**KERALA TECHNOLOGICAL UNIVERSITY**

**SCHEME AND SYLLABUS FOR**

**M. TECH.**

**in**

**ENERGY SYSTEMS**

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| **M.Tech Program Credit Assignment** |
| **ENERGY SYSTEMS** |

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| **Semester 1 (Credits: 22)** |  |  |  |  |  |  |  |

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| **Exam Slot** | **Course No:** | **Name** | **Hours/Week** | | | **Internal Marks** | **End Semester Exam** | | **Credits** |
| **L** | **T** | **P** | **Marks** | **Duration (hrs)** |
| A | 08EE6011 | Applied Mathematics | 3 | 0 | 0 | 40 | 60 | 3 | 3 |
| B | 08EE6021 | Advanced Energy Conversion Systems | 3 | 0 | 0 | 40 | 60 | 3 | 3 |
| C | 08EE6031 | Renewable Energy Technology | 4 | 0 | 0 | 40 | 60 | 3 | 4 |
| D | 08EE6041 | Electrical Energy Systems and Management | 3 | 0 | 0 | 40 | 60 | 3 | 3 |
| E | 08EE6051 | Elective I | 3 | 0 | 0 | 40 | 60 | 3 | 3 |
|  | 08GN6101 | Research Methodology | 0 | 2 | 0 | 100 | 0 | 0 | 2 |
|  | 08EE6071 | Seminar | 0 | 0 | 2 | 100 | 0 | 0 | 2 |
|  | 08EE6081 | Energy Systems Lab | 0 | 0 | 2 | 100 | 0 | 0 | 2 |
|  |  |  |  |  |  | Credits |  | 21 | |

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| **Elective – I** |
| 08EE6051(A): Energy Policies for Sustainable Development |
| 08EE6051(B): Energy Modelling, Economics and Project Management |
| 08EE6051(C): Advanced Instrumentation |

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| **Semester 2 (Credits: 19)** | | | | | | | | | |
| **Exam Slot** | **Course No:** | **Name** | **Hours/Week** | | | **Internal Marks** | **End Semester Exam** | | **Credits** |
| **L** | **T** | **P** | **Marks** | **Duration (hrs)** |
| A | 08EE6012 | Design and Analysis of Energy Systems | 4 | 0 | 0 | 40 | 60 | 3 | 3 |
| B | 08EE6022 | Energy Conservation in Thermal Systems | 3 | 0 | 0 | 40 | 60 | 3 | 3 |
| C | 08EE6032 | Energy and Environment | 3 | 0 | 0 | 40 | 60 | 3 | 3 |
| D | 08EE6042 | Elective- II | 3 | 0 | 0 | 40 | 60 | 3 | 3 |
| E | 08EE6052 | Elective -III | 3 | 0 | 0 | 40 | 60 | 3 | 3 |
|  | 08EE6062 | Mini Project | 0 | 0 | 4 | 100 | 0 | 0 | 2 |
|  | 08EE6072 | Power Electronics Lab | 0 | 0 | 2 | 100 | 0 | 0 | 2 |
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| **ELECTIVE - II** |  |
| 08EE6042(A):Hydro Power Systems | |
| 08EE6042(B): Optimization Techniques | |
| 08EE6042(C):Computational Fluid Dynamics | |
| **ELECTIVE - III** |  |
| 08EE6052(A): Wind Energy and its Utilization | |
| 08EE6052(B): Advanced Solar Thermal and PV Systems | |
| 08EE6052(C): Emerging Refrigeration Technologies | |

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| **Semester 3 (Credits :14)** | | | | | | | | | |
| **Exam Slot** | **Course No:** | **Name** | **Hours/Week** | | | **Internal Marks** | **End Semester Exam** | | **Credits** |
| **L** | **T** | **P** | **Marks** | **Duration (hrs)** |
| A | 08EE7013 | Elective - IV | 3 | 0 | 0 | 40 | 60 | 3 | 3 |
| B | 08EE7023 | Elective -V | 3 | 0 | 0 | 40 | 60 | 3 | 3 |
|  | 08EE7033 | Seminar | 0 | 0 | 2 | 100 | 0 | 0 | 2 |
|  | 08EE7043 | Research Project Phase- I | 0 | 0 | 12 | 50 | 0 | 0 | 6 |
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| **ELECTIVES - I** |  |
| 08EE7013(A): Cryogenic Engineering | |
| 08EE7013(B)Theory of Combustion | |
| 08EE7013(C) Energy Efficient Buildings | |
| **ELECTIVES– II** |  |
| 08EE7023(A) Optimal Design of Heat Exchangers | |
| 08EE7023(B) Soft Computing Techniques | |
| 08EE7023(C) Nanomaterials and Nanotechnology | |
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| **Semester 4 (Credits:12)** | | | | | | | | | |
| **Exam Slot** | **Course No:** | **Name** | **Hours/Week** | | | **Internal Marks** | **End Semester Exam** | | **Credits** |
| **L** | **T** | **P** | **Marks** | **Duration (hrs)** |
|  | 08EE7014 | Research Project -Phase II | 0 | 0 | 21 | 70 | 30 | 0 | 12 |
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**SEMESTER 1**

**Course No: 08EE6011 Course Title:Applied Mathematics Credits: 3-0-0: 3**

**Year:2015**

**Pre-requisites: Nil**

**Course Objectives**:

* To understand Fundamental concepts in Linear Algebra
* To understand Theories of non-linear programming
* To understand Various methods in numerical analysis
* To understand Concepts of PDE

**Syllabus**

Vector spaces, Linear Transformations, Matrix of transformations and Change of Basis, Non- linear programming, Non-linear programming unconstraint optimization, First order PDEs, Second order PDEs, Formulation and method of solutions of Wave equation, Heat equation and Laplace equation, Numerical solution of ODE, Numerical solution of PDE .

**Course Outcome:**

Students will be able to apply the knowledge of content in the syllabus in various Engineering & Technological field

**Text Books:**

1. D.C. Lay: Linear Algebra and its Applications, Addision Wesley, 2003.
2. F.G. Florey; Elementary Linear Algebra with Application, Prentice Englewood, 1979.
3. Singiresu S Rao, “Engineering Optimization Theory and Practice”, New Age International, 1996

**References**:

1. Steven C Chapra and Raymond P Canall, ‘Numerical Methods for Engineers with Software and Programming applications”, Tata McGraw Hill, 2004.
2. Curlis F Gerald and Patric O Wheatly “Applied Numerical analysis”, Pearson Education, 2002.

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| **COURSE NO:08EE6011 COURSE TITLE: Applied Mathematics (L-T-P :3-0-0)**  **CREDITS:3** | | |
| **MODULES** | **Contact**  **hours** | **Sem.Exam**  **Marks;%** |
| MODULE : 1  Vector spaces, Basis, Dimension, Inner product spaces, Gram-Schmidth Process, Linear Transformations, Range and Kernel, Isomorphism, Matrix of transformations and Change of Basis. | 7 | 15 |
| MODULE : 2  Non linear programming - unrestricted search, interval halving method, Fibonacci method.Non-linear programming unconstraint optimization - random search method, univariate method, pattern search methods, Hooke and Jeeve’s method, gradient of a function, steepest descent method, conjugate gradient method. | 7 | 15 |
| **FIRST INTERNAL TEST** |  |  |
| MODULE : 3  First order PDEs, Linear equations, Lagrange method, Cauchy method, Charpits method, Jacobi method. | 6 | 15 |
| MODULE : 4  Second order PDEs, Classifications, Formulation and method of solutions of Wave equation, Heat equation and Laplace equation. | 6 | 15 |
| **SECOND INTERNAL TEST** |  |  |
| MODULE : 5  Numerical solution of ODE - Taylor series method, Euler and Modified Euler method (Heun’s method), RungeKutta method, Milne’s method, Adams, Moulton method. | 6 | 20 |
| MODULE : 6  Numerical solution of PDE -classification of partial differential equations of second order, Liebmann’s method for Laplace equation and Poisson equation, explicit method and Crank-Nicolson method for parabolic equations, explicit method for hyperbolic equations. | 7 | 20 |

**Course No: 08EE6021 Course Title:Advanced Energy Conversion Systems**

**Credits: 3-0-0:3Year:2015**

**Pre-requisites: Nil**

**Course Objectives**:

* To develop knowledge about energy through thermal systems(Steam and Gas)
* To develop knowledge about energy through nuclear systems
* To understand about design of nuclear energy conversion systems

**Syllabus**

Classification of energy sources, Combustion calculations , Conventional thermal power plant design and operation, Gas turbine and combined cycle analysis , Combined cycles with heat recovery boiler, STAG combined cycle power plant, Nuclear energy conversion, Radioactivity, Nuclear power plants, Fuel rod design, Core thermal design, Safety analysis – LOCA

**Course Outcome:**

Students are capable to understand about complete analysis of thermal power plant and nuclear power plant.

**Text Books:**

1. M.M. E1- Wakil; Power Plant Technology, McGraw Hill, 1985.
2. A.W. Culp Jr; Principles of Energy Conversion, McGraw Hill, 2001.
3. H.A. Sorensen: Energy Conversion Systems, J. Wiley, 1983.

**References**:

1. T.F. Morse: Power Plant Engineering, Affiliated East West Press, 1978.
2. M.M. E1-Wakil: Nuclear Power Engineering, McGraw Hill, 1962.
3. R.H.S. Winterton: Thermal Design of Nuclear Reactors, Pergamon Press, 1981.
4. R.L. Murray: Introduction to Nuclear Engineering, Prentics Hall, 1961.

**COURSE PLAN**

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| **COURSE NO:08EE6021 COURSE TITLE: Advanced Energy Conversion Systems (L-T-P :3-0-0)**  **CREDITS:3** | | |
| **MODULES** | **Contact**  **hours** | **Sem.Exam**  **Marks;%** |
| MODULE : 1  Classification of energy sources- Utilization, economics and growth rates- Fossil fuels, nuclear fuels and solar energy – Combustion calculations | 4 | 15 |
| MODULE : 2  Conventional thermal power plant design and operation – Superheat, reheat and regeneration – Other auxiliaries of thermal plant – High – pressure boilers – Steam generator control. | 6 | 15 |
| **FIRST INTERNAL TEST** |  |  |
| MODULE : 3  Gas turbine and combined cycle analysis – Inter-cooling, reheating and regeneration-gas turbine cooling – design for high temperature | 6 | 15 |
| MODULE : 4  Combined cycles with heat recovery boiler – Combined cycles with multi-pressure steam – STAG combined cycle power plant – Influence of component efficiencies on cycle performance. | 4 | 15 |
| **SECOND INTERNAL TEST** |  |  |
| MODULE : 5  Nuclear energy conversion – Chemical and nuclear equations – Nuclear reactions – Fission and fusion – Energy from fission and fuel burn-up - Radioactivity – Neutron energies – Fission reactor types – Nuclear power plants – Fast breeder reactor and power plants – Production of nuclear fuels. | 10 | 20 |
| MODULE : 6  Fuel rod design – Steam cycles for nuclear power plants – reactor heat removal – Coolant channel orificing – Core thermal design – Thermal shields – Fins in nuclear plants – Core thermal hydraulics – Safety analysis – LOCA – Time scales of transient flow and heat transfer processes. | 9 | 20 |

**Course No: 08EE6031 Course Title:Renewable Energy Technology**

**Credits: 4-0-0: 4**

**Year: 2015**

**Pre-requisites: Nil**

**Course Objectives**:

* To impart the basics of renewable energy technology
* A foundation in the fundamentals about solar energy, wind energy, energy storage, design, performance and applications
* How to convert energy from biomass, conversion of biomass into fuels, design and operation, properties and characteristics of biogas, energy from wind, geothermal, ocean thermal energy conversion etc.

