Sukhatme, Solar Energy - Principles of thermal collection and storage, 2nd edition, Tata McGraw-Hill, New Delhi, 1996.
2. J. A. Duffie, W. A. Beckman, Solar Engineering of Thermal Processes, 2nd edition, John Wiley, New York, 1991.

References:

1. G. D Rai, Solar energy utilization, Khanna Publishers, New Delhi, 2004.
2. D. Y. Goswami, F. Kreith and J. F. Kreider, Principles of Solar Engineering, Taylor and Francis, Philadelphia, 2000.
3. M. S. Sodha, N. K. Bansal, P. K. Bansal, A. Kumar and M. A. S. Malik, Solar Passive Building: science and design, Pergamon Press, New York, 1986.
4. M. A. S. Malik, G. N. Tiwari, A. Kumar and M.S. Sodha, Solar Distillation, Pergamon Press, New York, 1982.

COURSE PLAN

COURSE NO.:	COURSE TITLE	L-T-P: 3-0-0	
04 EE 6508	UTILIZATION OF SOLAR THERMAL ENERGY	CREDITS: 3	
MODULES		Contact Hours	Sem. Exam Marks (%)
MODULE: 1 Solar Radiation – solar constant - availability – instruments for measuring solar radiation and sunshine Solar radiation geometry - estimation of monthly average of daily global and diffuse radiation – Isotropic and anisotropic models - numericals Solar radiation on tilted surfaces - empirical relations - numericals		9	15
MODULE: 2 Solar Collector: Liquid flat plate collector – performance analysis – transient analysis – testing procedures.		7	15
FIRST INTERNAL TEST			
MODULE: 3 Concentrating collectors – Design – Classification - flat plate collectors with plane reflectors – cylindrical parabolic collector – compound parabolic collector – paraboloid dish collector – central receiver collector - Concentrator mounting.		7	15
MODULE: 4 Thermal storage: Sensible heat storage – analysis of liquid storage tank – thermal stratification– latent heat storage – thermo chemical heat storage – Basic concepts. Power generation – Low/ Medium /High temperature systems.		6	15
SECOND INTERNAL TEST			
MODULE: 5 Solar heating Systems: Calculation of heating and hot water load in building – solar water heating system – liquid based solar heating system for buildings – solar air heating systems. Space heating and cooling of buildings – Passive methods and Active methods – Space cooling and refrigeration. Solar distillation – introduction – working principal of solar distillation – thermal efficiency of distiller unit		6	20

MODULE: 6 Solar drying – basic concepts – types, Solar pond – principle of working – types Methods of modelling and design of solar heating systems – design of active systems by f-chart and utilizability methods Introduction to simulation software - Transys.	9	20
END SEMESTER EXAM		

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 6512	FUEL CELLS AND HYDROGEN	3-0-0-3	2015

Pre-requisites: Nil

Course Objectives:

- To understand the parts and operation of Fuel cell
- To understand the various types of Fuel cells
- To understand production, storage, transport and utilization of Hydrogen as a fuel

Syllabus

Basics: Fuel cell definition –difference between batteries and fuel cells – fuel cell history, Components of fuel cells –principle of working of fuel cell, Performance characteristics of fuel cells –stack configurations and fuel cell system, Fuel cell types –alkaline fuel cell –polymer electrolyte membrane type fuel cell, Phosphoric acid fuel cell – molten carbonate fuel cell – solid oxide fuel cell, Geometries of solid oxide fuel cells – planar and tubular – Applications, Thermodynamics of fuel cells – introduction to electrochemical kinetics – transport related phenomena, Conservation equations for reacting multi-component systems, Fuel cell system design – optimization and economics, Hydrogen – merit as a fuel – applications – suitability of hydrogen as a fuel – fuel cell as energy conversion device, Hydrogen production methods – from fossil fuels – electrolysis – thermal decomposition – photochemical – photo catalytic – hybrid – Sea as the source of Deuterium. Hydrogen Storage – metal hydrides – metallic alloy hydrides – Carbon nano-tubes. Hydrogen Transport – Road – railway – pipeline – ship.

Course Outcome:

- The student will understand the details of Fuel cell and hydrogen fuel

Text Books:

1. Leo J. M. J. Blomen, Michael N. Mugerwa , Fuel Cell System, Plenum Press, New York, 1993.
2. 2.G. D. Rai, Non Conventional Energy Sources, Khanna Publishers, 2010.

References:

1. A. J. Appleby and F. R. Foulkers, Fuel Cell Handbook, Van Nostrand, 1989.
2. B. Sorensen, Hydrogen and Fuel Cells, Elsevier Academic Press, USA, 2005.
3. R. Narayan, B. Viswanathan, Chemical and Electrochemical Energy Systems, University Press India Ltd, 1998.
4. H. Khan, Non Conventional Energy Resources, 2nd edition, TMH 2013.
5. D. P. Kothari, K. C. Singhal, Rakesh Rajan, Renewable energy sources and emerging technologies, 2nd edition, 2013.

COURSE PLAN

COURSE NO.:	COURSE TITLE	L-T-P: 3-0-0	
04 EE 6512	FUEL CELLS AND HYDROGEN	CREDITS: 3	
MODULES		Contact Hours	Sem. Exam Marks (%)
MODULE: 1 Basics: Fuel cell definition –difference between batteries and fuel cells – fuel cell history, Components of fuel cells –principle of working of fuel cell		7	15
MODULE: 2 Performance characteristics of fuel cells –stack configurations and fuel cell system. Fuel cell types –alkaline fuel cell –polymer electrolyte membrane type fuel cell		7	15
FIRST INTERNAL TEST			
MODULE: 3 Phosphoric acid fuel cell – molten carbonate fuel cell – solid oxide fuel cell Geometries of solid oxide fuel cells – planar and tubular – Applications		6	15
MODULE: 4 Thermodynamics of fuel cells – introduction to electrochemical kinetics – transport related phenomena, Conservation equations for reacting multi-component systems		7	15
SECOND INTERNAL TEST			
MODULE: 5 Fuel cell system design – optimization and economics Hydrogen – merit as a fuel – applications – suitability of hydrogen as a fuel – fuel cell as energy conversion device		6	20
MODULE: 6 Hydrogen production methods – from fossil fuels – electrolysis – thermal decomposition – photochemical – photo catalytic – hybrid – Sea as the source of Deuterium. Hydrogen Storage – metal hydrides – metallic alloy hydrides – Carbon nano-tubes. Hydrogen Transport – Road – railway – pipeline – ship.		6	20
END SEMESTER EXAM			

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 6514	BIO-ENERGY ENGINEERING	3-0-0-3	2015

Pre-requisites: Nil

Course Objectives:

- To understand the economic matters involved in planning and operation of power system
- To understand the economic and scheduling problem that may arise in economic coordination of interconnected utilities
- To study about the various thermodynamic cycles and its operation

Syllabus

Overview – Need for bio energy – India's bio fuel policy and programmes – Bio energy sources and classification – chemical composition – properties of biomass, Energy plantations – size reduction – briquetting – drying – storage and handling of biomass, Feedstock for biogas – microbial and biochemical aspects – operating parameters for biogas production, Kinetics and mechanism – high rate digesters for industrial waste water treatment, Thermo chemical conversion of lignocelluloses biomass – incineration – processing for liquid fuel production, Pyrolysis – effect of particle size, temperature, and products obtained, Thermo chemical principles: Effect of pressure, temperature, steam and oxygen – fixed and fluidized bed Gasifiers – partial gasification of biomass by CFB, Combustion of woody biomass – design of equipment – cogeneration using bagasse – case studies about combustion of rice husk, Clean development mechanism (CDM) – potential for bio-diesel projects for India.

Course Outcome:

- The student will be able to understand the various economic problems involved in the planning, operation and transmission of power plants and also to understand the operation principle of different types of thermodynamic cycle

Text Books:

1. A. Chakravarthy, Biotechnology and Alternative Technologies for Utilization of Biomass or Agricultural Wastes, Oxford & IBH publishing Co, 1989.
2. K. M. Mithal, Biogas Systems: Principles and Applications, New Age International publishers (P) Ltd., 1996.

