AC-6.6.2012
Item No.4.59

# UNIVERSITY OF MUMBAI

**Syllabus for the M. E. Program**

## Program: M. E. (Mechanical Engineering)

## ENERGY ENGINEERING

(As per Credit Based Semester and Grading System introduced with effect from the academic year 2012–2013)

**Ordinances & Regulations are applicable as per**
**M.E. Mechanical Engg.**
**Program Structure for Mechanical Engineering (Energy Engineering)**
**Mumbai University**
**(With Effect from 2012-2013)**

## Semester –I

| Subject Code | Subject Name | Teaching Scheme (Contact Hours) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Pract. | Tut. | Theory | Pract. | Tut. | Total |
| EGC101 | Foundation of Energy Engineering | 04 | -- | -- | 04 | -- | -- | 04 |
| EGC102 | Advanced Thermodynamics and Heat Transfer[&] | 04 | -- | -- | 04 | -- | -- | 04 |
| EGC103 | Solar and Wind Energy | 04 | -- | -- | 04 | -- | -- | 04 |
| EGE101X | Elective I | 04 | -- | -- | 04 | -- | -- | 04 |
| EGE102X | Elective II | 04 | -- | -- | 04 | -- | -- | 04 |
| EGL101 | Laboratory I – Renewable Energy Sources Lab | -- | 02 | -- | -- | 01 | -- | 01 |
| EGL102 | Laboratory II – Computational Fluid Dynamics | -- | 02 | -- | -- | 01 | -- | 01 |
| | **Total** | **20** | 04 | -- | **20** | **02** | **--** | **22** |

| Subject Code | Subject Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term Work | Pract./ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam | Exam. Duration (Hrs.) | | | |
| | | Test 1 | Test 2 | Avg. | | | | | |
| EGC101 | Foundation of Energy Engineering | 20 | 20 | 20 | 80 | 03 | -- | -- | **100** |
| EGC102 | Advanced Thermodynamics and Heat Transfer[&] | 20 | 20 | 20 | 80 | 03 | -- | -- | **100** |
| EGC103 | Solar and Wind Energy | 20 | 20 | 20 | 80 | 03 | -- | -- | **100** |
| EGE101X | Elective I | 20 | 20 | 20 | 80 | 03 | -- | -- | **100** |
| EGE102X | Elective II | 20 | 20 | 20 | 80 | 03 | -- | -- | **100** |
| EGL101 | Laboratory I - Renewable Energy Sources Lab | -- | -- | -- | -- | -- | 25 | 25 | **50** |
| EGL102 | Laboratory II – Computational Fluid Dynamics | -- | -- | -- | -- | -- | 25 | 25 | **50** |
| | **Total** | -- | -- | **100** | **400** | -- | **50** | **50** | **600** |

| Subject Code | Elective I | Subject Code | Elective II |
|---|---|---|---|
| EGE1011 | Energy resources, Economics and Environment | EGE1021 | Computational Fluid Dynamics% |
| EGE1012 | Computational Heat Transfer | EGE1022 | Nuclear Reactor Theory |
| EGE1013 | Energy Systems modeling and Analysis | EGE1023 | Power Generation, Transmission and Utilization |
| EGE1014 | Fuels and Combustion | EGE1024 | Energy Conservation in buildings and HVAC |
| EGE1015 | Advanced Solar Thermal Energy | EGE1025 | Biomass Energy Technologies |

& **Common for Energy Engineering and Thermal Engineering**

**% Common for Machine Design, Automobile Engineering, CAD/CAM and Robotics and Energy Engineering**

**Semester-II**

| Subject Code | Subject Name | Teaching Scheme (Contact Hours) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Pract. | Tut. | Theory | Pract. | Tut. | Total |
| EGC201 | Fuel Cell and Hydrogen Technology | 04 | -- | -- | 04 | -- | -- | 04 |
| EGC202 | Materials and Devices for Energy Application | 04 | -- | -- | 04 | -- | -- | 40 |
| EGC203 | Energy Conservation and Management | 04 | -- | -- | 04 | -- | -- | 04 |
| EGE203X | Elective III | 04 | -- | -- | 04 | -- | -- | 04 |
| EGE204X | Elective IV | 04 | -- | -- | 04 | -- | -- | 04 |
| EGL203 | Laboratory III – Energy Audit Lab | -- | 02 | -- | -- | 01 | -- | 01 |
| EGL204 | Laboratory IV – Thermal Energy Lab | -- | 02 | -- | -- | 01 | -- | 01 |
| | **Total** | **20** | **04** | -- | **20** | **02** | -- | **22** |