**Syllabus**

Solar energy, Solar thermal collectors , Solar concentrators, Energy storage – Sensible heat storage, Phase change energy storage, Combined solar heating and cooling systems -Performance and cost calculations, Energy from biomass, Biogas plants, Wind energy, Geothermal energy, Ocean thermal energy conversion, Wave and tidal energy – Scope and economics – Introduction to integrated energy systems.

**Course Outcome:**

Students who successfully complete this subject will have an ability to understand the fundamental concept of renewable energy technology, how to convert the energy from various sources, Also, through knowledge about storage of energy and integrated energy systems.

**Text Books:**

1. J.A. Duffie and W.A. Beckman: Solar Energy thermal processes, J. Wiley, 1994.
2. A.A.M. Saigh (Ed): Solar Energy Engineering, Academic Press, 1977.
3. F. Kreith and J.F. Kreider: Principles of Solar Engineering, McGraw Hill, 1978.

**References**:

1. G.N. Tiwari: Solar Energy-Fundamentals, Design, Modelling and Applications, Narosa Publishers, 2002.
2. Ahmed: Wind energy Theory and Practice, PHI, Eastern Economy Edition, 2012
3. Kothari: Renewable Energy Sources and Emerging Technologies, PHI, Eastern Economy Edition, 2012

**COURSE PLAN**

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| **COURSE NO:08EE6031 COURSE TITLE: Renewable Energy Technology (L-T-P : 4-0-0)**  **CREDITS:4** | | |
| **MODULES** | **Contact**  **Hours** | **Sem.Exam**  **Marks;%** |
| MODULE : 1  Solar energy – The Sun – Production and transfer of solar energy – Sun-Earth angles – Availability and limitations of solar energy – Measuring techniques and estimation of solar radiation | 8 | 15 |
| MODULE : 2  Solar thermal collectors – General description and characteristics – Flat plate collectors – Heat transfer processes – Short term and long term collector performance – Solar concentrators – Design, analysis and performance evaluation. | 8 | 15 |
| **FIRST INTERNAL TEST** |  |  |
| MODULE : 3  Energy storage – Sensible heat storage – Liquid media storage – Solid media storage – Dual media storage – Phase change energy storage – Storage capacity – Other storage methods – Solar dehumidification – Design, performance and applications – Combined solar heating and cooling systems – Performance and cost calculations – Special topics on solar energy | 13 | 15 |
| MODULE : 4  Energy from biomass – Sources of biomass – Different species – Conversion of biomass into fuels – Energy through fermentation – Pyrolysis, gasification and combustion – Aerobic and anaerobic bio-conversion – Properties of biomass | 8 | 15 |
| **SECOND INTERNAL TEST** |  |  |
| MODULE : 5  Biogas plants – Types of plants – Design and operation – Properties and characteristics of biogas.Wind energy – Principles of wind energy conversion – Site selection considerations – Wind power plant design – Types of wind power conversion systems – Operation, maintenance and economics | 8 | 20 |
| MODULE : 6  Geothermal energy – Availability, system development and limitations – Ocean thermal energy conversion – Wave and tidal energy – Scope and economics – Introduction to integrated energy systems. | 7 | 20 |

**Course No: 08EE6041 Course Title:Electrical Energy Systems and Management**

**Credits: 3-0-0: 3**

**Year: 2015**

**Pre-requisites: Nil**

**Course Objectives**:

* To understand the various conventional and non- conventional energy sources
* To understand the various energy management techniques in electrical systems
* To develop an understanding about energy auditing techniques
* To understand the power consumption and various energy conservation measures

**Syllabus**

Overall structure of electrical systems, Load profiling, Electricity tariff types and calculation, Capacitor sizing, Energy accounting, monitoring and control – Electricity audit instruments – Energy consumption models, ECO assessment and Evaluation methods – Transformer loading/efficiency analysis, Lighting, Types and operating characteristics of electric motors, Industrial drives, Pumps and fans, Electric loads of air conditioning and refrigeration, Power consumption in compressors – Energy conservation measures, Cogeneration schemes, Computer controls – Software – EMS.

**Course Outcome:**

Students are capable to understand different electrical energy systems, economic evaluation, energy auditing techniques and energy management in various systems.

**Text Books:**

1. IEEE Bronze Book: IEEE Standard 739-1984 – Recommended Practice for Energy Conservation and Cost Effective Planning in Industrial Facilities, IEEE Publications, 1996.
2. A.P.W. Thumann: Plant Engineers and Managers Guide to Energy conservation, 7e, UNR, 1977.
3. H. Partab, Art and Science of Utilisation of Electrical Energy, Pritam, 1985.

**References**:

1. S.C. Tripathy, Electric Energy Utilization and Conservation, Tata McGraw Hill, 1991.
2. W.C. Turner, Energy Management Handbook, 2e, Fairmont press, 1993.
3. UNESCAP- Guide Book on Promotion of Sustainable Energy Consumption ([www.unescap.org/enrd/energy](http://www.unescap.org/enrd/energy))

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| **COURSE NO: 08EE6041COURSE TITLE:Electrical Energy Systems and Management**  **L-T-P : 3-0-0)**  **CREDITS:3** | | |
| **MODULES** | **Contact**  **hours** | **Sem.Exam**  **Marks;%** |
| MODULE : 1  Overall structure of electrical systems – Supply and demand side – Economic operation – Input-output curves – Load sharing – Industrial Distribution – Load profiling – Electricity tariff types and calculation – Reactive Power – Power factor – Capacitor sizing – Capacitor losses, location, placement and maintenance – Case studies. | 7 | 15 |
| MODULE : 2  Energy efficiency – Energy accounting, monitoring and control – Electricity audit instruments – Energy consumption models – Specific Energy Consumption | 6 | 15 |
| **FIRST INTERNAL TEST** |  |  |
| MODULE : 3  ECO assessment and Evaluation methods – Transformer loading/efficiency analysis – Feeder loss evaluation – Lighting – Energy efficient light sources – Domestic/commercial/industrial lighting – Lighting controls – Energy conservation in lighting schemes – Luminaries – Case studies. | 6 | 15 |
| MODULE : 4  Types and operating characteristics of electric motors – Energy efficient control and starting – Load matching – Selection of motors – Efficiency and load analysis – Energy efficiency – High efficiency motors | 6 | 15 |
| **SECOND INTERNAL TEST** |  |  |
| MODULE : 5  Industrial drives – Control schemes – Variable speed drives and Energy conservation schemes – Pumps and fans – Efficient control strategies – Over-sizing - Case studies. | 6 | 20 |
| MODULE : 6  Electric loads of air conditioning and refrigeration – Energy conservation – Power consumption in compressors – Energy conservation measures – Electrolytic process – Electric heating – Furnace operation and scheduling – Cogeneration schemes – Optimal operation – Case studies – Computer controls – Software – EMS. | 8 | 20 |

**Course No: 08EE6051(A) Course Title: Energy Policies For Sustainable Development**

**Credits: 3-0-0: 3**

**Year: 2015**

**Pre-requisites: Nil**

**Course Objectives**:

* To understand energy policies and development
* To impart knowledge on energy and environment
* To understand energy conservation schemes and energy planning

**Syllabus**

Energy policies of India – Supply focus approach and its limitations, Need for renewable energy policies in India, Energy and environment, environmental laws, Effluent standards and ambient air quality standards – Latest development in climate change policies & CDM, Energy conservation schemes – Statutory requirements of energy audit, Tax rebates , India’s Plan for a domestic energy cap & trade scheme, Social cost benefit analysis – Computation of IRR and ERR, Development of energy management systems – Decision support systems for energy planning and energy policy simulation.

**Course Outcome:**

Students will be able to understand energy policies, energy and environment, energy conservation and energy planning.

**Text Books:**

1. J. Goldemberg, T.B. Johansson, A.K.N. Reddy and R.H. Williams: Energy for a Sustainable World, Wiley Eastern, 1990.
2. IEEE Bronze Book: Energy Auditing, IEEE Publications, 1996.
3. P. Chandra: Financial Management Theory and Practice, Tata McGraw Hill, 1992.
4. Annual Energy Planning Reports of CMIE, Govt. of India.

**References**:

1. AmlanChakrabarti: Energy Engineering and Management, PHI, Eastern Economy Edition, 2012
2. A.K.N. Reddy and A.S. Bhalla: The Technological Transformation of Rural India, UN Publications, 1997.
3. A.K.N. Reddy, R.H. Williams and J.B. Johanson: Energy After Rio-Prospects and Challenges, UN publications, 1997.
4. P. Meier and M. Munasinghe: Energy Policy Analysis &Modeling, Cambridge University Press, 1993.
5. R.S. Pindyck and D. L. Rubinfeld: Economic Models and Energy Forecasts, 4e, McGraw Hill, 1998.

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| **COURSE NO:08EE6051(A) COURSE TITLE: Energy Policies For Sustainable Development**  **(L-T-P : 3-0-0)**  **CREDITS:3** | | |
| **MODULES** | **Contact**  **Hours** | **Sem.Exam**  **Marks;%** |
| MODULE : 1  Energy policies of India – Supply focus approach and its limitations – Energy paradigms – DEFENDUS approach – End use orientation – Energy policies and development – Case studies on the effect of Central and State policies on the consumption and wastage of energy – Critical analysis – Need for renewable energy policies in India | 7 | 15 |
| MODULE : 2  Energy and environment – Greenhouse effect – Global warming – Global scenario – Indian environmental degradation – environmental laws – Water (prevention & control of pollution) act 1974 – The environmental protection act 1986 | 6 | 15 |
| **FIRST INTERNAL TEST** |  |  |
| MODULE : 3  Effluent standards and ambient air quality standards – Latest development in climate change policies & CDM. | 5 | 15 |
| MODULE : 4  Energy conservation schemes – Statutory requirements of energy audit – Economic aspects of energy audit – Capital investments in energy saving equipment – Tax rebates – Advantages of 100% depreciation – India’s Plan for a domestic energy cap & trade scheme. | 8 | 15 |
| **SECOND INTERNAL TEST** |  |  |
| MODULE : 5  Social cost benefit analysis – Computation of IRR and ERR – Advance models in energy planning – Dynamic programming models in integrated energy planning – Energy planning case studies | 7 | 20 |
| MODULE : 6  Development of energy management systems – Decision support systems for energy planning and energy policy simulation. | 6 | 20 |

**Course No: 08EE6051(B) Course Title:Energy Modeling, Economics and Project**

**ManagementCredits: 3-0-0: 3**

**Year: 2015**

**Pre-requisites: Nil**

**Course Objectives**:

* To understand energy demand analysis, economics of energy sources
* To understand basic concepts of econometric and statical analysis
* To develop and understand about energy modelling, energy economics and policy
* To understand project evaluation and management, project evaluation techniques

**Syllabus**

Models and modeling approaches: Input output analysis, Energy demand analysis and forecasting, Economics of stand-alone power supply systems, Project management.Basic concept of econometrics and statistical analysis: The 2-variable regression model; The multiple regression model; Energy and environmental Input – Output analyses using I-O model, Energy Modeling: Interdependence of energy-economy-environent; Modeling concept, and application, Methodology of energy demand analysis; Methodology for energy forecasting;Energy Economics and Policies: National and Sectoral energy planning; Integrated resources planning; Energy pricing.Project Evaluation & Management: Financial analysis: Project cash flows, time value of money, life cycle approach & analysis. Network analysis for project management; Project material management, evaluation & analysis.