References:

1. D. Yogi Goswami, Frank Kreith, Jan F .Kreider, Principles of Solar Engineering, 2nd Edition, Taylor & Francis, 2000, Indian reprint, 2003.
2. B. T. Nijaguna,Biogas Technology, New Age International publishers (P) Ltd., 2002.
3. P. Venkata Ramana, S. N. Srinivas, Biomass Energy Systems, Tata Energy Research Institute, 1996.
4. J. Rezaiyan, N. P. Cheremisinoff, Gasification Technologies, A Primer for Engineers and Scientists, Taylor & Francis, 2005.
5. K. C. Khandelwal, S. S. Mahdi, Bio-Gas Technology, TMH, 1986.

COURSE PLAN

COURSE NO.:	COURSE TITLE	L-T-P: 3-0-0	
04 EE 6514	BIO-ENERGY ENGINEERING	**CREDITS: 3**	
MODULES		Contact Hours	Sem. Exam Marks (%)
MODULE: 1 Overview – Need for bio energy – India's bio fuel policy and programmes – Bio energy sources and classification – chemical composition – properties of biomass		6	15
MODULE: 2 Energy plantations – size reduction – briquetting – drying – storage and handling of biomass. Feedstock for biogas – microbial and biochemical aspects – operating parameters for biogas production		7	15
FIRST INTERNAL TEST			
MODULE: 3 Kinetics and mechanism – high rate digesters for industrial waste water treatment		6	15
MODULE: 4 Thermo chemical conversion of lignocelluloses biomass – incineration – processing for liquid fuel production Pyrolysis – effect of particle size, temperature, and products obtained.		6	15
SECOND INTERNAL TEST			
MODULE: 5 Thermo chemical principles: Effect of pressure, temperature, steam and oxygen – fixed and fluidized bed Gasifiers – partial gasification of biomass by CFB.		6	20
MODULE: 6 Combustion of woody biomass – design of equipment – cogeneration using bagasse – case studies about combustion of rice husk. Clean development mechanism (CDM) – potential for bio-diesel projects for India		7	20
END SEMESTER EXAM			

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 6516	NUCLEAR REACTOR THEORY	3-0-0-3	2015

Pre-requisites: Nil

Course Objectives:

- To understand the structure, operation and reactions in a nuclear reactor
- To understand the fuel processing of a Nuclear reactor
- To understand the waste disposal in a Nuclear reactor

Syllabus

Nuclear Reactions: Mechanism of Nuclear Fission - Nuclides - Radioactivity – Decay Chains - Neutron Reactions, The Fission Process - Reactors - Types of Fast Breeding Reactor - Design and Construction of Nuclear reactors - Heat Transfer Techniques in Nuclear Reactors - Reactor Shielding, Reactor Materials: Nuclear Fuel Cycles - Characteristics of Nuclear Fuels - Uranium - Production and Purification of Uranium - Conversion to UF4 and UF6 - Other Fuels like Zirconium, Thorium – Berylium, Reprocessing: Nuclear Fuel Cycles - Spent Fuel Characteristics - Role of Solvent Extraction in Reprocssing - Solvent Extraction Equipment, Separation of Reactor products: Processes to be Considered - 'Fuel Element' Dissolution, Precipitation Process – Ion Exchange - Redox - Purex - TTA - Chelation -U235 -Hexone - TBP and Thorax Processes - Oxidative Slaging and Electro - Refinng - Isotopes - Principles of Isotope Separation, Waste disposal and radiation protection: Types of Nuclear Wastes - Safety Control and Pollution Control and Abatement, International Convention on Safety Aspects - Radiation Hazards Prevention

Course Outcome:

- The student will understand the parts, operation, fuels and safety aspects of a Nuclear reactor

Text Books:

1. J.R.Lamarsh, Introduction to Nuclear Reactor Theroy, Wesley, 1966
2. J.J.Duderstadt and L.J.Hamiition, Nuclear Reactor Analysis - John Wiley 1976

References:

1. A.E.Walter and A.B.Reynolds Fast Breeder Reactor, Pergamon Press - 1981
2. S.Glasstone and A.Sesonske, Nuclear Reactor Engineering (3 rd Edition), Von Nostrand, 1981.
3. R.H.S.Winterton, Thermal Design of Nuclear Reactors - Pergamon Press - 1981

COURSE PLAN

COURSE NO.:	COURSE TITLE	L-T-P: 3-0-0	
04 EE 6516	NUCLEAR REACTOR THEORY	**CREDITS: 3**	
MODULES		Contact Hours	Sem. Exam Marks (%)
MODULE: 1 Nuclear Reactions: Mechanism of Nuclear Fission - Nuclides - Radioactivity – Decay Chains - Neutron Reactions The Fission Process - Reactors - Types of Fast Breeding Reactor - Design and Construction of Nuclear reactors - Heat Transfer Techniques in Nuclear Reactors - Reactor Shielding.		6	15
MODULE: 2 Reactor Materials: Nuclear Fuel Cycles - Characteristics of Nuclear Fuels - Uranium - Production and Purification of Uranium - Conversion to UF4 and UF6 - Other Fuels like Zirconium, Thorium - Berylium		7	15
FIRST INTERNAL TEST			
MODULE: 3 Reprocessing: Nuclear Fuel Cycles - Spent Fuel Characteristics - Role of Solvent Extraction in Reprocssing - Solvent Extraction Equipment		6	15
MODULE: 4 Separation of Reactor products: Processes to be Considered - 'Fuel Element' Dissolution		6	15
SECOND INTERNAL TEST			
MODULE: 5 Precipitation Process – Ion Exchange - Redox - Purex - TTA - Chelation - U235 -Hexone - TBP and Thorax Processes - Oxidative Slaging and Electro - Refinng - Isotopes - Principles of Isotope Separation		6	20
MODULE: 6 Waste disposal and radiation protection: Types of Nuclear Wastes - Safety Control and Pollution Control and Abatement, International Convention on Safety Aspects - Radiation Hazards Prevention		6	20
END SEMESTER EXAM			

COURSE NO.	COURSE TITLE	CREDITS	YEAR
04 EE 6200	ELECTRIC DRIVE SYSTEMS	3-0-0: 3	2015

Pre-requisites: Nil

Course Objectives:

To understand the characteristics of important types of electrical machines used in industry and the loads they drive, the speed control using solid state drives for energy efficient operation and the power electronic converters and control schemes required for realizing the drive systems.

Syllabus

Electric Drive: Components, its dynamics. Components of load torques ,types of load, four quadrant operation, steady state stability, load equalization, classes of motor duty ,motor rating ;DC motor drives: dc motors and its performance, types of braking, transient analysis of SEDC motor – converter control of DC motors, analysis of converter controlled SEDC and series motor drives ,dual converter, chopper controlled drives-analysis, closed loop control, transfer function model of self and SEDC motor, simulation study; Induction motor drive: stator voltage control , stator frequency control, slip control, harmonics, PWM inverter drives, rotor resistance control, slip power recovery schemes; Synchronous motor drives: speed control, principle, adjustable frequency operation-true synchronous mode and self- controlled modes of operation .

Course Outcome:

The students will be able to

- Gain knowledge about electric drive in detail and to understand the speed control techniques implemented in electric drives using solid state power electronics.
- Understand the closed loop control schemes applied in electric drives.

Text Books:

1. R. Krishnan, '*Electrical Motor Drives*', PHI-2003
2. G.K.Dubey, '*Fundamentals of Electrical Drives*', Narosa- 1995
3. Modern Power Electronics and AC drives by Bimal .K.Bose.