| Subject Code | Subject Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term Work | Pract. / Oral | Total |
| | | Internal Assessment | | | End Sem. Exam | Exam. Duration (Hrs.) | | | |
| | | Test 1 | Test 2 | Avg. | | | | | |
| EGC201 | Fuel Cell and Hydrogen Technology | 20 | 20 | 20 | 80 | 03 | -- | -- | **100** |
| EGC202 | Materials and Devices for Energy Application | 20 | 20 | 20 | 80 | 03 | -- | -- | **100** |
| EGC203 | Energy Conservation and Management | 20 | 20 | 20 | 80 | 03 | -- | -- | **100** |
| EGE203X | Elective III | 20 | 20 | 20 | 80 | 03 | -- | -- | **100** |
| EGE204X | Elective IV | 20 | 20 | 20 | 80 | 03 | -- | -- | **100** |
| EGL203 | Laboratory III – Energy Audit Lab | -- | -- | -- | -- | -- | 25 | 25 | **50** |
| EGL204 | Laboratory IV– Thermal Energy Lab | -- | -- | -- | -- | -- | 25 | 25 | **50** |
| | **Total** | -- | -- | **100** | **400** | -- | **50** | **50** | **600** |

| Subject Code | Elective III | Subject Code | Elective IV |
|---|---|---|---|
| EGE2031 | Power Generation and Systems Planning | EGE2041 | Heat Exchanger Design[&] |
| EGE2032 | Energy and Climate | EGE2042 | Instrumentation in Thermal Engineering |
| EGE2033 | Waste to Energy | EGE2043 | Thermal Energy Systems |
| EGE2034 | Thermodynamic Analysis of Industrial systems | EGE2044 | Hydropower systems |
| EGE2035 | Advanced Solar Photovoltaics | EGE2045 | Emerging Bio-fuel technologies |

& **Common for Energy Engineering and Thermal Engineering**

## Semester-III

| Subject Code | Subject Name | Teaching Scheme (Contact Hours) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Pract. | Tut. | Theory | Pract. | Tut. | Total |
| EGS301 | Seminar | -- | 06 | -- | -- | 03 | -- | 03 |
| EGD301 | Dissertation-I | -- | 24 | -- | -- | 12 | -- | 12 |
| | **Total** | -- | 30 | -- | -- | **15** | -- | **15** |

| Subject Code | Subject Name | Examination Scheme | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | Term Work | Pract./ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam | | | |
| | | Test 1 | Test 2 | Avg. | | | | |
| EGS301 | Seminar | -- | -- | -- | -- | 50 | 50 | **100** |
| EGD301 | Dissertation-I | -- | -- | -- | -- | 100 | -- | **100** |
| | **Total** | -- | -- | -- | -- | **150** | **50** | **200** |

## Semester-IV

| Subject Code | Subject Name | Teaching Scheme (Contact Hours) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Pract. | Tut. | Theory | Pract. | Tut. | Total |
| EGD401 | Dissertation-II | -- | 30 | -- | -- | 15 | -- | 15 |
| | **Total** | -- | 30 | -- | -- | **15** | -- | **15** |

| Subject Code | Subject Name | Examination Scheme | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | Term Work | Pract./ Oral | Total |
| | | Internal Assessment | | | End Sem. Exam | | | |
| | | Test 1 | Test 2 | Avg. | | | | |
| EGD401 | Dissertation-II | -- | -- | -- | -- | 100 | 100 | **200** |
| | **Total** | -- | -- | -- | -- | **100** | **100** | **200** |