**Course Outcome:**

Students are capable to understand energy demand analysis, economics of energy sources, energy modelling and project evaluation techniques

**Text Books:**

1. Energy Policy Analysis and Modeling, M. Munasinghe and P. Meier Cambridge University Press, 1993.
2. The Economics of Energy Demand: A Survey of Applications, W.A Donnelly New York, 1987.
3. Econometrics Models and Economic Forecasts, S. Pindyck and Daniel L Rubinfeld, 3rd edition McGraw Hill, New York 1991.

**References**:

1. Sectoral Energy Demand Studies: Application of the END-USE Approach to Asian Countries, UN-ESCAP, New York 1991.
2. Guide Book on Energy – Environment Planning in Developing Countries – Methodological Guide on Economic Sustainability and Environmental Betterment Through Energy Savings and Fuel Switching in Developing Countries, UN-ESCAP, New York 1996.
3. Forecasting Methods and Applications, S.Makridakis, Wiley 1983.

**COURSE PLAN**

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| **COURSE NO:08EE6051(B) COURSE TITLE: Energy Modeling, Economics and Project**  **Management (L-T-P : 3-0-0)**  **CREDITS:3** | | |
| **MODULES** | **Contact**  **Hours** | **Sem.Exam**  **Marks;%** |
| MODULE : 1  Models and modeling approaches**:** Input output analysis, Energy demand analysis and forecasting, Economics of stand-alone power supply systems, Project management. Macroeconomic Concepts - Measurement of National Output - Investment Planning and Pricing – Economics of Energy Sources – Reserves and Cost Estimation. Multiplier Analysis – Energy and Environmental Input / Output Analysis - Energy Aggregation - Econometric Energy Demand | 6 | 15 |
| MODULE : 2  Modeling - Overview of Econometric Methods. Methodology for Energy Demand Analysis – Methodology for Energy Technology Forecasting - Methodology for Energy Forecasting - Sectoral Energy Demand Forecasting. Solar Energy - Biomass Energy - Wind Energy and other Renewable Sources of Energy – Economics of Waste Heat Recovery and Cogeneration – Energy Conservation Economics. Cost Analysis – Budgetary Control-Financial Management-Techniques for Project Evaluation | 7 | 15 |
| **FIRST INTERNAL TEST** |  |  |
| MODULE : 3  Basic concept of econometrics and statistical analysis**:** The 2-variable regression model; The multiple regression model; Tests of regression coefficients and regression equation; Econometric techniques used for energy analysis and forecasting with case studies form India; Operation of computer package Input – Output Analysis, Basic concept of Input-output analysis; Concept of energy multiplier and implication of energy multiplier for analysis of regional and national energy policy; Energy and environmental Input – Output analyses using I-O model. | 7 | 15 |
| MODULE : 4  Energy Modeling**:** Interdependence of energy-economy-environent; Modeling concept, and application, Methodology of energy demand analysis; Methodology for energy forecasting; Sectoral energy demand forecasting; Interfuel substitution models; SIMA model, and I-O model for energy policy analysis; Simulation and forecasting of future energy demand consistent with macroeconomic parameters in India; Energy Economics and Policies: National and Sectoral energy planning; Integrated resources planning; Energy pricing. | 7 | 15 |
| **SECOND INTERNAL TEST** |  |  |
| MODULE : 5  Project Evaluation & Management**:** Financial analysis: Project cash flows, time value of money, life cycle approach & analysis, conception, definition, planning, feasibility and analysis; Project appraisal criteria; Risk analysis; Project planning matrix; Aims oriented project planning; Social cost benefit analysis. | 6 | 20 |
| MODULE : 6  Network analysis for project management; Time estimation; Critical path determination; PERT, CPM and CERT: Fuzzy logic analysis; Stochastic based formulations; Project evaluation techniques; Funds planning; Project material management, evaluation & analysis; Implementation and monitoring; Performance indices; Case studies.  2 Autonomous Fossil Fuel and renewable energy (RE) - based Power Systems. | 6 | 20 |

**Course No: 08EE6051(C) Course Title:Advanced InstrumentationCredits: 3-0-0: 3**

**Year: 2015**

**Pre-requisites: Nil**

**Course Objectives**:

* To understand and measure the physical and thermal properties of various materials at various levels
* To understand the various methods of radiation and pressure measurements
* To understand the concept of radiometry and the measuring techniques
* To understand the principle of high temperature measurements

**Syllabus**

Measurements of thermal and physical properties-Measurement of specific heat of gases -Statical analysis – Goodness of data-Error estimates in Temperature measurements. Bridges- Thermal radiation measurements – Errors in radiation measurements -Quasi steady measurements-Temperature Measurements in high temperature gases – Calorimetric electrostatic, radiation, – Thermocouple-Optical measurement of temperature – Schlieren shadow-graph and interferometer – Errors in optical measurements.

**Course Outcome:**

Students are capable to understand the properties of various materials and its impact in measurements.

**Text Books:**

1. E.R.G. Eckert and R.J Goldstein; Measurements in Heat Transfer, McGraw Hill, 1976.
2. J.P. Holman: Experimental Methods for engineers, McGraw Hill, 1971.

**References**:

1. E.O. Doebelin: Measurements Systems: Application and Design.
2. T. G. Beekwith and L.M. Buck: Mechanical measurements, Adison-Wesley, 1965.
3. Barney; Intelligent Instrumentation, Printice Hall, 1988.

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| **COURSE NO: 08EE6051(C) COURSE TITLE: Advanced Instrumentation (L-T-P : 3-0-0)**  **CREDITS:3** | | |
| **MODULES** | **Contact**  **hours** | **Sem.Exam**  **Marks;%** |
| MODULE : 1  Measurements of thermal and physical properties – Viscosity – Use of poiseuille flow, Falling, Rotating and Oscillating bodies – Thermal conductivity of solids and liquids – Low conductivity and metallic | 6 | 15 |
| MODULE : 2  Steady and unsteady sates – Measurement of specific heat of gases – data acquistiton – Analog and digital conversion – Post processing of data – Statical analysis – Goodness of data – Correlating data – Linear and non-linear regression. | 7 | 15 |
| **FIRST INTERNAL TEST** |  |  |
| MODULE : 3  Error estimates in Temperature measurements – Solids and fluids – Steady state and unsteady measurements – Radiation effects – Platinum resistance thermometers – Construction and usage – Calibration – Bridges – Fluid pressure measurement – Capacitive probes – Piezoelectric pressure sensors – Anemometry. | 7 | 15 |
| MODULE : 4  Thermal radiation measurements – Radiometry – Surface radiation measurements – Gas radiation instruments – Errors in radiation measurements – Transient experimental techniques for surface heat flux rates – Negligible internal resistance – Negligible surface resistance – Rapid response measurements – Thick film and thin film gauges – Non uniform surface temperatures – Quasi steady measurements. | 7 | 15 |
| **SECOND INTERNAL TEST** |  |  |
| MODULE : 5  Temperature Measurements in high temperature gases – Calorimetric electrostatic, radiation, cyclic, transient pressure and heat flux probes – Spectroscopic methods | 6 | 20 |
| MODULE : 6  Cooled film sensors – Temperature measurement in cryogenics – Scales of measurement – Thermocouple, resistance and magnetic thermometry – Optical measurement of temperature – Schlieren shadow-graph and interferometer – Errors in optical measurements. | 6 | 20 |

**Course No. 06 GN 6101 Course Title: Research Methodology Credits: 0-2-0:2**

**Year:2015**

**Pre-requisites: Nil**

**Course No. 08EE6071 Course Title: Seminar Credits:0-0-2:1**

**Year:2015**

**Pre-requisites: Nil**

**Course Objectives**:

* To assess the debating capability of the student to present a technical topic.
* To impart training to a student to face audience and present his ideas and thus creating in him self-esteem and courage that are essential for an engineer.

**Syllabus**

Individual students are required to choose a topic of their interest from Energy/Renewable Energy systems and related topics preferably from outside the M.Tech syllabus and give a seminar on that topic about 30 minutes. A committee consisting of at least three faculty members (preferably specialized in Energy/Renewable Energy) shall assess the presentation of the seminar and award marks to the students. Each student shall submit two copies of a write up of this seminar topic. One copy shall be returned to the student after duly certifying it by the chairman of the assessing committee and the other will 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.

**Course Outcome:**

Students are capable to present a technical topic and to face audience and present his ideas and thus creating in him self-esteem and courage that are essential for an engineer.

**Course No. 08EE6081 Course Title: Energy Systems Lab Credits:0-0-2:2 Year:2015**

**Pre-requisites: Nil**

**Course Objectives**:

* To familiarise different solar equipments
* To gain basics of energy audit
* To achieve knowledge about pump performance and its energy efficiency measures

**Syllabus**

In this course, students will be provided with an orientation programme on the following equipments/software. After this orientation, each student is expected to formulate and complete an activity of interest which has to be derived from the orientation programme under the guidance of a faculty. the details like background, problem definition, status of technology/knowledge in that area by a good literature review (5 latest papers), objectives, methodology, equipment that can be used (from the orientation programme), results from the experiments and their interpretation with respect to the assumption /background and a formal conclusion are expected in the report which is to be submitted at the end of the semester. This work is evaluated for the credit assigned.

1. Experimental study of solar water heating systems.
2. Experimental study of solar PV pumping system.
3. Experimental study of solar lighting systems and system optimization.
4. Analysis and study of biomass gasifier based power plant.
5. Analysis and study of CHP/CCHP systems.
6. Performance evaluation of Solar Air-conditioning systems (various types).
7. Design of measurement and control systems using virtual instrumentation software.
8. Life Cycle Analysis (LCA) using software.
9. Building energy analysis using software.
10. Efficiency evaluation of pumps/fans/compressors.
11. Power quality measurements.
12. Energy Efficiency in motors.
13. Design of lighting system (Room).