References:

1. S.A. Nasar, Boldea , 'Electrical Drives', Second Edition, CRC Press – 2006
2. M. A. ElSharkawi , 'Fundamentals of Electrical Drives' , Thomson Learning -2000
3. W. Leohnard, 'Control of Electric Drives',-Springer- 2001
4. Murphy and Turnbull, 'Power Electronic Control of AC motors', Pergamon Press
5. Vedam Subrahmaniam, 'Electric Drives', TMH-1994

COURSE PLAN

Course No:	Course Title	CREDITS	
04 EE 6200	Electric Drive systems	3-0-0:3	
MODULES		Contact hours	Sem. Exam Marks;%
MODULE : 1 Components of electrical Drives – electric machines, power converter, controllers - dynamics of electric drive - torque equation - equivalent values of drive parameters- components of load torques types of load, Four quadrant operation of a motor — steady state stability, Load equalization – classes of motor duty- determination of motor rating		8	15
MODULE : 2 DC motor drives – dc motors & their performance (shunt, series, compound, permanent magnet motor, universal motor, dc servomotor) – braking – regenerative, dynamic braking, plugging, Transient analysis of separately excited motor, Converter control of dc motors, analysis of separately excited & series motor with 1-phase and 3-phase converters, dual converter –analysis of chopper controlled dc drive.		10	15
FIRST INTERNAL TEST			
MODULE : 3 Converter ratings and closed loop control – transfer function of self, separately excited DC motors – linear transfer function model of power converters – sensing and feedback elements – current and speed loops, P, PI and PID controllers – response comparison – simulation of converter and chopper fed DC drive		6	15
MODULE : 4 Induction motor drives – stator voltage control of induction motor – torque-slip characteristics – operation with different types of loads – operation with unbalanced source voltages and single phasing – analysis of induction motor fed from non-sinusoidal voltage supply.		5	15
SECOND INTERNAL TEST			

MODULE : 5 Induction motor drives : Stator frequency control – variable frequency operation – V/f control, controlled current and controlled slip operation; Effect of harmonics and control of harmonics – PWM inverter drives – multi-quadrant drives – rotor resistance control – slip torque characteristic – torque equations, constant torque operation; Slip power recovery scheme – torque equation – torque slip characteristics – power factor – methods of improving power factor – limited sub synchronous speed operation – super synchronous speed operation.	8	20
MODULE : 6 Synchronous motor drives – speed control of synchronous motors – adjustable frequency operation of synchronous motors – principles of synchronous motor control – voltage source inverter drive with open loop control. Self-controlled synchronous motor with electronic commutation – self-controlled synchronous motor drive using load commutated thyristor inverter.	5	20
END SEMESTER EXAM		

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 6434	COMPUTER AIDED POWER SYSTEM ANALYSIS	3-0-0-3	2015

Pre-requisites: Nil

Course Objectives:

1. To develop an idea about graph theory and building algorithm.
2. To identify and represent various power system components.
3. Learn to analyze power systems with different load flow studies and short circuit studies.

Syllabus

Elementary linear graph theory; Building algorithm for Bus impedance matrix; Load Flow Studies; Three phase Load Flow; Representation of power system components; Incorporation of FACTS devices in Load Flow; Types of faults-Short circuit study of a large power system; Unsymmetrical Faults; Short circuit calculations using Z bus.

Course Outcome:

The student will get acquainted with mathematical approach for load flow studies and fault calculations.

Text Books:

1. Singh L P, “Advanced Power Systems Analysis and Dynamics”, New Age Intl. Publishers, 1983.
2. Stagg and EL Abiad , “Computer Methods in Power system Analysis”, McGraw Hill, 1968.
3. Kusic G L, “Computer Aided Power System Analysis”, Prentice Hall, 1986.

References:

1. Hadi Saadat, “Power System Analysis”, McGraw Hill-1999.
2. Arriliga J and Watson N R, “Computer Modeling of Electrical Power Systems”, Wiley, 2001.
3. Nagrath J J and Kothari D P, “Modern Power system Analysis”, Tata McGraw Hill, 1980.

COURSE PLAN

COURSE NO:	COURSE TITLE:	CREDITS	
04 EE 6434	Computer Aided Power System Analysis	3-0-0:3	
MODULES		**Contact hours**	**Sem. Exam Marks; %**
MODULE : 1 **Elementary linear graph theory:** Incidence and Network matrices- Development of network matrices from Graph theoretic approach.Building algorithm for Bus impedance matrix. Modification of ZBus matrix due to changes in primitive network.		8	15
MODULE : 2 **Load Flow Studies:** Overview of Gauss- Seidel and Newton - Raphson Methods- Decoupled Newton Load Flow. Fast Decoupled Load Flow-AC/DC load flow- Three phase Load Flow.		6	15
FIRST INTERNAL TEST			
MODULE : 3 Triangular factorization – Optimal ordering – Optimal load flow in power Systems. Representation of Synchronous machine, transmission system, three phase power network.		6	15
MODULE : 4 Incorporation of FACTS devices in Load Flow: Static Tap Changing, Phase Shifting (PS), Static Var Compensator (SVC), Thyristor Controlled Series Compensator (TCSC) and Unified power Flow Controller.		8	15
SECOND INTERNAL TEST			
MODULE : 5 Types of faults-Short circuit study of a large power system-Algorithm for calculating system conditions after fault-Three phase short circuit fault.		6	20
MODULE : 6 Unsymmetrical Faults: Three phase to ground, double line to		8	20

ground, line to line and single line to ground fault. Short circuit calculations using Z bus –Short circuit calculations for balanced and unbalanced three phase network using Z-bus.		
END SEMESTER EXAM		

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 6444	FACTS AND POWER QUALITY	3-0-0-3	2015

Pre-requisites: Nil

Course Objectives:

To give the Student:-

- An idea about transmission problems and different types of FACTS controllers to improve the power quality
- An idea about the principles of shunt connected and series connected FACTS controllers to increase the transmission capability of transmission system.
- An introduction to the different power quality problems occurring in our power systems
- An idea about the effect of harmonic in our power system and its elimination using power quality conditioner

Syllabus

Fundamental concepts of FACTS Controllers; Shunt Compensation; Series Compensation; Electric Power Quality; Harmonic Mitigation ; Power Quality Conditioners.

Course Outcome:

Students who successfully complete this course will have demonstrated an ability to understand the basic idea of different FACTS controllers; Describe shunt compensation for power quality improvement; Understand the different types of series connected FACTS controllers; Understand different power quality disturbance and voltage variations in a power system; Will have a full understanding of the presence of harmonics and different power.

References

1. Flexible ac transmission systems (FACTS) Song, Y.H. and Allan T. John , Institution of Electrical Engineers Press, London, 1999.
2. Concepts and Technology of flexible ac transmission system, Hingorani, L.Gyugyi, IEEE Press New York, 2000 ISBN –078033 4588
3. http://nptel.ac.in/courses.php?disciplineId=108
4. IEE Tutorials on 'Flexible ac transmission systems', published in Power Engineering Journal, IEE Press, 1995.
5. R M Mathur and R K Varma, Thyristor based FACTS Controllers for Electrical Transmission, IEEE Press.
6. Heydt, G.T., 'Electric Power Quality', Stars in Circle Publications, Indiana, 1991.

7. Bollen, M.H.J., 'Understanding Power Quality Problems: Voltage sags and interruptions', IEEE Press, New York, 1999.
8. Arrillaga, J, Watson, N.R., Chen, S., 'Power System Quality Assessment', Wiley, New York, 1999.
9. C Sankaran; Power Quality, C R C Press.

COURSE PLAN

COURSE NO:	COURSE TITLE:	CREDITS	
04 EE 6444	FACTS And Power Quality	3-0-0: 3	
MODULES		Contact hours	Sem. Exam Marks;%
MODULE : 1 Fundamentals of ac power transmission, Transmission problems and needs, Emergence of FACTS, FACTS control considerations, FACTS controllers		5	15
MODULE : 2 Principles of shunt compensation, Variable Impedance type & switching converter type, Static Synchronous Compensator, (STATCOM) configuration; Characteristics and control. Principles of static series compensation using GCSC, TCSC and TSSC, applications. Static Synchronous Series Compensator (SSSC)		7	15
FIRST INTERNAL TEST			
MODULE : 3 UPFC -Principles of operation and characteristics, Independent active and reactive power flow control; Comparison of UPFC with the controlled series compensators and phase shifters.		5	15
MODULE : 4 Electric power quality phenomena- IEC and IEEE definitions, Power quality disturbances: voltage fluctuations, voltage variations, transients, unbalance, waveform distortion, power frequency variations. Voltage sags and short interruptions : flicker, longer duration variations and impact on sensitive circuits, standards		6	15

SECOND INTERNAL TEST		
MODULE : 5 Harmonics: sources, definitions & standards, impacts, Calculation and simulation, Harmonic power flow, mitigation and control techniques, Filtering: passive and active.	10	20
MODULE : 6 Power Quality conditioners: shunt and series compensators, D-STATCOM, Dynamic voltage restorer, Unified power quality conditioners: case studies.	9	20
END SEMESTER EXAM		

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 6604	DIGITAL CONTROLLERS FOR POWER APPLICATIONS	3-0-0-3	2015

Pre-requisites: [04 EE 6303] POWER ELECTRONIC DEVICES AND CIRCUITS

Course Objectives:

To give students:

- A foundation in the fundamentals of PIC 18F4580 controller based system design;
- An ability to design and develop various power converter circuits using embedded system;
- An introduction to TMS320F2407 DSP controller for developing embedded controllers for power electronic applications.