**Note:**

- In case of Seminar, 01 Hour / week / student should be considered for the calculation of load of a teacher
- In case of Dissertation I, 02 Hour / week / student should be considered for the calculation of load of a teacher
- In case of Dissertation II, 02 Hour / week / student should be considered for the calculation of load of a teacher

| Subject Code | Subject Name | Credits |
|---|---|---|
| **EGC101** | **FOUNDATION OF ENERGY ENGINEERING** | **04** |

| **Module** | **Detailed Content** | **Hours** |
|---|---|---|
| 1 | Thermodynamics: first law and its application, second law and its application, Irreversibility and energy, basic power generation cycles.<br><br>Heat Transfer: conduction, radiation, convective heat transfer | 10 |
| 2 | Fluid Mechanics: stress-strain relations and viscosity, mass and momentum balance, flow through pipe. | 10 |
| 3 | Network analysis: simple network analysis, power factor improvement. | 10 |
| 4 | Electrical Machines: Transformer, Induction motor and generators, Synchronous generators, Introduction to modern speed control techniques, DC machines | 10 |
| 5 | Power systems: Introduction to power transmission and distribution. | 10 |
| 6 | Introduction to solid state power controllers: Power devices-Triggering Circuits-Rectifiers-Choppers-Inverters-AC Controllers | 10 |

## Texts/References


1. M. W. Zemansky, Heat and Thermodynamics 4th Edn. McGraw Hill, 1968.
2. A. L. Prasuhn, Fundamentals of Fluid Mechanics, Prentice Hall, 1980
3. S. P. Sukhatme, A Text book on Heat Transfer, Orient Longman, 1979.
4. P. C. Sen, Modern Power Electronics, Wheeler, New Delhi, 1998.
5. N. Balbanian, T. A. Bickart, Electrical network theory, John Wiley, New York, 1969
6. B. L. Theraja, A. K. Theraja, Text-book of electrical technology: in S.I. units: v.2 AC and DC machines, Nirja Construction & development, New Delhi, 1988.


## Assessment:

**Internal:** Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

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

| Subject Code | Subject Name | Credits |
|---|---|---|
| **EGC102** | **ADVANCED THERMODYNAMICS AND HEAT TRANSFER[&]** | **04** |

| Module | Detailed Content | Hours |
|---|---|---|
| 1 | Laws of thermodynamics , Entropy , Availabilty and Exergy, Equilibrium of thermodynamics system , pinch technology. | 08 |
| 2 | GENERAL THERMODYNAMIC RELATIONSHIPS: Fundamental relation for simple compressible system, generalized relations for changes in entropy, Internal energy and enthalpy, Cp and Cv. Clausius Clayperons equation, Joule Thompsons Coefficient | 10 |
| 3 | STATISTICAL THERMODYNAMICS: Microstates and Macrostates, Thermodynamic probability, Degeneracy of energy levels, Maxwell- Boltzman, Fermi- Dirac, Bose- Einstein statistics | 10 |
| 4 | Microscopic interpretation of heat and work, Evaluation of Entropy, Partition function, Calculation of the Macroscopic properties from partition functions, Equilibrium constant statistical thermodynamic approach. | 08 |
| 5 | CONDUCTION AND RADIATION HEAT TRANSFER:<br>One dimensional energy equations and boundary condition, three dimensional heat conduction equations, Extended surface heat transfer, Conduction with moving boundaries, Porous-media heat transfer, Radiation in gases and vapor | 12 |
| 6 | TURBULENT FORCED CONVECTIVE HEAT TRANSFER:<br>Momentum and Energy Equations, Turbulent Boundary Layer Heat Transfer, Mixing length concept, Turbulence Model - K-E Model, Analogy between Heat and Momentum Transfer - Reynolds, Colburn, Von Karman, Turbulent flow in a Tube, High speed flows. | 12 |

& **Common for Energy Engineering and Thermal Engineering**

## REFERENCES:


1. Kenneth Wark Jr., Advanced Thermodynamics for Engineers, Mc Graw-Hill Inc., 1995.
2. Bejan, A., Advanced Engineering Thermodynamics, John Willey and Sons, 1988.
3. Holman, J.P, Thermodynamics , Fourth Edition, Mc Graw-Hill Inc., 1988.
4. Sonntag, R.E., and Van Wylen,G, Introduction to Thermodynamics, Classical and Statistical, Third edition, John Wiley and Sons,1991.
5. Sears, S.W, and Salinger G.I., Thermodynamics, Kinetic theory and Statstical Thermodynamics, Third edition, Narosa publishing house, New Delhi, 1993.
6. Winterbone D.E, Advanced Thermodynamics for engineers, Arnold
7. Incropera F.P. and DeWitt. D.P., Fundamentals of Heat & Mass Transfer, John Wiley & Sons, 1996.