**Course Outcome:**

Students are capable to understand about energy efficiencies of various equipments and energy management techniques

**SEMESTER 2**

**Course No: 08EE6012 Course Title:Design And Analysis Of Energy Systems**

**Credits: 3-0-0:3**

**Year: 2015**

**Pre-requisites: Nil**

**Course Objectives**:

* To understand engineering design fundamentals
* To understand the economic evaluation of a system
* To understand the heat exchanger and cooling tower design
* To understand the performance of pumps, fans, nozzles
* To understand the applications in thermal design

**Syllabus:**

Engineering design fundamentals, Design optimization, Heat exchanger design calculations, Rectifiers, Cooling towers, Pump characteristics, Cavitation prevention, Basics of Second law analysis in heat and fluid flow, Newton- Raphson simulation method, Mathematical modelling of thermodynamic properties

**Course Outcome:**

Students are capable to understand the engineering design fundamentals, economic evaluation, applications in thermal design and designing of heat exchangers and cooling towers

**Text Books:**

1. Y. Jaluria: Design and Optimization of Thermal Systems, McGraw Hill, 1998.
2. A. Bejan: Thermal Design and Optimization, John Wiley, 1995.
3. W.F. Stoeker: Design of Thermal Systems, 3e, McGraw Hill, 1989.

**References**:

1. R.F. Boehm: Design Analysis of Thermal Systems, John Wiley, 1987.
2. Jones J.B and Dugan R.E: engineering thermodynamics, Prentice Hall of India, 1998.
3. Yunus A. Cengel: Thermodynamics: An Engineering approach, McGraw Hill, 1994

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| **COURSE NO: 08EE6012 COURSE TITLE: Design and Analysis 0f Energy Systems**  **(L-T-P : 3-0-0)**  **CREDITS:3** | | |
| **MODULES** | **Contact**  **hours** | **Sem.Exam**  **Marks;%** |
| MODULE : 1  Engineering design fundamentals – Designing a workable system – Economic evaluation – Fitting data and solving equations – Design optimization – Knowledge based system design. | 9 | 15 |
| MODULE : 2  Heat exchanger design calculations – Evaporators and condensers temperature concentration pressure characteristics of binary solutions | 8 | 15 |
| **FIRST INTERNAL TEST** |  |  |
| MODULE : 3  Rectifiers – Cooling towers – Pressure drop and pumping power. | 8 | 15 |
| MODULE : 4  Pump characteristics – Manufacturer’s specifications – Relations among performance characteristics – Pump system operation | 8 | 15 |
| **SECOND INTERNAL TEST** |  |  |
| MODULE : 5  Cavitation prevention – Other system considerations, Fans and nozzles. | 9 | 20 |
| MODULE : 6  Basics of Second law analysis in heat and fluid flow – Applications in thermal design – Modelling and simulation principles – Hardy – Cross method – Multi – variable, Newton- Raphson simulation method – Simulation of a gas turbine system – Simulation using differential equations – Mathematical modelling of thermodynamic properties – Steady state simulation of large systems. | 10 | 20 |

**Course No: 08EE6022 Course Title:Energy Conservation in Thermal Systems**

**Credits: 3-0-0: 3**

**Year: 2015**

**Pre-requisites: Nil**

**Course Objectives**:

* To understand the fundamentals of energy management, energy consumption, energy auditing
* To understand the concept of thermo economics and cogeneration
* To understand the concept of waste heat recovery system, power economics
* To understand the concept of optimization technology and energy conservation methodology

**Syllabus:**

Definition of energy management, Waste heat management, Energy auditing, Thermodynamic availability analysis, Thermodynamics and economic, Systematic approach to steam pricing, Steam trap principles, Linear programming approach, Thermodynamic analysis of common unit operations, Systematic design methods, System interaction and economics, Potential for waste heat recovery, Industrial boiler inventory, General economic problems

**Course Outcome:**

Students are capable to understand the concept of energy management, energy auditing, power economics and energy conservation methodology

**Text Books:**

1. W.F. Kenney: Energy Conservation in the Process Industries, Academic press, 1984.
2. A.P.E. Thummann: Fundamentals of Energy Engineering, Prentice Hall, 1984.
3. M.H. Chiogioji: Industrial energy Conservation, Marcel Dekker, 1979.

**References**:

1. AmlanChakrabarti: Energy Engineering and Management, PHI, Eastern Economy Edition, 2012
2. A.P.E. Thummann, Plant Engineers and Managers Guide to Energy Conservation, van Nostrand, 1977.
3. W.R. Murphy and G. McKay: Energy Management, Butterworth-Heinemann, 2001.

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| **COURSE NO:08EE6022 COURSE TITLE: Energy Conservation in Thermal Systems**  **(L-T-P : 3-0-0)**  **CREDITS:3** | | |
| **MODULES** | **Contact**  **hours** | **Sem.Exam**  **Marks;%** |
| MODULE : 1  Definition of energy management – Energy conservation schemes – Optimizing steam usage – Waste heat management – Insulation – Optimum selection of pipe size – energy conservation in space conditioning – Energy and cost indices – Energy diagrams – Energy auditing – Thermodynamic availability analysis – Thermodynamic efficiencies – Available energy and fuel. | 7 | 15 |
| MODULE : 2  Thermodynamics and economic – Systematic approach to steam pricing – Pricing other utilities – Investment optimization – Limits of current technology – Process improvements – Characterizing energy use – Optimum performance of existing facilities | 6 | 15 |
| **FIRST INTERNAL TEST** |  |  |
| MODULE : 3  Steam trap principles – Effective management of energy use – Overall site interactions – Total site cogeneration potential – Linear programming approach. | 5 | 15 |
| MODULE : 4  Thermodynamic analysis of common unit operations – Heat exchange – Expansion – Pressure let down – Mixing – Distillation – Combustion air pre-heating – Systematic design methods – Process synthesis – Application to cogeneration system | 6 | 15 |
| **SECOND INTERNAL TEST** |  |  |
| MODULE : 5  Thermo-economics – Systematic optimization – Improving process operations – chemical reactions – Separation – Heat transfer – process machinery – System interaction and economics. | 7 | 20 |
| MODULE : 6  Potential for waste heat recovery – Direct utilization of waste heat boilers – Use of heat pumps – Improving boiler efficiency – Industrial boiler inventory – Use of fluidized beds – Potential for energy conservation – Power economics – General economic problems – Load curves – Selections of plants – Specific economic energy problems – Energy rates. | 8 | 20 |

**Course No: 08EE6032 Course Title: Energy and Environment Credits: 3-0-0: 3**

**Year: 2015**

**Pre-requisites: Nil**

**Course Objectives**:

The students will be able to:

* To understand the connection between energy, environment and ecology
* To learn about the problem of air pollution
* To study about water pollution and its control
* prepare environmental impact statements

**Syllabus:**

Energy Overview: Basics of energy, Fundamentals of environment, Environmental aspects of energy utilization, Energy characteristics, Air Pollution: Classification of air pollutants, sources of emission and air quality standards , Air pollution sampling and measurement, Meteorological aspects of air pollutant dispersion, Air Pollution Control methods and Water Pollution, Basic process of waste water treatment, Environmental impact assessment, Principles and methodology of Environmental impact assessment

**Course Outcome:**

Students will be able to implement the ideas of the sustainable development in their activities, taking care to prepare, protect and involve the quality of environment.

**Text Books:**

1. Abbasi and Abbasi: Renewable Energy Sources: Their Impact on Global Warming and Pollution, PHI, Eastern Economy Edition, 2012
2. C.S. Rao: Environmental Pollution Control Engineering, Wiley Eastern, 1992.
3. Y. Anjaneyulu: Air Pollution and Control Technologies, Allied Publishers, 2002.

**References**:

1. J. Rau and D.C. Wooten: Environmental Impact analysis Handbook, McGraw Hill, 1980.
2. D.H.T. Liu: Environmental Engineers Handbook, Lewis, 1997.

**COURSE PLAN**

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| **COURSE NO: 08EE6032 COURSE TITLE: Energy and Environment (L-T-P :3-0-0)**  **CREDITS:3** | | |
| **MODULES** | **Contact**  **hours** | **Sem.Exam**  **Marks;%** |
| MODULE : 1  Energy Overview: Basics of energy – Types of energy and its utilization – Energy characteristics – Energy Measures – global energy scenario – India energy scenario – Types of energy and its utilization – Energy characteristics – Energy measures | 6 | 15 |
| MODULE : 2  Fundamentals of environment – Water cycle – Oxygen cycle – Carbon cycle – Nitrogen cycle – Phosphorous cycle – Bio-diversity – Environmental aspects of energy utilization – Public health issues related to environmental Pollution. | 6 | 15 |
| **FIRST INTERNAL TEST** |  |  |
| MODULE : 3  Air Pollution: Classification of air pollutants, sources of emission and air quality standards – Physical and chemical characteristics – Meteorological aspects of air pollutant dispersion – Temperature lapse rate and stability – Factors influencing dispersal of air pollutant – Air pollution dispersion models – Air pollution sampling and measurement – types – Ambient air sampling – Gaseous air pollutants – Particulate air pollutants – Analysis of air pollutants. | 9 | 15 |
| MODULE : 4  Air Pollution Control methods: Types of controls – Particulate emission control- Gaseous emission control | 6 | 15 |
| **SECOND INTERNAL TEST** |  |  |
| MODULE : 5  Sources and classification of water pollutants – Waste water sampling and analysis – Basic process of waste water treatment – Primary treatment – Secondary treatment – Advanced treatment Methods of feed water treatment. | 6 | 20 |
| MODULE : 6  Environmental impact assessment: Air quality and water quality standards – Pollution prevention and control acts – Principles and methodology of Environmental impact assessment, Air and water quality impacts by project types. | 6 | 20 |

**Course No: 08EE6042(A) Course Title:Hydropower Systems Credits: 3-0-0: 3**

**Year: 2015**

**Pre-requisites: Nil**

**Course Objectives**:

* To impart knowledge about hydroenergy systems and economics related to systems with different hydropower plants
* To understand about design and construction of hydroelectric power stations
* To understand about governing of power turbines

**Syllabus:**

Principles of modeling and similitude as applied to Turbo-machines, Development of prototype systems, Importance of Mini and micro-hydro power systems, Overview of Hydropower systems, Hydroelectric Power-Basic Economic Factor, Analysis of Hydropower projects, Design and Construction of Hydroelectric Power Stations, Updating and Refurbishing of Turbines, Governing of Power Turbines-Functions of Turbine Governor, Maintenance of civil Engineering works, Design-Execution-Testing-Operation and control of Monitoring of Hydropower Services.

**Course Outcome:**

Students are able to understand about different hydro power plants with considering economic aspects, functions of power turbines and computer aided hydropower system analysis.