Syllabus

PIC 18F4580 - Architecture, Programming, fundamental of embedded system design; Typical functions of PIC18F4580 microcontrollers in power electronic systems; Use of microcontroller in power converters, control; Introduction to TMS 320LF2407, Architecture details, basic programming

Course Outcome:

The students who successfully complete this course will have an ability develop embedded controllers for power electronic based system.

Text Books:

1. Muhammad Ali Mazidi, Rolind D. Mckinlay, Danny Causey. " PIC microcontroller and Embedded Systems – using assembly and C for PIC18" 13th impression, Pearson, 2013
2. Han Way Huang, "PIC Microcontroller, An introduction to software and hardware interfacing", Delmar, 2007
3. George Terzakis, Introduction to C Programming With the TMS320LF2407A DSP Controller, Create Space Independent Publishing Platform, February 2011

References:

1. Richard H. Barnett, Larry O'Cull, Sarah Alison Cox, Embedded C Programming and the Microchip PIC, Volume 1, Thomson Delmar Leaning
2. Kenjo.T, "Power electronics for microprocessor Age", Clarendon press, Oxford, 1999
3. GourabSen Gupta, Subhas Chandra Mukhopadhyay, "Embedded Microcontroller Interfacing, Designing Integrated Projects", Springer, 2010
4. Harprit Singh Sandhu, Making PIC Microcontroller Instruments and Controllers, McGraw-Hill Professional , 2009
5. Harprit Singh Sandh, Running Small Motors with PIC Microcontrollers, McGraw-Hill Professional, 2009
6. Sen M. Kuo, Woon-Seng S. Gan, Digital Signal Processors: Architectures, Implementations, And Applications, Pearson Education , 2009

7. Phil Lapsley, Jeff Bier, Amit Shoham, Edward A. Lee, DSP Processor fundamentals: Architectures and Features , IEEE Press -1997 , Wiley India Pvt Ltd
8. H.A. Toliyat, S.Campbell, DSP based Electro Mechanical Motion Control, CRC Press-2004
9. Avtar Singh and S. Srinivasan, Digital Signal Processing, Thomson/Brooks/Cole, 2004
10. PIC18F4580 Data Sheet – DS39637D, Microchip Technology Inc., 2009
11. TMS320LF2407 Data Sheet , Texas Instrument, September 2003

COURSE PLAN

COURSE NO.:	COURSE TITLE	CREDITS	
04 EE 6604	DIGITAL CONTROLLERS FOR POWER APPLICATIONS	3-0-0:3	
MODULES		Contact Hours	Sem. Exam Marks (%)
MODULE : 1 - Microchip PIC 18F4580: Architecture of PIC 18F4580 microcontroller, PIC memory organization, Interrupt structure, Timers / Counters, Capture / Compare / PWM modules, Master Synchronous Serial Port (MSSP) module, USART A / D Converter module, Comparator module.		10	15
MODULE : 2 – PIC 18F Programming: Different addressing modes. Instruction set, General Programming – .LST and .HEX files generation for applications using MPLab IDE		6	15
FIRST INTERNAL TEST			
MODULE: 3 Typical functions of PIC18F4580 microcontrollers in power electronic systems: Measurement of voltage, current, speed, power and power factor, Frequency measurement, PWM implementation; Interfacing LCD Display, Keyboard Interfacing		6	15
MODULE: 4 Use of PIC18F4580 microcontroller in power converters: Overview of Zero Crossing Detectors, Generation of gating signals for Converters, Inverters and chopper circuit, Control of AC/DC electric drives.		6	15
SECOND INTERNAL TEST			
MODULE: 5 PIC18F4580 based system control: Implementation of PI, PID controller, Power quality/power factor correction, Solar Power Conditioning (MPPT) - Miscellaneous examples		6	20

MODULE: 6 Introduction to TMS 320LF2407: Introduction to DSP architecture- computational building blocks - Address generation unit, Program control and sequencing- Parallelism, Pipelining Architecture of TMS320LF2407 - Addressing modes- I/O functionality, Interrupt. ADC, PWM, Event managers- Elementary Assembly Language Programming	8	20
END SEMESTER EXAM		

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 6594	ADVANCED RENEWABLE ENERGY LABORATORY	0-0-2-1	2015

Pre-requisites:

Non-Conventional Energy Sources

Course Objectives:

- To understand basics of solar PV Systems
- To understand Solar Thermal System
- To understand how a Solar PV system Synchronized with Grid

Syllabus

Solar PV systems

1. Performance analysis of standalone PV systems
2. Effect of bypass diode and blocking diode for a solar PV panel
3. Analysis of grid synchronized solar PV system
4. Solar simulator experiment
5. Effect of tilt angle on solar PV system
6. Performance testing of PV system with tracking
7. Effect of shading on solar panels
8. Analysis of effect of dust and temperature on Solar PV Module

Solar thermal systems

9. Testing of solar flat plate collectors thermosyphonic flow and forced flow
10. Testing of evacuated tube type solar water heater
11. Performance testing of solar thermal concentrators
12. Performance testing of solar thermal concentrators with oil for heat transfer
13. Performance testing of solar cooker

Simulation

14. Simulation of solar PV cell
15. Simulation of Wind turbine system
16. Simulation of fuel cell

Optional Experiments

1. Simulation of MPPT algorithm
2. Study and Simulation of charge Controllers
3. Study and simulation of inverters

Note:

At least 12 experiments need to be completed by students in a lab. Also, the additional advanced experiments can be offered as Demo experiments to students. In addition to the above, the Department can offer newly developed experiments which are relevant to the course.

Course Outcome:

- The student will be in a position analyse Solar PV, Solar Thermal systems and Grid Integration

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 7501	ENERGY AND CLIMATE	3-0-0-3	2015

Pre-requisites: Nil

Course Objectives:

- To introduce the impact of various energy extraction strategies on climate

Syllabus

Current energy scenario of World, USA and India – Energy terms – Fossil energy vs renewable sources – Electricity – Future projections, Externalities of energy use. Cycles Water cycle – Oxygen cycle – Carbon cycle – Nitrogen cycle – Phosphorous cycle, Climate Science Research: Climate history – Greenhouse gas effect – Anthropogenic climate change – role of different gases, Impacts and adaptation – uncertainties – precautionary principle, Global problems – Integrated assessment models, Bio-diversity – Environmental aspects of energy utilization – Public health issues related to environmental pollution, Carbon Sequestration: Biological pathways – physicochemical methods, CO capture from large point sources – pre, post and oxy-combustion technology, Transport– storage – monitoring – feasibility – economics and public perceptions, Case studies, Climate Policy: Kyoto protocol – UNFCCC – IPCC – Geopolitics of GHG control, Carbon market – CDM and other emission trading mechanisms – Non-CO GHGs - Relevance for India.

Course Outcome:

- Students will have the knowledge of the impact of various energy extraction strategies on climate

Text Books:

The Energies, MIT Press, Cambridge, 1999.

J. Houghton, Global Warming, Cambridge University Press, New York, 1997.

References:

1. B. Metz, IPCC Special Report on Carbon Dioxide Capture and Storage, Cambridge University Press, NY, 2005.
2. Various reports published by IPCC, http://www.ipcc.ch/, 1990 onwards.
3. CDM Country Guide for INDIA: Institute for Global Environmental Strategies (Ed), Ministry of the Environment, Japan, 2005.
4. F. Harris, Global Environmental Issues, John Wiley, Chichester, 2004.
5. E. J. Wilson and D. Gerard, Carbon Capture and Sequestration: Integrating Technology, Monitoring, and Regulation, edited by, Blackwell Publishing, Ames, Iowa, USA, 2007.