8. Eckert. E.R.G., and Drake.R.M., Analysis of Heat and Mass Transfer, McGraw Hill Co., 1980.
9. Bejan. A., Convection Heat Transfer, John Wiley and Sons, 1984.
10. 10. Rohsenow. W.M., Harnett. J.P., and Ganic. E.N., Handbook of Heat Transfer Applications, McGraw-Hill, NY1985

## Assessment:

**Internal:** Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

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

| Subject Code | Subject Name | Credits |
|---|---|---|
| **EGC103** | **SOLAR AND WIND ENERGY** | **04** |

| **Module** | **Detailed Content** | **Hours** |
|---|---|---|
| 1 | SOLAR RADIATION: Availabilty, Measurement and Estimation. | 4 |
| 2 | MODELING OF SOLAR THERMAL SYSTEMS AND SIMULATIONS IN PROCESS: Isotropic and anisotropic models- Introduction to solar collectors(Liquid flat –Plate collectors, Air Heater and concentrating Collector) and Thermal Storage- Steady state Transient Analysis- Solar Pond- Solar Refrigeration.<br>DESIGN-Design of Active Systems by f-charts and Utility Method- Water heating systems – Active and Passive- Passive heating and cooling of buildings-Solar Distillation- Solar Drying. | 10 |
| 3 | PHOTOVOLTAIC SOLAR CELL: P:N Junction, Metal- Schottky Junction, electrolyte-Semiconductor Junction, Types of Solar cells – their Application- Experimental techniques to determine the characteristics of Solar cells- Photovoltaic Hybrid Systems, photovoltaic thermal systems- Storage Battery- Solar Array and their characteristic evaluation- Solar Chargeable Batteries. | 10 |
| 4 | WIND: Its Structure- Statistics- Measurements and data presentation | 6 |
| 5 | WIND ENERGY CONVERSION SYSTEM(WECS): Wind Turbine Aerodynamics- Momentum Theories- Basics Aerodynamics- Airfoils and their characteristics- HAWT- Blade element Theory- Prandtl's lifting line theory (prescribed wake analysis) – VAWT Aerodynamics- Wind turbine Loads- Aerodynamic loads in Steady Operation- Wind Turbulence- Yawed operation and Tower Shadow. Siting- Rotor Selection- Annual Energy output- Horizontal Axis Wind Turbine(HAWT) Vertical Axis Wind Turbine- Rotor Design Considerations - Number of Blades- Blade Profile- 2/3 Blades and Teetering- Coning- Upwind/Downwind- Power Regulation- Yaw System- Tower- Synchronous and Asynchronous Generators and Loads- Integration of Wind Energy Convertors to Electrical Networks- Inverters | 20 |
| 6 | Testing of WECS- WECS Control Systems- Requirements and strategies**.** Miscellaneous Topics- Noise etc- Other Applications | 10 |

## REFERENCES:


1. L.L. Freris, Wind Energy Conservation Systems, Prentice Hall , 1990.
2. D.A. Spera, Wind Turbine Technology: Fundamental Concepts of Wind Turbine Engineering ASME Press.
3. S.P. Sukhatme- Solar Energy: Principles of Thermal Collection and Storage, Tata Mac Graw-Hill
4. J.A.Juffie and W.A. Beckman- Solar Engineering of Thermal Processes- John Wiley (1991).
5. J.F.Kreiderand F.Kreith-Solar Energy Handbook Mc Graw-Hill (1981).