**Text Books:**

1. Principles of Turbo machinery, Shephered D.G., Macmillan Company, Newyork
2. Hydraulic Turbines, Krevichenko, MIR Publishers.
3. Micro Hydro Electric Power Station (1984), L. Monition, M. Lenir and J Roux

**References**:

1. Micro Hydro Power Source book (1986), Alen R. Inversin.
2. Power Plant Evaluation and design (1988) Tyler G. Hicks.

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| **COURSE NO:08EE6042(A) COURSE TITLE: Hydro Power Systems (L-T-P :3-0-0)**  **CREDITS:3** | | |
| **MODULES** | **Contact**  **hours** | **Sem.Exam**  **Marks;%** |
| MODULE : 1  Principles of modeling and similitude as applied to Turbo-machines-Euler’s turbine equation – Analysis of turbines – constructional features of Pelton, Francis and Kaplan turbines. | 7 | 15 |
| MODULE : 2  Development of prototype systems. Power station operation and maintenance. Load control and controlling power distribution Reservoirs. Importance of Mini and micro-hydro power systems. | 4 | 15 |
| **FIRST INTERNAL TEST** |  |  |
| MODULE : 3  Overview of Hydropower systems - Case studies- Preliminary Investigation –Determination of Requirements – preparation of Reports and Estimates –Review of World resources – Cost of Hydroelectric Power-Basic Economic Factors | 7 | 15 |
| MODULE : 4  Analysis of Hydropower projects – Project Feasibility – Load Prediction and Planned Development – Advances in Planning, Design and Construction of Hydroelectric Power Stations | 7 | 15 |
| **SECOND INTERNAL TEST** |  |  |
| MODULE : 5  Trends in Development of Generating Plant and Machinery –Plant Equipment for pumped Storage Schemes – Some aspects of Management and Operations – Updating and Refurbishing of Turbines | 4 | 20 |
| MODULE : 6  Governing of Power Turbines-Functions of Turbine Governor-Condition for Governor Stability-Surge Tank Oscillation and Speed Regulative Problem of Turbine Governing in Future Problem of management – Maintenance of civil Engineering works-Maintenance of Electrical Engineering works Computer aided Hydropower System analysis -Design-Execution-Testing-Operation and control of Monitoring of Hydropower Services. | 10 | 20 |

**Course No: 08EE6042(B) Course Title: Optimization Techniques Credits: 3-0-0: 3**

**Year: 2015**

**Pre-requisites: Nil**

**Course Objectives**:

* To impart knowledge on linear programming
* To understand about parametric programming, transportation problems
* To impart knowledge on dynamic programming and integer linear programming

**Syllabus:**

Linear Programming: Systems of linear equations and inequalities, Theory of simplex method, Big M method, Two Phase method, Dual simple method, Sensitivity analysis, Integrality property, Development of the Hungarian method, Routing problems, Non linear Programming: Quadratic Programming,Frank& Wolfe’s method, Kelley’s cutting plane method, Rosen’s gradient projection method, Reeve’s method, Penalty and Barrier methods, Nature of Dynamic programming problem, Gomory’s cutting plane method, Knapsack problem

**Course Outcome:**

Students are capable to understand different optimization techniques in engineering design

**Text Books:**

1. Taha. H. A., Operations Research, An Introduction, Sixth edition PHI.
2. Simmons D. M, Nonlinear Programming for Operations Research, PHI.
3. M.S. Bazaraa. H.D. Sherali, C. M. Shetty, Nonlinear programming theory and Algorithm, John Wiley, II edition, 1993.

**References**:

1. Deb: Optimization for Engineering Design – Algorithms and Examples, PHI, Eastern Economy Edition, 2012
2. Hadley G, Linear Programming, Addison Wesley.
3. Hillier F.S & Lieberman G.J., Introduction to Operations Research, McGraw Hill.

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| **COURSE NO: 08EE6042(B) COURSE TITLE: Optimization Techniques (L-T-P :3-0-0)**  **CREDITS:3** | | |
| **MODULES** | **Contact**  **hours** | **Sem.Exam**  **Marks;%** |
| MODULE : 1  Linear Programming: Systems of linear equations and inequalities – Convex sets – Convex functions – Formulation of linear programming problems | 6 | 15 |
| MODULE : 2  Theory of simplex method – Simplex algorithm – Big M method – Two Phase method – Duality in linear programming – Dual simple method. | 6 | 15 |
| **FIRST INTERNAL TEST** |  |  |
| MODULE : 3  Sensitivity analysis – Parametric programming – Bounded variable problems – Transportation problems – Development of the method – Integrality property – Degeneracy – Unbalanced problems – Assignment problems – Development of the Hungarian method – Routing problems. | 7 | 15 |
| MODULE : 4  Non linear Programming: Quadratic Programming – Separable convex programming – Frank & Wolfe’s method – Kelley’s cutting plane method – Rosen’s gradient projection method – Fletcher – Reeve’s method – Penalty and Barrier methods – Scheduling – 2 jobs M machining – N jobs 2 machining – N jobs 3 Machines Scheduling. | 8 | 15 |
| **SECOND INTERNAL TEST** |  |  |
| MODULE : 5  Nature of Dynamic programming problem – Bellman’s Optimality principle – Replacement problems Integer linear programming – Gomory’s cutting plane method. | 6 | 20 |
| MODULE : 6  Branch and Bound Algorithm – Travelling Salesman problem – Knapsack problem – Introduction to Optimization tools and software. | 6 | 20 |

**Course No: 08EE6042(C) Course Title: Computational Fluid Dynamics Credits: 3-0-0: 3**

**Year: 2015**

**Pre-requisites: Nil**

**Course Objectives**:

1. To understand the importance of fluid flow and heat transfer
2. To understand the difference between compression and incompression
3. To understand the concepts of methods of discretisation like FDM, FEM
4. To understand the concepts of turbulence, modelling algorithms and schemes for discretisation

**Syllabus:**

Philosophy of Computational Fluid Dynamics, Mathematical behaviour of partial Differential Equations, Discretization, Simple CFD Techniques, Vorticity method of solution, Finite Volume Method, One Dimensional steady convection & diffusion, Upwind differencing scheme, Finite Volume Method for Unsteady flow ,Explicit scheme, Crank-Nicholson scheme, Reynolds stress equation model.

**Course Outcome:**

Inorder to analyse the compressive flow in details through different schemes and algorithm. Therefore it is necessary to concentrate on computational fluid dynamics as in physics and chemistry behind the fluid flow problem or highly complex

**Text Books:**

1. John D Anderson Jr: Computational Fluid Dynamics, McGraw Hill.
2. H. K Versteeg 7 Malalasekera: An Inroduction to Computational Fluid Dynamics
3. S. V. Patankar: Hemisphere, Numerical Fluid Flow & Heat transfer

**References**:

1. HoftmanKlaw: Computational Fluid Dynamics, Vol-1 & 2
2. T. Sundernajan: Narosa, Computational Fluid Flow and Heat Transfer

**COURSE PLAN**

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| **COURSE NO: 08EE6042(C) COURSE TITLE: Computational Fluid Dynamics (L-T-P :3-0-0)**  **CREDITS:3** | | |
| **MODULES** | **Contact**  **Hours** | **Sem.Exam**  **Marks;%** |
| MODULE : 1  Philosophy of Computational Fluid Dynamics, Forms of Governing equations particularly suitable for CFD, Mathematical behavior of partial Differential Equations – Hyperbolic equations – Parabolic equations – Elliptical equations. | 8 | 15 |
| MODULE : 2  Discretization – Introduction to finite differences – Difference equations – Explicit and Implicit approaches – stability – Simple CFD Techniques – Lax-Wendroff – Mac Cormack’s | 6 | 15 |
| **FIRST INTERNAL TEST** |  |  |
| MODULE : 3  Viscous flow - Conservation form – Space marching – The Relaxation Technique – Pressure correction – Stream function, Vorticity method of solution. | 6 | 15 |
| MODULE : 4  Finite Volume Method – One Dimensional steady state diffusion – two and Three Dimensional diffusion problems | 6 | 15 |
| **SECOND INTERNAL TEST** |  |  |
| MODULE : 5  One Dimensional steady convection & diffusion – Central differencing scheme – Upwind differencing scheme – QUICK scheme – SIMPLE, SIMPLER, SIMPLEC, PISO. | 6 | 20 |
| MODULE : 6  Finite Volume Method for Unsteady flow – One Dimensional Steady heat conduction – Explicit scheme – Crank-Nicholson scheme – Fully implicit scheme – Turbulence models – K-€model – Reynolds stress equation model. | 7 | 20 |

**Course No: 08EE6052(A) Course Title: Wind Energy and Its Utilization**

**Credits: 3-0-0: 3**

**Year: 2015**

**Pre-requisites: Nil**

**Course Objectives**:

* A foundation in the fundamentals about historical and latest developments, state of art of wind energy technology, turbine rating, cost of energy, Indian scenario and worldwide development
* To provide knowledge on basic concepts of aerodynamics of aerofoil, lift and drag force, stall and pitch control, stiff and soft towers and power train dynamics
* To understand the working and design principle of pitch control, yaw control, wind turbine dynamics with DC and AC generators, induction and synchronous generators, variable speed operation power electronics converter and inverter, interfaces etc.

**Syllabus:**

Historical developments, latest developments, state of art of wind energy technology, Indian scenario and worldwide developments, wind resource characteristics and assessment, Aerodynamics of aerofoil, design of wind turbine blade, Vertical and horizontal axis turbines, wind turbine design programs, Aerodynamic damping and stability, Pitch control, yaw control, Power electronics Converter and Inverter interfaces for wind energy utilization system for isolated and grid connected system, Wind farm electrical design, Environmental assessment

**Course Outcome:**

By studying the subject, students will have an ability to understand the fundamental concepts of wind energy and its application, how to design the wind farm, planning of wind farm and wind farm arrangement, site selection etc.

**Text Books:**

1. Paul Gipe, Wind Energy Comes of Age, John Wiley & Sons Inc.
2. Ahmed: Wind Energy Theory and Practice, PHI, Eastern Economy Edition, 2012
3. L.L. Freris, Wind Energy Conversion System, Printice Hall.

**References**:

1. Tony Burton et al, Wind energy Hand Book, John Wiley & Sons Inc.
2. Directory, Indian Wind Power 2004, CECL, Bhopal.

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| **COURSE NO: 08EE6052(A) COURSE TITLE: Wind Energy and its Utilization**  **(L-T-P : 3-0-0)**  **CREDITS: 3** | | |
| **MODULES** | **Contact**  **hours** | **Sem.Exam**  **Marks;%** |
| MODULE : 1  Historical developments, latest developments, state of art of wind energy technology, turbine rating, cost of energy, wind power plant economics, installation and operation costs, decommissioning, Indian scenario and worldwide developments, present status and future trends. | 7 | 15 |
| MODULE : 2  Nature of atmospheric winds; wind resource characteristics and assessment; anemometry; wind statistics; speed frequency distribution, effect of height, wind rose, Weibull distribution, atmospheric turbulence, gust wind speed, effect of topography. | 6 | 15 |
| **FIRST INTERNAL TEST** |  |  |
| MODULE : 3  Aerodynamics of aerofoil; lift; drag; stall; effect of Reynold’s number; actuator disc; momentum theory and Betz coefficient; design of wind turbine blade; effect of stall and blade pitch on coefficient of power vs tip speed ratio and cut-out wind speeds, blade materials. | 6 | 15 |
| MODULE : 4  Vertical and horizontal axis turbines, design characteristics, multiple stream tube theory, vortex wake structure; tip losses; rotational sampling, wind turbine design programs, aerodynamic loads, tower shadow, wind shear, blade coning, gyroscopic, transient and extreme loads. Aerodynamic damping and stability, teetering motion, stiff and soft towers, Power train dynamics. | 7 | 15 |
| **SECOND INTERNAL TEST** |  |  |
| MODULE : 5  Pitch control, yaw control, Electrical and Mechanical aerodynamic braking, teeter mechanism. Wind turbine dynamics with DC and AC generators: induction and synchronous generators, variable speed operation, effect of wind turbulence. Power electronics Converter and Inverter interfaces for wind energy utilization system for isolated and grid connected system. | 7 | 20 |
| MODULE : 6  Wind farm electrical design, Planning of wind farms, special application for developing countries, maintenance and operation, wind farm management, site selection. Environmental assessment; noise, visual impact etc. Instrumentation, data loggers, remote monitoring and control. | 7 | 20 |

**COURSE PLAN**

**Course No: 08EE6052(B) Course Title: Advanced Solar Thermal and PV Systems**

**Credits: 3-0-0: 3**

**Year: 2015**

**Pre-requisites: Nil**

**Course Objectives**:

* To impart the basics of solar energy estimation and measurement of solar radiation, various methods of using solar energy etc.
* A foundation in the fundamental study about solar cells and panels, PV systems, storage autonomy, voltage regulation, tracking etc.
* To provide knowledge on ‘F’ chart, ϕ-F chart, Life Cycle analysis of solar energy systems and evaluation of carbon credit of solar energy systems

**Syllabus:**

Sun as source of energy, Estimation of solar Radiation, Various Methods of using solar energy, Flat Plate Collector, Thermal Analysis of Solar Collectors Performance of Solar Collectors, Solar Water Heating Systems(Active & Passive), Solar Thermal Power Systems, Solar cells & panels, solar panels PV systems, PV power plants, Shadow analysis, Maximum tracking, F Chart method, φ-F Chart method, Evaluation of Carbon Credit of Solar Energy Systems.