COURSE PLAN

COURSE NO.:	COURSE TITLE	L-T-P: 3-0-0	
04 EE 7501	ENERGY AND CLIMATE	CREDITS: 3	
MODULES		Contact Hours	Sem. Exam Marks (%)
MODULE: 1 Current energy scenario of World, USA and India – Energy terms – Fossil energy vs renewable sources – Electricity – Future projections Externalities of energy use. Cycles Water cycle – Oxygen cycle – Carbon cycle – Nitrogen cycle – Phosphorous cycle		8	15
MODULE: 2 Climate Science Research: Climate history – Greenhouse gas effect – Anthropogenic climate change – role of different gases Impacts and adaptation – uncertainties – precautionary principle		7	15
FIRST INTERNAL TEST			
MODULE: 3 Global problems – Integrated assessment models Bio-diversity – Environmental aspects of energy utilization – Public health issues related to environmental pollution.		8	15
MODULE: 4 Carbon Sequestration: Biological pathways – physicochemical methods CO capture from large point sources – pre, post and oxy-combustion technology		6	15
SECOND INTERNAL TEST			
MODULE: 5 Transport– storage – monitoring – feasibility – economics and public perceptions, Case studies		6	20
MODULE: 6 Climate Policy: Kyoto protocol – UNFCCC – IPCC – Geopolitics of GHG control, Carbon market – CDM and other emission trading mechanisms – Non-CO GHGs - Relevance for India		8	20
END SEMESTER EXAM			

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 7503	RENEWABLE ENERGY SYSTEMS	3-0-0-3	2015

Pre-requisites: Nil

Course Objectives:

- To study the difference between renewable and non-renewable energy resources.
- To demonstrate the different types of renewable energy technologies that are currently available, and how they are used to provide energy.

Syllabus

Solar Energy and its availability; Solar thermal Conversion systems; Wind Energy systems; Chemical energy ; Hydrogen energy; Energy from Oceans ;Geothermal Energy

Course Outcome:

- Students will be able to create a list of renewable energy technologies that can be used in a particular situation, based on the situational factors.
- Ability to evaluate the environmental and social impacts of renewable and nonrenewable energy use

References:

1. S P Sukatme, “Solar Energy – Principles of thermal collection and storage, second edition, Tata McGraw Hill, 1991.
2. G D Rai, “Non Conventional Energy Sources”.
3. J. A. Duffie and W. A. Beckman, “Solar Engineering of Thermal Processes”, Second Edition, John Wiley, New York, 1991.
4. D. Y. Goswami, F. Kreith and J.F. Kreider, “Principles of Solar Engineering, Taylor and Francis, Philadelphia, 2000.
5. D. D. Hall and R.P. Grover, “Bio-Mass Regenerable Energy, John Wiley, Newyork, 1987.
6 J. Twidell and T. Weir, “Renewable Energy Resources”, E&FN Spon Ltd., London, 1986.Thokal.S.K., “Electrical Energy Conservation by Improvement of Power factor”, Electrical India, Jul’04,pp.38-41
7. Dr. Omprakash G. Kulkarni, “Load End Energy Management”, Electrical India

COURSE PLAN

Course No:	Course Title:	CREDITS	
04 EE 7503	RENEWABLE ENERGY SYSTEMS	3-0-0:3	
MODULES		Contact hours	Sem. Exam Marks;%
MODULE1: Solar Energy-Introduction to solar energy: solar radiation, availability, measurement and estimation- Solar thermal conversion devices and storage- PV systems – MPPT. Applications of PV Systems – solar energy collectors and storages.		8	15
MODULE: 2 Wind Energy-Introduction – Basic principles of wind energy conversion – wind data and energy estimation – site selection consideration - Types of wind machines – basic components of wind electric conversion systems- Schemes for electric generations – generator control, load control, energy storage- Inter connected systems		8	15
FIRST INTERNAL TEST			
MODULE: 3 Chemical Energy Sources-Introduction – fuel cells – design and principles of operation of a fuel cell- classification of fuel cells. Types of fuel cells – conversion efficiency of fuel cells. Types of electrodes, work output and emf of fuel cell, Applications of fuel cells.		7	15
MODULE: 4 Hydrogen energy: Introduction – hydrogen production – electrolysis, thermochemical methods, Westinghouse Electro-chemical thermal sulphur cycle. Fossil fuel methods. Hydrogen storage, Utilization of hydrogen gas.		6	15
SECOND INTERNAL TEST			
MODULE: 5 Energy from oceans-Introduction, ocean thermal electric conversion (OTEC), methods of ocean thermal electric power generation, open cycle OTEC system, closed OTEC cycle. Energy from tides: Basic principles of tidal power, component of tidal power plants, operation methods of utilization of tidal energy, site requirements, storage, advantages and limitations of		7	20

tidal power generation. Ocean waves, energy and power from the waves, wave energy conversion devices.		
MODULE: 6 Geothermal energy-Introduction, estimation of geothermal power, nature of geothermal fields, geothermal sources, inter connection of geothermal fossil systems, prime movers for geo thermal energy conversion. Energy from biomass: Biomass conversion technologies, photosynthesis, classification of biogas plants. Biomass Energy conversion, Energy from waste.	6	20
END SEMESTER EXAMINATION		

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 7505	ENERGY EFFICIENT BUILDINGS	3-0-0-3	2015

Pre-requisites: Nil

Course Objectives:

- To understand the basic concepts of indoor lighting system and energy efficiency in lighting
- To understand the various passive cooling methods for buildings
- Air Conditioner load estimation and energy conservation in AC systems

Syllabus

Climates and buildings: Climatic zones in India and their characteristics, Implications of climate on building design – human comfort conditions in building indoors, Urban climate and Micro climate, Energy Conscious buildings: Building envelope, site, form and orientation, building components - internal and external shading devices, need for proper ventilation, Passive cooling and heating concepts for various climate zones in India- advantages and disadvantages, Air Conditioning- Estimation of heat loads – Air conditioning load calculation - Brief concept only, Chilled water system, Energy conservation techniques in air conditioning systems, Lighting Design: Lighting Design Principles, Quantity and Quality determination method of interior lighting design – general design considerations only. Solid State Lighting: Basics of solid state lamps – white light generation techniques – Power LEDs – LED driver considerations, Daylight – Artificial light integration, lighting control strategies – Energy Management strategies – Switching Control – sensor technology – Applications, Digital lighting control based system – lighting Automation – DMX, DALI, Green buildings: Specialities and benefits, target areas of a Green building design –BEE in building energy conservation in India - ECBC - Green building rating systems such as LEED and GRIHA – brief overview only.

Course Outcome:

- The student will understand the modern building concept of building for sustainability

Text Books:

1. Handbook of Energy Conscious Buildings, J. K. Nayak, J. A. Prajapathi, Ministry of Non-conventional Energy Sources, Government of India, 2006.
2. IES Lighting Handbook, 10th Edition IESNA, 2011.

References:

1. M. S. Sodha, N. K. Bansal, P. K. Bansal, A. Kumar and M.A.S. Malik, Solar Passive Building, Science and Design, Pergamon Press, 1986.
2. Energy Management Guide Books, Revision – II, Bureau of Energy Efficiency, India.
3. A.K Mittal, Electrical and Mechanical Services in High Rise Buildings – Design and Estimation Manual , CBS Publishers and Distributors Pvt. Ltd, New Delhi, 2014.
4. Jan F. Kreider, Peter S. Curtiss, Ari Rabl, Heating and Cooling for Buildings – Design for Efficiency, II Edition, McGraw Hill, 2009.

5. Robert S. Simpson, Lighting Control – Technology and Applications, Focal Press, 2003.
6. Michael Stiller, Quality lighting for high performance Buildings, I Edition, CRC Press, London, 2012.
7. J. R. Williams, Passive Solar Heating, Ann Arbor Science, 1983.
8. H. B. Awbi, Ventilation of Buildings, Spon Press, London, 2003.
9. Energy Conservation Building Code, Bureau of Energy Efficiency, 2007.
10. http://www.usgbc.org/, United States Green Building Council, USA.
11. http://www.igbc.in, Indian Green Building Council, LEED India.
12. http://www.grihaindia.org, GRIHA Website, India.
13. Sustainable Building Design Manual, Volumes 1 & 2, TERI, 2004.