## Assessment:

**Internal:** Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

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

| Subject Code | Subject Name | Credits |
|---|---|---|
| **EGE1011** | **ENERGY RESOURCES , ECONOMICS AND ENVIRONMENT** | **04** |

| **Module** | **Detailed Content** | **Hours** |
|---|---|---|
| 1 | OVERVIEW OF WORLD ENERGY SCENARIO– Dis-aggregation by end-use, by supply ; Fossil Fuel Reserves - Estimates, Duration; Overview of India's Energy Scenario - Dis-aggregation by end-use, by supply, reserves; Country Energy Balance Construction – Examples; Trends in energy use patterns; energy and development linkage. | 12 |
| 2 | ENERGY ECONOMICS- Simple Payback Period, Time Value of Money, IRR, NPV, Life Cycle Costing, Cost of Saved Energy, Cost of Energy generated, Examples from energy generation and conservation | 12 |
| 3 | Energy Chain, Primary energy analysis Life Cycle Assessment, Net Energy Analysis | 07 |
| 4 | ENVIRONMENTAL IMPACTS OF ENERGY USE- Air Pollution - SOx, NOx, CO, particulates Solid and Water Pollution, Formation of pollutants, measurement and controls; sources of emissions, effect of operating and design parameters on emission, control methods, Exhaust emission test, procedures, standards and legislation; environmental audits | 12 |
| 5 | Emission factors and inventories Global Warming, CO2 Emissions, Impacts, Mitigation Sustainability | 11 |
| 6 | Future Energy Systems | 06 |

## Texts/References:


1. Energy and the Challenge of Sustainability, World energy assessment, UNDP New York, 2000.
2. AKN Reddy, RH Williams, TB Johansson, Energy after Rio, Prospects and challenges, UNDP, United Nations Publications, New York, 1997.
3. Nebojsa Nakicenovic, Arnulf Grubler and Alan McDonald Global energy perspectives, Cambridge University Press, 1998
4. Fowler, J.M., Energy and the environment, 2nd Edn., McGraw Hill, New York, 1984


## Assessment:

**Internal:** Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

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

| Subject Code | Subject Name | Credits |
|---|---|---|
| **EGE1012** | **COMPUTATIONAL HEAT TRANSFER** | **04** |

| **Module** | **Detailed Content** | **Hours** |
|---|---|---|
| 1 | MATHEMATICAL DESCRIPTION OF PHYSICAL PHENOMENA **:**<br><br>Governing Differential Equation - Energy Equation - Momentum Equation - Nature of Co-ordinates -Discretization Methods | 10 |
| 2 | FINITE DIFFERENCE METHODS IN PARTIAL DIFFERENTIAL EQUATIONS :<br><br>Parabolic Equations - Explicit, Implicit and Crank Nicholson Methods. Finite Differences in Cartesian and Polar Co-ordinates. Local Truncation Error - Consistency Convergence - Stability - ADI Methods. Elliptic Equations -Laplace's Equation. Laplace's Equation in a Square - Non-rectangular Regions - Mixed Boundary Condition -Jacobi - Gauss-siedel and SOR Methods. Necessary and Sufficient Conditions for Iterative Methods | 14 |
| 3 | FINITE DIFFERENCE APPLICATIONS IN HEAT CONDUCTION AND CONVECTION:<br><br>Control Volume Approach - Steady and Unsteady One Dimensional Conduction - Two and Three Dimensional Situations - Solution Methodology. Convection and Diffusion : Upwind Scheme - Exponential Scheme. Hybrid Scheme - Power Law Scheme : Calculation of the Flow Field - Simpler Algorithm<br>. | 10 |
| 4 | FINITE ELEMENT METHOD CONCEPT :<br><br>General Applicability of the Method using one dimensional heat transfer equation - Approximate Analytical Solution Rayleigh's Method. Galerikin Solution Methods | 10 |
| 5 | FINITE ELEMENT METHOD PACKAGES **:**<br><br>General Procedure - Discretisation of the domain - Interpolation Polynomials - Formulation of Element Characteristic Matrices and Vectors - Direct, Variational and Weighted - Residual Approach - Higher Order Isoparametric Element Formulations, Conduction and Diffusion Equations - Heat Transfer Packages - Heat 2, HEATAX, RADIAT, ANSYS | 14 |