**Course Outcome:**

Students who successfully complete this topic will have through knowledge on advanced solar thermal and PV systems, estimation and measurements of solar radiation, various components available for solar radiation, design of collection of PV system, various applications of solar energy and PV systems.

**Text Books:**

1. J. A. Duffie& W. A. Beckman: Solar Engineering of Thermal Process.
2. Mukherjee and Thakur: Photovoltaic Systems Analysis and Design, PHI, Eastern Economy Edition, 2012

**References**:

1. Solanki: Solar Photovoltaics- Fundamentals, Technologies and Applications, PHI, Eastern Economy Edition, 2012
2. S. A. Kalogirou: Solar Energy Engineering.

**COURSE PLAN**

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| **COURSE NO: 08EE6052(B) COURSE TITLE: Advanced Solar Thermal and PV Systems**  **(L-T-P : 3-0-0)**  **CREDITS:3** | | |
| **MODULES** | **Contact**  **hours** | **Sem.Exam**  **Marks;%** |
| MODULE : 1  Sun as source of energy, availability of Solar Energy. Nature of Solar Radiation - global, beam and diffuse Radiation, Hourly, Daily and Seasonal variation of solar Radiation, Estimation of solar Radiation, Measurement of Solar Radiation., Solar Energy & Environment. | 6 | 15 |
| MODULE : 2  Various Methods of using solar energy –Photothermal, Photovoltaic, and Photosynthesis- basic concepts. Present & Future Scope of Solar energy. | 6 | 15 |
| **FIRST INTERNAL TEST** |  |  |
| MODULE : 3  Flat Plate Collector, Hot Air Collector, Evacuated Tube Collector, Parabolic, Compound Parabolic and Fresnel Solar Concentrators, Central Receiver System, Thermal Analysis of Solar Collectors Performance of Solar Collectors. | 6 | 15 |
| MODULE : 4  Solar Water Heating Systems(Active & Passive), Solar Space Heating & Cooling Systems, Solar Industrial Process Heating Systems, Solar Dryers & Desalination Systems, Solar Thermal Power Systems. | 6 | 15 |
| **SECOND INTERNAL TEST** |  |  |
| MODULE : 5  Solar cells & panels, performance of solar cell, estimation of power obtained from solar power, solar panels PV systems, components of PV systems, performance of PV systems, design of PV systems, application of PV systems, concentrating PV systems, PV power plants, Solar cell array system analysis and performance prediction; Shadow analysis: Solar cell array design concepts; Storage autonomy; Voltage regulation; Maximum tracking. | 8 | 20 |
| MODULE : 6  F Chart method, φ-F Chart method, Utilizabilitymodeling& simulation of Solar Energy Systems, Life cycle analysis of Solar Energy Systems, Time Value of Money, Evaluation of Carbon Credit of Solar Energy Systems. | 7 | 20 |

**Course No: 08EE6052(C) Course Title: Emerging Refrigeration Technologies**

**Credits: 3-0-0: 3**

**Year: 2015**

**Pre-requisites: Nil**

**Course Objectives**:

* To impart knowledge on advancements in refrigeration
* To understand the concepts of thermoelectric refrigeration
* To understand about magnetic refrigeration, steam jet refrigeration systems and its components and characteristics of refrigerants

**Syllabus:**

Introduction to refrigeration systems, Thermoelectric refrigeration, Review of vapour compression refrigeration system, vapour absorption system and adsorption systems, Thermoelectric refrigeration, System description, Advanced vapour compression system, Introduction to Magnetic refrigeration, clean refrigeration in future, Principles and application of steam jet refrigeration system, Modern refrigerants

**Course Outcome:**

In order to enhance the eco- friendly refrigerants towards minimum climate change and global warming, various advanced refrigeration techniques are used.

**Text Books:**

1. Arora C. P Refrigeration and Air conditioning-Tata McGraw Hill, 2004
2. Arora: Refrigeration and Air-conditioning, PHI, Eastern Economy Edition, 2012
3. Gosney W. B Principles of Refrigeration, Cambridge University Press, 1983

**References**:

1. Stanley W Angrist Direct Energy conversions, Allyn& Bacon, 1982
2. HJ Goldsmid, Thermoelectric Refrigeration, Springer, 1st Ed. 1995

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| **COURSE NO: 08EE6052(C) COURSE TITLE: Emerging Refrigeration Technologies**  **(L-T-P : 3-0-0)**  **CREDITS:3** | | |
| **MODULES** | **Contact**  **hours** | **Sem.Exam**  **Marks;%** |
| MODULE : 1  Introduction to refrigeration systems, methods of refrigeration, units of refrigeration, COP. Introduction to nonconventional refrigeration technologies- Thermoelectric refrigeration, magnetic refrigeration, pulse tube refrigeration, acoustic refrigeration, steam jet refrigeration, vortex tube refrigeration. Review of vapour compression refrigeration system, vapour absorption system and adsorption systems. | 8 | 15 |
| MODULE : 2  Thermoelectric refrigeration - principle, thermoelectric properties, Seabeck effect, Peltier effect and Thompson effect. System description, performance, analysis, Applications | 6 | 15 |
| **FIRST INTERNAL TEST** |  |  |
| MODULE : 3  Advanced vapour compression systems – compound compression, multistage evaporation. Solar based refrigeration technologies – absorption and adsorption. | 6 | 15 |
| MODULE : 4  Introduction to Magnetic refrigeration, magneto-caloric effect, magnetic materials, magnetic refrigeration near room temperature cooling, advantages over traditional refrigeration system, clean refrigeration in future-pulse tube refrigerator-principle-analysis. | 7 | 15 |
| **SECOND INTERNAL TEST** |  |  |
| MODULE : 5  Principles and application of steam jet refrigeration system – performance analysis, vortex tube refrigeration system, system description, Applications | 6 | 20 |
| MODULE : 6  Modern refrigerants – Need for alternative refrigerants – eco friendly refrigerants – properties of mixtures of refrigerants – modifications required for retrofitting , safety precautions and compatibility of refrigerants with the materials. | 6 | 20 |

**COURSE PLAN**

**Course No. 08EE6062 Course Title:Mini Project Credits:0-0-4:2**

**Year:2015**

**Pre-requisites: Nil**

**Course Objectives**:

* To estimate the ability of the student in transforming the theoreticalknowledge studied so far into a working model of an electrical/electronic systems.
* For enabling the students to gain experience in organisation andimplementation of a small project and thus acquire the necessaryconfidence to carry out main project in the final year.

**Syllabus:**

In this practical course, each Student is expected to designand develop a moderately complex system on any of the topics in the area of Energy/Renewable energy with practical applications.The project work is allotted individually on different topics. The students shall be encouraged to do their project work in the parent institute itself.The basic concepts of product design may be taken intoconsideration while designing the project. A committee consisting of minimum threefaculty members will perform assessment of the mini project. Students have to submit areport on the mini project and demonstrate the mini project before the evaluation committee.

**Course Outcome:**

It enables students to transforming the theoretical knowledge and implementation of a small project.

**Course No. 08EE6072 Course Title: Power Electronics Laboratory Credits:0-0-2:2**

**Year:2015**

**Pre-requisites: Nil**

**Course Objectives**:

* To provide practical knowledge through hardware implementation of various power electronic circuits.
* To enable the students to study and simulate various power electronic converters using Matlab.
* To familiarize the students by introducing P-Sim and help them to simulate and analyse different converters**.**

In this course, students will be provided with an orientation programme on the following equipments/software. After this orientation, each student is expected to formulate and complete an activity of interest which has to be derived from the orientation programme under the guidance of a faculty. The details like background, problem definition, status of technology/knowledge in that area by a good literature review (5 latest papers), objectives, methodology, equipment that can be used (from the orientation programme), results from the experiments and their interpretation with respect to the assumption /background and a formal conclusion are expected in the report which is to be submitted at the end of the semester. This work is evaluated for the credit assigned.

1. Analysis of Dual Converter Fed DC Motor Drive.
2. Chopper Fed DC Drive.
3. DSP Controlled AC Drive.
4. Performance study of Stator Voltage Controlled Induction Motor Drive.
5. Analysis of Vector Controlled Induction Motor Drive.
6. Harmonic Analysis of Converter Fed Drive.
7. IGBT Based Three Phase PWM Inverter.
8. Simulation of Power Electronics Systems using P Spice.
9. Modelling and Simulation of Electric Drives using MATLAB.
10. Modelling and Simulation of Electric Drives using PSIM.

**Course Outcome:**

* Students are introduced to hardware, software, and measurement techniques used in power electronic systems.
* Students are exposed to analysis, design, and applications of power electronic

converters.

**SEMESTER 3**

**Course No. 08EE7013(A) Course Title: Cryogenic Engineering Credits: 3-0-0:3**

**Year: 2015**

**Pre-requisites: Nil**

**Course Objectives**:

* To understand the concepts of cryo system for space application and other application
* To understand concept of liquefaction system
* To understand cryogenic refrigeration system
* To understand cryogenic storage vessels and transportation of cryogenic liquid

**Syllabus**

Introduction to cryogenic systems -Mechanical properties – Thermal properties – Electric and magnetic properties – Cryogenic fluids and their properties -Liquefaction systems-Cryo Coolers- Gas liquefaction systems-Production of low temperatures-Cryogenic Refrigeration systems-Cryogenic storage vessels and transportationLevel and temperature measurements- Types of heat exchangers used in cryogenic systems.

**Course Outcome:**

To set a complete picture about importance of cryogenic system with very low temperature towards special applications through liquefaction systems.