COURSE PLAN

COURSE NO.:	**COURSE TITLE**	**L-T-P: 3-0-0**	
04 EE 7505	**ENERGY EFFICIENT BUILDINGS**	**CREDITS: 3**	
MODULES		Contact Hours	Sem. Exam Marks (%)
MODULE: 1 **Climates and buildings:** Climatic zones in India and their characteristics, Implications of climate on building design – human comfort conditions in building indoors, Urban climate and Micro climate		7	15
MODULE: 2 Energy Conscious buildings: Building envelope, site, form and orientation, building components - internal and external shading devices, need for proper ventilation		6	15
FIRST INTERNAL TEST			
MODULE: 3 Passive cooling and heating concepts for various climate zones in India- advantages and disadvantages, **Air Conditioning-** Estimation of heat loads – Air conditioning load calculation - Brief concept only, Chilled water system, Energy conservation techniques in air conditioning systems		8	15
MODULE: 4 **Lighting Design:** Lighting Design Principles, Quantity and Quality determination method of interior lighting design – general design considerations only. Daylight – Artificial light integration Solid State Lighting: Basics of solid state lamps – white light generation		7	15

techniques – Power LEDs – LED driver considerations		
SECOND INTERNAL TEST		
MODULE: 5 **Introduction to lighting control** – lighting control strategies – Energy Management strategies – Switching Control – sensor technology – Applications Digital lighting control based system – lighting Automation – DMX, DALI	7	20
MODULE: 6 **Green buildings:** Specialities and benefits, target areas of a Green building design –BEE in building energy conservation in India - ECBC - Green building rating systems such as LEED and GRIHA – brief overview only.	6	20
END SEMESTER EXAMINATION		

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 7507	WASTE MANAGEMENT AND ENERGY GENERATION TECHNOLOGIES	3-0-0-3	2015

Pre-requisites: Nil

Course Objectives:

- To understand the basic problems associated with waste handling and various methods for waste management, control and energy generation from waste

Syllabus

Solid Waste:– Municipal solid waste - waste minimization and recycling of Municipal waste, Waste Treatment: Size Reduction – aerobic composting– furnace type and design – medical/pharmaceutical waste incineration – environmental impacts.

Waste Disposal -Hazardous Waste Management: Definition – identification of hazardous waste – sources and nature of hazardous waste – impact on environment, Hazardous waste control – minimization and recycling – Assessment of hazardous waste sites – disposal of hazardous waste – underground storage tank construction – installation – closure, Energy generation from waste : Types - biochemical conversion – sources of energy generation – industrial waste – agro residues – anaerobic digestion – Biogas production – types of biogas plant thermo-chemical conversion, Sources of energy generation – gasification– utilization and advantages of briquetting – environment benefits of biochemical and thermo-chemical conversion

Course Outcome:

- The student will have a basic knowledge about waste management and energy generation from waste

Text Books:

1. D.O. Hall, R. P. Overeed, Biomass regenerable energy, John Wiley and Sons Ltd. New York, 1987.
2. Kanti L. Shah, Basics of Solid & Hazardous Waste Management Technology, Prentice Hall, 2000.

References:

1. M. M. EL-Halwagi, Biogas Technology- Transfer and diffusion, Elsevier Applied science Publishers, New York, 1984.
2. Colin Parker, Tim Roberts, Energy from Waste - An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985.
3. Manoj Dutta, Waste Disposal in Engineered Landfills, Narosa Publishing House, 1997.
4. Gerald Rich et. al., Hazardous Waste Management Technology, Podvan Publishers, 1987.
5. A. D. Bhide, B. B. Sundaresan, Solid Waste Management in Developing Countries, INSDOC, New Delhi, 1983.
6. Nelson L. Nemerow, Zero Pollution for Industry: Waste minimization through industrial complexes, John Wiley & Sons, New York, 1995

COURSE PLAN

COURSE NO.:	COURSE TITLE	L-T-P: 3-0-0	
04 EE 7507	WASTE MANAGEMENT AND ENERGY GENERATION TECHNOLOGIES	CREDITS: 3	
MODULES		Contact Hours	Sem. Exam Marks (%)
MODULE: 1 Solid Waste: Definitions – sources – types – compositions – properties of solid waste – Municipal solid waste - Physical, Chemical and Biological properties – collection – transfer stations – waste minimization and recycling of Municipal waste		6	15
MODULE: 2 Waste Treatment: Size Reduction – aerobic composting – incineration – furnace type and design – medical/pharmaceutical waste incineration – environmental impacts – measures to mitigate environmental effects due to incineration		6	15
FIRST INTERNAL TEST			
MODULE: 3 Waste Disposal: Land fill method of solid waste disposal – land fill classifications – types – methods – siting consideration, Layout and preliminary design of landfills – composition, characteristics, generation, movement and Control of landfill, Leachate & gases – environmental monitoring system for land fill gases		6	15
MODULE: 4 Hazardous Waste Management: Definition – identification of hazardous waste – sources and nature of hazardous waste – impact on environment Hazardous waste control – minimization and recycling – Assessment of hazardous waste sites – disposal of hazardous waste – underground storage tank construction – installation – closure		6	15
SECOND INTERNAL TEST			
MODULE: 5 Energy generation from waste : Types - biochemical conversion – sources of energy generation – industrial waste – agro residues – anaerobic digestion – Biogas production – types of biogas plant thermo-chemical conversion		6	20
MODULE: 6 Sources of energy generation – gasification – types of gasifiers –		6	20

briquetting – industrial applications of gasifiers – utilization and advantages of briquetting – environment benefits of biochemical and thermo-chemical conversion		
END SEMSTER EXAM		

COURSE NO.	COURSE TITLE	L-T-P:C	YEAR
04 EE 7001	BIO INSPIRED ALGORITHMS	3-0-0:3	2015

Pre-requisites: Nil

Course Objectives:

To enable the student to apply fuzzy logic based analysis tools in optimization of power systems and power electronic problems.

Syllabus

Fuzzy Logic-concepts-set theory -operations-membership function-fuzzy rules-fuzzy reasoning-fuzzy inference systemsMamdani and Sugeno type-defuzzification- fuzzy controllers-applications in electric drives, power system **Genetic Algorithm Application :** Modern Heuristic Search Techniques Genetic Algorithm-Introduction- -Encoding-Fitness Function, Premature Convergence, Slow Finishing,Basic Operators, Selection-Tournament Selection, Truncation Selection, Linear Ranking Selection, Exponential Ranking Selection, Elitist Selection, Proportional Selection-Crossover, Mutation, Control Parameters Estimation, Niching Methods, Parallel Genetic Algorithms-Application in Drives.- Tunning of membership function using genetic algorithm. Application of GA to neural network.- Tunning of controllers.

Swarm Intelligence: Ant Colony Optimization

Swarm intelligence general characteristics, Ant Colony Optimization: Basic Concepts- The Ant Colony System- Ants' Foraging Behaviour and Optimization,- The Max-Min Ant System Minimum Cost Paths, Combinatorial Optimization, Major Characteristics of Ant Colony Search Algorithms- Positive Feedback-Rapid Discovery of Good Solution - Use of Greedy Search and Constructive Heuristic Information- Ant Colony Optimization Algorithms Applications.

Particle swarm optimization and Firefly Algorithm

Particle swarm optimization: Application and Implementation. **Fire Fly Algorithm** – Basic Concepts-Application in optimization, power electronics and power system problems.

Course Outcome:

Students who successfully complete this course will have demonstrated an ability to apply optimization techniques in engineering applications.

Text Books:

1. Leandro Nunes de Castro," Fundamentals of Natural Computing: Basic Concepts, Algorithms, and Applications". Chapman & Hall/CRC, 2006.
2. G. Rozenberg, T. Bäck, J. N. Kok ,"Handbook of Natural Computing", Springer Verlag- 2010.

References:

1. Melanie Mitchell, " An Introduction to Genetic Algorithms", MIT Press- 1996.
2. Mohamed E. El-Hawary, "Modern Heuristic Optimisation technique –Theory and application to power system",IEEE Press.
3. Xin-She Yang, "Nature-Inspired Metaheuristic Algorithms", Luniver Press 2010.
4. J. R. Koza: " Genetic Programming: On the programming of computers by means of natural selection", MIT Press- 1992 .