## References:


1. Suhas V.Patnakar, Numerical Heat Transfer and Fluid Flow, Hemisphere Publishing Corporation, 1980
2. Jaluria and Torrance, Computational Heat Transfer - Hemisphere
3. Publishing Corporation, 1986
4. A.R.Mitchell and D.F.Grifths, Finite Difference Method in Partial Differential Equations, John Wiley & Sons, 1980
5. S.S.Rao, The Finite Element Method in Engineering, Pergamon Press - 1989
6. O.C. Zienkiewicz & R.L.Taylor, The Finite Element Method IV Edition - Vol. I & II,
7. McGraw Hill International Edition, 1991


## Assessment:

**Internal:** Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

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

| Subject Code | Subject Name | Credits |
|---|---|---|
| **EGE1013** | **ENERGY SYSTEMS MODELING AND ANALYSIS** | **04** |

| Module | Detailed Content | Hours |
|---|---|---|
| 1 | MODELING OVERVIEW: levels of analysis, steps in model development, examples of models. | 6 |
| 2 | QUANTITATIVE TECHNIQUES: Interpolation-polynomial, Lagrangian. Curve-fitting, regression analysis, solution of transcendental equations. | 8 |
| 3 | SYSTEMS SIMULATION: information flow diagram, solution of set of nonlinear algebraic equations, successive substitution, Newton Rhapson. Examples of energy systems simulation.<br>Numerical solution of Differential equations- Overview, Convergence, Accuracy. Transient analysis- application example | 16 |
| 4 | OPTIMISATION : Objectives/constraints, problem formulation. Unconstrained problems- Necessary & Sufficiency conditions. Constrained Optimisation- Lagrange multipliers, constrained variations, Kuhn-Tucker conditions<br>Linear Programming - Simplex tableau, pivoting, sensitivity analysis. Dynamic Programming. Search Techniques- Univariate / Multivariate | 16 |
| 5 | Case studies of optimisation in Energy systems problems. Dealing with uncertainty- probabilistic techniques. Trade-offs between capital & energy using Pinch Analysis | 8 |
| 6 | Energy- Economy Models: Scenario Generation, Input Output Model | 6 |

## Texts/References:


1. W. F. Stoecker Design of Thermal Systems, Mcgraw Hill, 1981
2. S.S.Rao Optimisation theory and applications, Wiley Eastern, 1990
3. S.S. Sastry Introductory methods of numerical analysis,Prentice Hall, 1988
4. P. Meier Energy Systems Analysis for Developing Countries, Springer Verlag, 1984
5. R.de Neufville, Applied Systems Analysis, Mcgraw Hill, International Edition, 1990
6. Beveridge and Schechter,Optimisation Theory and Practice,Mcgraw Hill, 1970


## Assessment:

**Internal:** Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

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

| Subject Code | Subject Name | Credits |
|---|---|---|
| **EGE1014** | **FUELS AND COMBUSTION** | **04** |