**Text Books:**

1. Klaus D Timmerhaus, Thomas M Flynn, Cryogenic Process Engineering, Plenum Press, New York, 1989
2. Randal F Barron, Cryogenic systems, McGraw Hill, 1986

**References**:

1. R B Scott, Cryogenic Engineering
2. J H Boul Jr., Cryogenic Engineering

**COURSE PLAN**

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| **COURSE NO:08EE7013(A) COURSE TITLE: Cryogenic Engineering (L-T-P : 3-0-0)**  **CREDITS:3** | | |
| **MODULES** | **Contact**  **hours** | **Sem.Exam**  **Marks;%** |
| MODULE : 1  Introduction to cryogenic systems, Historical development, Low temperature properties of Engineering materials, Mechanical properties – Thermal properties – Electric and magnetic properties | 6 | 15 |
| MODULE : 2  Cryogenic fluids and their properties. Applications of Cryogenics: Applications in Space, Food processing, Super conductivity, Electrical power, Biology, Medicine, Electronics, and Cutting Tool industry. | 6 | 15 |
| **FIRST INTERNAL TEST** |  |  |
| MODULE : 3  Liquefaction systems: Ideal system, Joule Thomson expansion, Adiabatic expansion, LindeHampson Cycle, Claude & Cascaded System, Magnetic cooling, Stirling Cycle Cryo Coolers. Gas liquefaction systems: Introduction – Production of low temperatures – General liquefaction systems – Liquefaction systems for Neon. Hydrogen and Helium – Critical components of Liquefaction systems. | 8 | 15 |
| MODULE : 4  Cryogenic Refrigeration systems: Ideal Refrigeration systems – Refrigeration using liquids and gases as refrigerant – Refrigerators using solids as working media, Cryogenic fluid storage and transfer systems. | 6 | 15 |
| **SECOND INTERNAL TEST** |  |  |
| MODULE : 5  Cryogenic storage vessels and transportation, Thermal insulation and their performance at cryogenic temperature, Super insulators, Vacuum insulation, Powder insulation. | 7 | 20 |
| MODULE : 6  Cryogenic fluid transfer systems, Pressure flow – Level and temperature measurements – Types of heat exchangers used in cryogenic systems. Cryo pumping applications. | 6 | 20 |

**Course No. 08EE7013(B) Course Title: Theory of Combustion Credits:3-0-0:3**

**Year:2015**

**Pre-requisites: Nil**

**Course Objectives**:

* To understand the basic concepts of kinetic behaviour of fuels and combustion of different characteristics of fuels including explosive and oxidative nature
* To understand the basic concepts of detonation phenomena
* To understand the basic concepts of ignition characteristics

**Syllabus**

Chemical thermodynamics -Chemical Kinetics -Explosive and general oxidative characteristics of fuels -Flame phenomena in premixed combustible gases -detonation phenomena -Diffusion flames -Ignition, chain spontaneous ignition, thermal spontaneous ignition, Semenov approach of thermal ignition -Ignition by adiabatic compression and shock waves Environmental combustion considerations .

**Course Outcome:**

Inorder to enhance the compression process in engine and gas turbine, it is necessary to access the level of chemical kinetic behaviour of fuels and combustion through chemical equilibrium and classification. It is desirable to optimize the performance combustion, emission characteristics in engine and gas turbines in terms of both compressible and incompressible stages

**Text Books:**

1. Irvin Glassman, combustion, Academic Press, Third Edition 1996.
2. Turns R S, An Introduction to Combustion, McGraw Hill, New York, 1996.
3. Kuro K K, Principles of Combustion, Second Edition, Wiley, New York, 2005.

**References**:

1. Warnatz, J., Maas, U., and Dibble, R.W., Combustion: Physical and Chemical Fundamentals, Modelling and Simulation, Experiments, Pollutant Formation, Fourth Edition, Springer: Berlin, 2006.
2. Zel’dovich, Y.B., and Razier, Y.P., Physics of Shock Waves and High-Temperature Hydrodynamic Phenomena, Dover, New York, 2002.

**COURSE PLAN**

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| **COURSE NO:08EE7013(B) COURSE TITLE: Theory of Combustion (L-T-P :3-0-0)**  **CREDITS:3** | | |
| **MODULES** | **Contact**  **hours** | **Sem.Exam**  **Marks;%** |
| MODULE : 1  Chemical thermodynamics: Heat of reaction and formation. Free energy and equilibrium constants. Flame temperature and its calculation. Chemical Kinetics: Rates of reactions, temperature dependence. Simultaneous independent reactions, chain reactions. Pseudo first order reactions. Partial equilibrium assumptions, pressure effect. | 8 | 15 |
| MODULE : 2  Explosive and general oxidative characteristics of fuels: Chain branching reactions, criteria for explosions. Explosion limits and oxidation characteristics of Hydrogen, carbon monoxide and hydrocarbons. | 6 | 15 |
| **FIRST INTERNAL TEST** |  |  |
| MODULE : 3  Flame phenomena in premixed combustible gases: Laminar flame speed, stability limits of laminar flames. Turbulent flames. | 6 | 15 |
| MODULE : 4  Introduction to detonation phenomena. Hugoniot theory and hydrodynamic theory of detonation. ZND structure of detonation waves. Diffusion flames: Appearance, structure and theoretical considerations. Gaseous fuel jets, burning of condensed phases, droplet clouds. | 7 | 15 |
| **SECOND INTERNAL TEST** |  |  |
| MODULE : 5  Ignition, chain spontaneous ignition, thermal spontaneous ignition, Semenov approach of thermal ignition. Forced ignition, spark ignition and minimum ignition energy. | 6 | 20 |
| MODULE : 6  Ignition by adiabatic compression and shock waves. Environmental combustion considerations. Nature of photochemical smog, formation and reduction of nitrogen oxides. Sox emission and particulate formation. | 6 | 20 |

**Course No. 08EE7013(C) Course Title: Energy Efficient Buildings Credits:3-0-0:3**

**Year:2015**

**Pre-requisites: Nil**

**Course Objectives**:

* To understand about energy efficiency buildings
* To understand about solar architecture
* To understand about design guidelines for energy efficient buildings
* To understand about control system for energy efficient buildings

**Syllabus**

Modern architecture – Examples from different climate zones -Solar geometry and shading -Integrative Modelling methods and building simulation-Principles of Energy conscious building design-Energy conservation in buildings-Water heating and photovoltaic systems-Passive solar heating-Passive cooling-Energy conservation in building-Control systems for energy efficient buildings- Intelligent building design principles.

**Course Outcome:**

Students are capable to familiarise about designing of energy efficient buildings and solar architecture

**Text Books:**

1. J.K. Nayak and J.A. PrajapatiHadbook on Energy Consious Buildings, Solar Energy Control MNES, 2006.
2. J.L. Threlkeld, Thermal Environmental Engineering, Prentice Hall, 1970.
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, 1986.

**References**:

1. Energy Conservation Building Codes 2006; Bereau of Energy Efficiency.
2. R.W. Jones, J.D. Balcomb, C.E. Kosiewiez, G.S. Lazarus, R.D. McFarland and W.O. Wray, Passive Solar Design Hanbook, Vol.3, Report of U.S. Department of Energy (DOE/CS-0127/3), 1982.
3. J.R. Williams, Passive Solar Heating, Ann Arbar Science, 1983.
4. J.A. Clarke, Energy Simulation in Building Design (2e) Butterworth 2001.

**COURSE PLAN**

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| **COURSE NO:08EE7013(C) COURSE TITLE: Energy Efficient Buildings (L-T-P :3-0-0)**  **CREDITS:3** | | |
| **MODULES** | **Contact**  **hours** | **Sem.Exam**  **Marks;%** |
| MODULE : 1  Climate and shelter – Historic buildings – Modern architecture – Examples from different climate zones – Thermal comfort – Solar geometry and shading – Heating and cooling loads – Energy estimates and site planning – Integrative Modeling methods and building simulation. | 8 | 15 |
| MODULE : 2  Principles of Energy conscious building design – Energy conservation in buildings – Day lighting – Water heating and photovoltaic systems – Advances in thermal insulation – Heat gain/loss through building components – Solar architecture. | 8 | 15 |
| **FIRST INTERNAL TEST** |  |  |
| MODULE : 3  Passive solar heating – Direct gain – Thermal storage wall – Sunspace – Convective air loop | 5 | 15 |
| MODULE : 4  Passive cooling – Ventilation – Radiation – Evaporation and Dehumidification – Mass effect – Design guidelines. | 6 | 15 |
| **SECOND INTERNAL TEST** |  |  |
| MODULE : 5  Energy conservation in building – Air conditioning – HVAC equipments – Computer packages for thermal design of buildings and performance prediction – Monitoring and instrumentation of passive buildings | 6 | 20 |
| MODULE : 6  Control systems for energy efficient buildings – Illustrative passive buildings – Integration of emerging technologies – Intelligent building design principles. | 6 | 20 |

**Course No. 08EE7023(A) Course Title: Optimal Design of Credits:3-0-0:3**

**Heat Exchangers Year:2015**

**Pre-requisites: Nil**

**Course Objectives**:

* To understand about design procedures of heat exchangers
* To understand about the geometries and size of heat exchangers
* To study about characteristics of heat exchangers in engineering applications
* To study about concept of special type of heat exchanger and compact heat exchangers

**Syllabus**

Heat exchanger classification and design fundamentals -Optimization criteria – Core pressure loss-Direct sizing of heat exchangers-Fine turning and design for curved tubes-Isothermal shell side conditions-Transients in heat exchangers-Direct solution by finite differences-Single-blow testing and regenerators- Cryogenic heat exchangers- Direct sizing and stepwise rating of multi- stream heat exchangers.

**Course Outcome:**

The performance of conventional heat exchangers in terms of design procedures and ratings.

**Text Books:**

1. E.M. Smith: Thermal Design of Heat Exchangers, John Wiley, 1999.
2. W.M. Rohsenow and J.P. Harnett: Handbook of Heat Exchanger application, McGraw Hill, 1985.

**References**:

1. A.P. Fraas: Heat Exchanger Design, 2e, J. Wiley, 1989.
2. D.Q. Kern: Process Heat Transfer, McGraw Hill, 1950.

**COURSE PLAN**

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| **COURSE NO:08EE7023(A) COURSE TITLE: Optimal Design of Heat Exchangers**  **(L-T-P :3-0-0)**  **CREDITS:3** | | |
| **MODULES** | **Contact**  **hours** | **Sem.Exam**  **Marks;%** |
| MODULE : 1  Heat exchanger classification and design fundamentals – LMTD-NTU rating and sizing problems – Theta methods – L-NTU rating and sizing problems | 6 | 15 |
| MODULE : 2  Dimensionless groups – Steady-state temperature profiles – Optimization criteria – Core pressure loss. Direct sizing of heat exchangers – Plate fin exchangers – Exchanger lay up – Surface geometries – Distribution headers – Multi-stream design – Helical-tube exchangers | 7 | 15 |
| **FIRST INTERNAL TEST** |  |  |
| MODULE : 3  Design frame work – Basic and simplified geometries – Fine turning and design for curved tubes – Bayonet tube exchangers – Isothermal shell side conditions – Explicit, complete and non-explicit solutions. | 7 | 15 |
| MODULE : 4  Transients in heat exchangers – Fundamental equations – Solution methods – Analytical considerations – Method of characteristics – Direct solution by finite differences – Engineering applications. | 6 | 15 |
| **SECOND INTERNAL TEST** |  |  |
| MODULE : 5  Single-blow testing and regenerators- Theory and physical assumptions – Choice of test method – Practical considerations | 6 | 20 |
| MODULE : 6  Cryogenic heat exchangers – Direct sizing and stepwise rating of multi- stream heat exchangers – Commercial applications. | 7 | 20 |

**Course No. 08EE7023(B) Course Title: Soft Computing Credits:3-0-0:3**

**Techniques Year:2015**

**Pre-requisites: Nil**

**Course Objectives**:

* To understand about artificial intelligent system
* To understand about back propagation network
* To understand about fuzzy relations
* To understand about genetic algorithms

**Syllabus**

Artificial Intelligent systems – Neural Networks, Fuzzy Logic and Evolutionary Programming concepts -Back propagation Networks: Architecture – Multi layer perceptron – Back propagation learning -Fuzzy sets and crisp sets-Fuzzy sets – Fuzzy set operations-Fuzzy relations – Membership functions -Defuzzification-Fuzzy Logic Control Systems -Genetic Algorithms -Fitness function – Reproduction -convergence of Genetic Algorithm – Differences and Similarities between GA and other traditional methods.