COURSE PLAN

COURSE NO:	Course Title	CREDITS
04 EE 7001	BIO INSPIRED ALGORITHMS	3-0-0:3

MODULES	Contact hours	Sem. Exam Marks;%
MODULE : 1 Fuzzy Logic-concepts-set theory -operations-membership function-fuzzy rules-fuzzy reasoning-fuzzy inference systems Mamdani and Sugeno type-defuzzification- fuzzy controllers-applications in electric drives, power system.	10	15
MODULE : 2 **Genetic Algorithm Application :** Modern Heuristic Search Techniques Genetic Algorithm-Introduction- -Encoding-Fitness Function, Premature Convergence, Slow Finishing, Basic Operators, Selection-Tournament Selection, Truncation Selection, Linear Ranking Selection, Exponential Ranking Selection, Elitist Selection, Proportional Selection-Crossover, Mutation, Control Parameters Estimation, Niching Methods, Parallel Genetic Algorithms-Application in Drives.- Tuning of membership function using genetic algorithm. Application of GA to neural network.- Tuning of controllers.	8	15
FIRST INTERNAL TEST		
MODULE : 3 **Swarm Intelligence: Ant Colony Optimization** Swarm intelligence general characteristics, Ant Colony Optimization: Basic Concepts- The Ant Colony System- Ants' Foraging Behavior and Optimization,- The Max-Min Ant System Minimum Cost Paths, Combinatorial Optimization.	6	15
MODULE : 4 Major Characteristics of Ant Colony Search Algorithms- Positive Feedback-Rapid Discovery of Good Solution - Use of Greedy Search and Constructive Heuristic Information- Ant Colony Optimization Algorithms Applications.	8	15
SECOND INTERNAL TEST		
MODULE : 5 Particle swarm optimization: -Fundamentals- Concepts of PSO-Comparison	5	20

with Genetic Algorithm-Application and Implementation.		
MODULE : 6 **Firefly Algorithm** –Basic Concepts-Application in optimization, power electronics and power system problems.	5	20
END SEMESTER EXAMINATION		

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 7115	DATA ACQUISITION AND SIGNAL CONDITIONING	3-0-0:3	2015

Pre-requisites: Nil

Course Objectives:

- To understand the concepts of data acquisition and signal conditioning for real-time applications

Syllabus

Classification of Signals & Signal Encoding Techniques - Fundamentals of data acquisition, Transducers and sensors-Field wiring and communications cabling,-Signal conditioning, Data acquisition hardware, Analog-to-Digital Converters(ADC)-Multiplexers and demultiplexers - Digital multiplexer . A/D Conversion, Conversion Processes, Speed, Quantization Errors. Successive Approximation ADC . Dual Slope ADC. Flash ADC, Introduction to Sensor-Based Measurement Systems: Features & characteristics, Micro sensor Technology, Signal Conditioning - Introduction- Types of signal conditioning, Classes of signal conditioning

Field wiring and signal measurement- Noise and interference, Minimizing noise, Digital-to-Analog Conversion (DAC), Techniques, Speed, Conversion Errors, Post Filtering- Weighted Resistor, R-2R, Weighted Current type of DACs, Field wiring and communications cabling,-Signal conditioning, Data acquisition hardware, Shielded and twisted-pair cable - Resistive Sensors & Signal Conditioning for Resistive Sensors, Reactance Variation and Electromagnetic Sensors Signal Conditioning for Reactance Variation, Sensors - Self-Generating Sensors, Communication Systems for Sensors: Current telemetry: 4 to 20 mA loop, Simultaneous analogue and digital communication, Serial data communications, Error detection, DAS Boards-Introduction . Study of a representative DAS Board-Interfacing Issues with DAS Boards, Virtual Instrumentation: Introduction to LABVIEW, Creating Virtual Instruments, Making decisions in a Virtual Instrument, Plotting data in VI, Data Acquisition Using NI DAQ & LAB View

Course Outcome:

- The student will be able to implement data acquisition system

Text Books:

1. Ramon Pallas-Areny, John G. Webster, Sensors & Signal Conditionin, John Wiley & Sons, Inc, 2001.
2. John Park & Steve Mackay , Practical Data Acquisition for Instrumentation & Control Systems, Elsevier, 2003

References:

1. LABVIEW_Data Acquisition Manual, National Instruments, 2000
2. LABVIEW Graphical Programming Course, National Instruments, 2007
3. S. Sumathi and P. Surekha , LABVIEW based Advanced Instrumentation Systems, SPRINGER, 2007.
4. Gary Johnson, LabVIEW Graphical Programming (2e), McGraw Hill, New York, 1997.

COURSE PLAN

COURSE NO.:	COURSE TITLE	CREDITS	
04 EE 7115	DATA ACQUISITION AND SIGNAL CONDITIONING	3-0-0: 3	
MODULES		**Contact Hours**	**Sem. Exam Marks (%)**
MODULE: 1 Classification of Signals & Signal Encoding Techniques - Fundamentals of data acquisition, Transducers and sensors-Field wiring and communications cabling,-Signal conditioning, Data acquisition hardware Field wiring and communications cabling,-Signal conditioning, Data acquisition hardware		7	15
MODULE: 2 Analog-to-Digital Converters(ADC)-Multiplexers and demultiplexers - Digital multiplexer . A/D Conversion Conversion Processes , Speed, Quantization Errors . Successive Approximation ADC. Dual Slope ADC. Flash ADC Digital-to-Analog Conversion (DAC) . Techniques, Speed, Conversion Errors, Post Filtering- Weighted Resistor, R-2R, Weighted Current type of DACs		8	15
FIRST INTERNAL TEST			
MODULE: 3 Introduction to Sensor-Based Measurement Systems: Features & characteristics, Micro sensor Technology Signal conditioning: Introduction- Types of signal conditioning, Classes of signal conditioning Field wiring and signal measurement- Noise and interference, Minimizing noise		8	15
MODULE: 4 Shielded and twisted-pair cable - Resistive Sensors & Signal Conditioning for Resistive Sensors Reactance Variation and Electromagnetic Sensors Signal Conditioning for Reactance Variation Sensors - Self-Generating Sensors, Communication Systems for Sensors: Current telemetry: 4 to 20 mA loop		7	15
SECOND INTERNAL TEST			

MODULE: 5 Simultaneous analog and digital communication, Serial data communications, Error detection DAS Boards-Introduction . Study of a representative DAS Board-Interfacing Issues with DAS Boards	6	20
MODULE: 6 Virtual Instrumentation: Introduction to LABVIEW Creating Virtual Instruments, Making decisions in a Virtual Instrument, Plotting data in VI Data Acquisition Using NI DAQ & LAB View	7	20
END SEMESTER EXAMINATION		

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 7421	ELECTRICITY DEREGULATION	3-0-0-3	2015

Pre-requisites: Nil

Course Objectives:

- To acquaint the students with the deregulated electricity market;
- To equip the students with knowledge of the role of the system operator and the pricing mechanisms of the deregulation process

Syllabus

Introduction, Deregulated electric markets, Current international situation, Benefits and effects, Review of economic load dispatch problem, Optimal power flow, Basic OPF model, Unit commitment, Power pools, Energy brokerage system, Independent system operator, British and Nordic electricity sector deregulation, Pool and bilateral markets, Activities of a Genco, Market participation issues, Unit Commitment in deregulated environment, Competitive bidding, Power wheeling, Transmission open access, Cost components, Pricing of power transactions, Different types of transmission pricing, Security management, Scheduling of spinning reserves, Congestion management

Course Outcome:

1. Gain a good level of knowledge of the structure, participants, relations and principles of the deregulated electric power market..
2. Be knowledgeable of the stock markets, especially those with connected to commodity exchange.

Text Books:

1. Kankar Bhattacharya, Math H J Bollen, Jaap E Daader, “Operation of Restructured Power Systems, Kluwer academic publishers”, USA, first Edition, 2001.
2. Marjia Ilic, Francisco Galiana and Lester Fink, “Power systems restructuring engineering and economics”, Kluwer academic publishers, 1998.