**Course Outcome:**

Students are capable to familiarise propagation networks, fuzzy relation and genetic algorithm.

**Text Books:**

1. S. N. Sivanandam, S. N. Deepa, Principles of Soft Computing, Wiley India Pvt. Ltd [Module I&III].
2. R. Rajasekharan and G.A. VijayalakshmiPai, Nerural Networks, Fuzzy Logic and Genetic algorithms-Synthesis and Applications, Prentice Hall of India. [Module II&IV]
3. Fakhreddine O. Karray, Clarence De Silva, Intelligent Systems Design, Theory, Tools and Application, Pearson Education.

**References**:

1. S. Haykins, Neural Networks – A Comprehensive foundation, Prentice Hall 2002.
2. L. Fausett, Fundamentals of Neural Networks, Prentice Hall 1994.
3. T. Ross, Fuzzy Logic with Engineering Applications, Tata McGraw Hill, New Delhi 1995.
4. D. E. Goldberg, Genetic Algorithms in search, Optimization and machine Learning, Addison Wesley M A, 1989.

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| **COURSE NO:08EE7023(B) COURSE TITLE:Soft Computing Techniques**  **(L-T-P :3-0-0)**  **CREDITS:3** | | |
| **MODULES** | **Contact**  **Hours** | **Sem.Exam**  **Marks;%** |
| MODULE : 1  Artificial Intelligent systems – Neural Networks, Fuzzy Logic and Evolutionary Programming concepts. Artificial Neural Networks – Biological neural networks – Model of an artificial neuron – Comparison between biological neuron and artificial neuron. | 6 | 15 |
| MODULE : 2  Basic models of artificial neural networks – Learning methods – Activation function and terminologies of ANN – McCulloch Pitts Neuron – Linear Separability – Hebb network – Perceptron Networks, Adaline, Madaline. | 6 | 15 |
| **FIRST INTERNAL TEST** |  |  |
| MODULE : 3  Back propagation Networks: Architecture – Multi layer perceptron – Back propagation learning – Input layer, Hidden Layer, Output Layer computations, Calculation of error, Training of ANN, Back propagation Algorithm, Momentum and Learning rate, Selection of various parameters in BP networks – Radial Basis Function Networks. | 6 | 15 |
| MODULE : 4  Variations in standard BP algorithms – Decremental iteration procedure, Adaptive BP, GA based BP, Quick prop training, Augmented BP networks, Sequential learning Approach for single hidden layer Neural networks. | 5 | 15 |
| **SECOND INTERNAL TEST** |  |  |
| MODULE : 5  Fuzzy sets and crisp sets-Fuzzy sets – Fuzzy set operations-Fuzzy relations – Membership functions – Features of the membership function – Methods of membership value assignment – Defuzzification – Defuzzification methods – Fuzzy Rule Base and approximate reasoning – Truth values and tables in fuzzy logic, Fuzzy propositions, Formation of rules, Decomposition of rules, Aggregation of fuzzy rules – Fuzzy Inference Systems – Construction and Working Principle of FIS – Methods of FIS – Mamdani FIS and Sugeno FIS – Fuzzy Logic Control Systems – Architecture and Operation of FLC System – FLC System Models – Application of FLC Systems. | 8 | 20 |
| MODULE : 6  Genetic Algorithms – Basic Concepts – Creation of off-springs – Working Principle – Encoding – Fitness function – Reproduction – Roulette – Wheel Selection, Boltzmann Selection – Tournament selection – Rank Selection – Steady – State Selection – Elitism – Generation gap and steady state replacement – Inheritance operators – Cross Over-Inversion and deletion – Mutation operator – Bit – wise operators – Generational Cycle – convergence of Genetic Algorithm – Differences and Similarities between GA and other traditional methods – Applications. | 8 | 20 |

**COURSE PLAN**

**Course No. 08EE7023(C) Course Title: Nanomaterial and Nanotechnology Year:2015**

**Pre-requisites: Nil**  **Credits:3-0-0:3**

**Course Objectives**:

* To understand about Nanomaterials and Nanotechnology
* To understand about preparation of Nanomaterials
* To study about Nanocomposites, Nanofillers.
* To understand about Nanomanipulation, Micro and nanofabrication techniques

**Syllabus**

Introduction to nanotechnology, Nanoscale, Electromagnetic spectrum-Electronic phenomenon in nanostructures -Preparation of nanomaterials-Different types of characterization techniques -Nanocomposites, Nanofillers-Nanomanipulation, Micro and nanofabrication techniques.

**Course Outcome:**

Students will be able to know about Nanomaterial, preparation techniques,,Nanocomposites, Nanofillers, Nanomanipulation, micro and nanofabrication techniques.

**Text Books:**

1. Nanocomposite science and technology, Pulikel M. Ajayan, Wiley – VCH 2005.
2. Nanolithography and patterning techniques in microelectronics, Davis G. Bucknall, Wood head publishing 2005.
3. Hand book of Nanoscience, Engineering, and Technology, William A Goddard, CRC press 2003.
4. Nanoelectronics and Information Technology, Rainer Waser, Wiley –VCH 2003.

**References**:

1. Optical properties of solids, F. Wooten, Academic press 1972.
2. Micro and Nanofabrication, Zheng Cui, Springer 2005.
3. Nanostructured materials, Jackie Y. Ying, Academic press 2001.
4. Nanotechnology and nanoelectronics, W.R, Fahrner, Springer 2005

**COURSE PLAN**

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| **COURSE NO:08EE7023(C) COURSE TITLE:Nanomaterials and Nanotechnology**  **(L-T-P :3-0-0)**  **CREDITS:3** | | |
| **MODULES** | **Contact**  **Hours** | **Sem.Exam**  **Marks;%** |
| MODULE : 1  Introduction to nanotechnology, Nanoscale, Electromagnetic spectrum, Top down and Bottom up approach, Particle size, Chemistry and Physics of nanomaterials, Electronic phenomenon in nanostructures, Optical absorption in solids, Quantum effects. | 7 | 15 |
| MODULE : 2  Nanomaterials, Preparation of nanomaterials like gold, silver, Different types of nano - oxides, A12O3, TiO2, ZnO etc. Sol-gel methods, Chemical vapour deposition, Ball milling etc.6  Carbon nanotubes, Preparation properties and Applications like field emission displays. Different types of characterization techniques like SEM, AFM, TEM& STM. | 6 | 15 |
| **FIRST INTERNAL TEST** |  |  |
| MODULE : 3  Nanocomposites, Nanofillers, High performance materials, Polymer nanocomposites, Nanoclays, Nanowires, Nanotubes, Nanoclusters etc. | 6 | 15 |
| MODULE : 4  Types and operating characteristics of electric motors – Energy efficient control and starting – Load matching – Selection of motors – Efficiency and load analysis – Energy efficiency – High efficiency motors | 6 | 15 |
| **SECOND INTERNAL TEST** |  |  |
| MODULE : 5  Smart materials, Self-assembly of materials, Safety issues with nanoscale powders. | 6 | 20 |
| MODULE : 6  Nanomanipulation, Micro and nanofabrication techniques, Photolithography, E-Beam, FIB etc. Nanolithography.,Softlithography, Photoresist materials. Introduction to MEMS, NEMS and nanoelectronics. Introduction to bionanotechnology and nanomedicines. | 8 | 20 |

**Course No. 08EE7033 Course Title: Seminar Credits:0-0-2:2**

**Year:2015**

**Pre-requisites: Nil**

**Course Objectives**:

* To assess the debating capability of the student to present a technical topic.
* To impart training to a student to face audience and present his ideas and thus creating in him self-esteem and courage that are essential for an engineer.

**Syllabus**

Individual students are required to choose a topic of their interest from Energy/Renewable Energy systems and related topics preferably from outside the M.Tech syllabus and give a seminar on that topic about 30 minutes. A committee consisting of at least three faculty members (preferably specialized in Energy/Renewable Energy) shall assess the presentation of the seminar and award marks to the students. Each student shall submit two copies of a write up of this seminar topic. One copy shall be returned to the student after duly certifying it by the chairman of the assessing committee and the other will 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.

**Course Outcome:**

Students are capable to present a technical topic and to face audience and present his ideas and thus creating in him self-esteem and courage that are essential for an engineer.

**Course No. 08EE7043 Course Title:Research Project Phase I Credits:0-0-12:6**

**Year:2015**

**Pre-requisites: Nil**

**Course Objectives**:

* To improve the professional competency and research aptitude by touching the areas which otherwise not covered by theory or laboratory classes.
* 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.

**Syllabus**

The project work can be a design project/ experimental project and / or computer simulation project on any of the topics in the area of Energy/Renewable energy. The project work is allotted individually on different topics. The students shall be encouraged to do their project work in the parent institute itself. If found essential, they may be permitted to continue their project outside the parent institute, subject to the conditions in cause 10 of M.Tech regulations. Department will constitute an Evaluation Committee to review the project work. The Evaluation committee consists of at least three faculty members of which internal guide and another expert in the specified area of the project shall be two essential members.

The student is required to undertake the master research project phase 1 during the third semester and the same is continued in the 4th semester (Phase 2). Phase 1 consist of preliminary thesis work, two reviews of the work and the submission of 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 Outcome:**

Students are capable to apply theoretical and practical tools/ techniques to solve real life problems related to industry and current research.

**SEMESTER 4**

**Course No. 08EE7014(C) Course Title:Research Project Phase II Credits:0-0-21:12**

**Year:2015**

**Pre-requisites: Nil**

**Course Objectives**:

* To improve the professional competency and research aptitude by touching the areas which otherwise not covered by theory or laboratory classes.
* 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.

**Syllabus**

Master Research project phase 2 is a continuation of project phase 1 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. This would be a pre-qualifying exercise for the students for getting approval by the departmental committee for the submission of the thesis. At least one technical paper is to be prepared for possible publication in journal or conferences. The technical paper is to be submitted along with the thesis. The final evaluation of the project will be external evaluation.

**Course Outcome:**

Students are capable to apply theoretical and practical tools/ techniques to solve real life problems related to industry and current research.