References:

1. Zaccour G, ‘Deregulation of Electric Utilities’, Kluwer Academic Publisher, 1998,
2. Wood A J and Woolenberg B F, ‘Power Generation, Operation and Control’, John Wiley and Sons, 1996

COURSE PLAN

Course No:	Course Title:	CREDITS	
04 EE 7421	Electricity Deregulation	3-0-0:3	
MODULES		**Contact hours**	**Sem. Exam Marks; %**
MODULE : 1 Deregulation-Introduction, Different entities in deregulated electric markets, Background to deregulation, Current world situation , Benefits from a competitive electricity market		7	15
MODULE : 2 After effects of deregulation, Review of economic load dispatch problem, Recent developments in Electric load dispatch		6	15
FIRST INTERNAL TEST			
MODULE : 3 Optimal power flow, Basic OPF models, Examples, Characteristic features of OPF, Unit commitment, Basic model, Additional issues, Formation of power pools, Energy brokerage system		7	15
MODULE : 4 Independent system operator, Role of the ISO, Structure of British and Nordic electricity sector deregulation, Operational planning activities of ISO, Role of ISO in pool and bilateral markets		6	15
SECOND INTERNAL TEST			
MODULE : 5 Operational planning activities of a Genco, Genco in pool and bilateral markets, Market participation issues, Unit commitment in deregulated environment, Competitive bidding		6	20
MODULE : 6 Power wheeling, Transmission open access, Cost components in transmission, Pricing of power transactions -Embedded cost based transmission pricing, Incremental cost based transmission pricing, Security management in deregulated environment, Scheduling of		10	20

spinning reserves, Interruptible load options for security management, Congestion management in deregulation, Economic instruments for handling congestion		
END SEMESTER EXAMINATION		

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 7423	POWER GENERATION AND SYSTEM PLANNING	3-0-0-3	2015

Pre-requisites: Nil

Course Objectives:

- To understand the Indian power system practical aspects
- To understand power interchanges and production in power system
- To understand the cost models and various power plants

Syllabus

Overview of Indian power sector– load duration curve – energy load curve – maximum demand – demand factor – diversity factor – coincidence factor – contribution factor – load factor – plant capacity factor, Plant use factor – utilization factor power factor and economics of power factor correction – Interchange of Power and Energy - Energy broker system– availability based tariff, Production cost models - Outages considered, Probabilistic Production Cost Programs : Probabilistic production cost computation - simulating economic scheduling with the Unserved Load Method, The Expected Cost Method - A discussion of some practical Problems - Steam power plants: Rankine cycle - Nuclear power plants-Gas power plants- Diesel power plants- Hydroelectric power plants.

Course Outcome:

- The student will understand the power system practical aspects, power interchanges and production in power system, cost models and various power plants.

Text Books:

1. J. Wood, B. F. Wollenberg, Power Generation, Operation and Control, Willey India, 2007.
2. P.K. Nag, Power plant engineering, Tata Mc Graw Hill, 2002.
3. D. P. Kothari and I. J. Nagrath, Power System Engineering, Tata McGraw Hill.

References:

1. P. K. Nag, Engineering Thermodynamics, Tata Mc Graw Hill, 2005.
2. P.S. Pabla, Electric Power Distribution, Tata McGraw Hill.
3. K. Bhattacharya, M. H. J. Bollen, J. E. Daalder, Operation of Restructured Power Systems, Kluwer Academic Publishers, 2001.
4. V. Kamaraju, Electrical Power Distribution Systems, Tata McGraw Hill.
5. M. V. Deshpande, Elements of Electrical Power Station Design, PHI.
6. Lucas M. Faulkenberry, Walter Coffer, Electrical power Distribution and Transmission, Pearson Education.
7. C. L. Wadhwa, Electrical Power System, New age International.
8. Indian Electricity Act - 2003, Govt. of India.

COURSE PLAN

COURSE NO.:	COURSE TITLE	L-T-P: 3-0-0	
04 EE 7423	POWER GENERATION AND SYSTEM PLANNING	CREDITS: 3	
MODULES		Contact Hours	Sem. Exam Marks (%)
MODULE 1: Overview of Indian power sector – installed capacity and generation – duties and functions of govt. agencies for energy (India) – CEA, CERC, Ministry of Power, Ministry of New and Renewable Energy – Ministry of Petroleum and Natural Gas – State electricity agencies of India (KSEB) – Load Dispatch Centers – SLDC – RLDC – NLDC, Overview of Indian Electricity Act-2003. Load Curve – load duration curve – energy load curve – maximum demand – demand factor – diversity factor – coincidence factor – contribution factor – load factor – plant capacity factor.		7	15
MODULE 2: Plant use factor – utilization factor power factor and economics of power factor correction - Numericals Interchange of Power and Energy: Economy interchange between interconnected utilities – interutility economy energy evaluation Interchange evaluation with unit commitment – multiple utility interchange transactions – capacity interchange – diversity interchange – energy banking – emergency power interchange –inadvertent power exchange – Power pools		9	15
FIRST INTERNAL TEST			
MODULE 3: Energy broker system – allocating pool savings –transmission effects and issues – transfer limitations – wheeling –transactions involving nonutility parties – availability based tariff.		6	15
MODULE 4: Production cost models: Introduction - Uses and types of production cost program - production costing using load duration curves - Outages considered Probabilistic Production Cost Programs : Probabilistic production cost computation - simulating economic scheduling with the Unserved Load Method		9	15
SECOND INTERNAL TEST			

MODULE 5: The Expected Cost Method - A discussion of some practical Problems Sample Computation and Exercise : No Forced Outages - Forced Outages Included Probability methods and uses in generation planning	6	20
MODULE 6: Steam power plants: Rankine cycle (ideal, actual and reheat) – layout – components – alternators – excitation system – governing system of steam turbine – simple problems. Nuclear power plants: Layout – components – pressurized water reactor – boiling water reactor – heavy water reactor – gas cooled reactor – fast breeder reactor. Gas power plants: Gas turbine cycle – layout – open cycle, closed cycle and combined cycle gas power plants. Diesel power plants: Thermal cycle – diesel plant equipment. Hydroelectric power plants: Selection of site – mass curve – flow duration curve – hydrograph – classification of hydro plants – layout – components – classification of hydro turbines.	8	20
END SEMESTER EXAM		

COURSE NO.	COURSE TITLE	L-T-P:C	YEAR
04 EE 6591/7591	SEMINAR –I/II	0-0-2: 2	2015

Course Objectives:

1. Improve the technical presentation skills of the students.
2. To train the students to do literature review.
3. To impart critical thinking abilities.

Methodology

Individual students are required to choose a topic of their interest from related topics to the stream of specialization, preferably from outside the M. Tech syllabus. The students are required to do a moderate literature review on the topic and give seminar. A committee consisting of at least three faculty members (preferably specialized in the respective stream) shall assess the presentation of the seminar and award marks to the students based on merits of topic of presentation. Each student shall submit two copies of a write up of his seminar topic. The seminar report shall not have any plagiarised content (all sources shall be properly cited or acknowledged). One copy shall be returned to the student after duly certifying it by the chairman of the assessing committee and the other shall be kept in the departmental library. Internal continuous assessment marks are awarded based on the relevance of the topic, presentation skill, quality of the report and participation. It is encouraged to do simulations related to the chosen topic and present the results at the end of the semester.

COURSE NO.	COURSE TITLE	L-T-P:C	YEAR
04 EE 7593	PROJECT PHASE - I	0-0-12: 6	2015

Course Objectives:

The project work aims to develop the work practice in students to apply theoretical and practical tools/techniques to solve real-life problems related to industry and current research.

The project work can be a design project/experimental project and/or computer simulation project on any of the topics related to the stream of specialisation. The project work is chosen/allotted individually on different topics. Work of each student shall be supervised by one or more faculty members of the department. The students shall be encouraged to do their project work in the parent institute itself. If found essential, they may be permitted to carry out their main project outside the parent institute, subject to the conditions specified in the M. Tech regulations of the Kerala Technological University. Students are encouraged to take up industry problems in consultation with the respective supervisors.

The student is required to undertake the main project phase-1 during the third semester and the same is continued in the 4th semester (Phase 2). Phase-1 consist of preliminary work, two reviews of the work and the submission of a preliminary report. First review would highlight the topic, objectives, methodology and expected results. Second review evaluates the progress of the work, preliminary report and scope of the work which is to be completed in the 4th semester.

COURSE NO.	COURSE TITLE	L-T-P: C	YEAR
04 EE 7594	PROJECT PHASE - II	0-0-21: 12	2015

Main project phase II is a continuation of project phase-I started in the third semester. There would be two reviews in the fourth semester, first in the middle of the semester and the second at the end of the semester. First review is to evaluate the progress of the work, presentation and discussion. Second review would be a pre -submission presentation before the evaluation committee to assess the quality and quantum of the work done. It is encouraged to prepare at least one technical paper for possible publication in journals or conferences. The project report (and the technical paper(s)) shall be prepared without any plagiarised content and with adequate citations, in the standard format specified by the Department/Cluster/University.