| **Module** | **Detailed Content** | **Hours** |
|---|---|---|
| 1 | INTRODUCTION:<br>General, Conventional Energy Sources, Solar Energy, Nuclear Power, Energy from Biomass, Wind Power, Tidal Power, Geothermal Energy, Energy Survey of India, Rocket Fuels | 8 |
| 2 | SOLID FUELS:<br>General, Family of Coal, Origin of Coal, Gasification of Coal, Analysis and Properties of Coal, Action of Heat on Coal, Classification of Coal, Oxidation of Coal, Hydrogenation of Coal, Efficient use of Solid Fuels.<br>Manufactured Fuels, Agro Fuels, Solid Fuel Handling, Properties Related to Combustion, Handling, Storage | 10 |
| 3 | LIQUID AND GASEOUS FUELS:<br>Origin and Classification of Petroleum, Refining and Other Conversion Processes, Composition of Petroleum with respect to Combustion, Property & Testing of Petroleum Products, Various Petroleum Products, Nature of Indian Crudes & Petroleum Refining in India, Liquid Fuels from Other Sources, Storage and Handling of Liquid Fuels, Liquid Fuels Combustion Equipment<br>Types of Gaseous Fuels, Natural Gases, Methane from Coal Mines, Manufactured Gases, Producer Gas, Water Gas, Carburetted Water Gas, Blast Furnace Gas<br>Fuels through Non-Thermal Route - Biogas, Refinery Gas, LPG, Cleaning and Purification of Gaseous Fuels. | 12 |
| 4 | THEORY OF COMBUSTION PROCESS:<br>Stoichiometry and Thermodynamics, Combustion Stoichiometry General, Rapid Methods of Combustion Stoichiometry, Combustion Thermodynamics, Problem, Combustion Problems with Chemical Reactions Burners | 11 |
| 5 | STOICHIOMETRY:<br>Stoichiometry Relations, Theoretical Air Required for Complete Combustion, Calculation of Minimum Amount of Air Required for a Fuel of known Composition, Calculation of Dry Flue Gases if Fuel Composition is Known, Calculation of the Composition of Fuel & Excess Air Supplied,from Exhaust Gas Analysis, Dew Point of Products, Flue Gas Analysis (O 2, CO 2, CO, NO x, SO x). | 9 |
| 6 | BURNER DESIGN:<br>Ignition, Concept of Ignition, Auto Ignition, Ignition Temperature. Flame Propagation, Various Methods of Flame Stabilization, Incorporation in Burner Design, Basic Features and Types of Solid, Liquid and Gaseous Fuel Burner, Design Consideration of Different Types of Coal - Oil and Gas Burners, Recuperative & Regenerative Burners | 10 |

## References books:


1. Samir Sarkar; Fuels & Combustion, 2nd Edition, Orient Longman, 1990
2. Bhatt ,Vora; Stoichiometry, 2nd Edition, Tata Mcgraw Hill, 1984
3. Blokh AG; Heat Transfer in Steam Boiler Furnace, Hemisphere Publishing Corpn, 1988
4. Civil Davies; Calculations in Furnace Technology, Pergamon Press, Oxford, 1966
5. Sharma SP, Mohan Chander; Fuels & Combustion, Tata Mcgraw Hill, 1984


## Assessment:

**Internal:** Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

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

| Subject Code | Subject Name | Credits |
|---|---|---|
| **EGE1015** | **ADVANCED SOLAR THERMAL ENERGY** | **04** |

| **Module** | **Detailed Content** | **Hours** |
|---|---|---|
| 1 | INTRODUCTION:<br>Models for solar radiation- estimation of global solar energy incident from sunshine hours, Liu and Jordan's correlation, Collares-Pereira & Rabl relations, Shading analysis<br>Status of application of solar thermal energy in India; Industrial process heat applications | 10 |
| 2 | LOW/MEDIUM TEMPERATURE COLLECTORS*:*<br>Manufacture of FPC- Selective coatings- materials, methods of deposition; anti-reflective coatings; Theory of flat plate collector (Hottel-Whillier-Bliss analysis); Test procedure for FPC, collector efficiency equation; evacuated tube collectors, Solar drying- analysis of direct and indirect driers; Distillation- basin and multiple effect stills; box type and parabolic dish solar cookers | 11 |
| 3 | HIGH-TEMPERATURE COLLECTORS:<br>Analysis of cylindrical parabolic trough and compound parabolic concentrator; Dish concentrators with point focus- tracking, analysis; Central receiver systems, heliostats; Linear Fresnel reflector technologies; Fresnel lenses; Micro CSP; solar furnace; optical design of concentrators | 10 |
| 4 | HEAT STORAGE:-<br>Construction of hot water storage tanks- Model of well-mixed and stratified tank; Testing of solar water heaters;<br>Solid storage media- rock bed, concrete, graphite, transient analysis; Steam accumulator; Molten salt storage; Phase-change materials for storage- analysis of each; seasonal storage in underground aquifers | 10 |
| 5 | SOLAR ARCHITECTURE:<br>Thermal comfort, sun motion. Building orientation and design, Active and passive heating and cooling concepts; Trombe wall; heat transfer in buildings : thermal modeling of passive concepts; evaporative cooling, monitoring and instrumentation of passive buildings | 09 |
| 6 | SOLAR COOLING AND REFRIGERATION**:**<br>Potential and scope of solar cooling; Vapour absorption cooling – ammonia-water & lithium bromide-water systems, solid adsorbent systems; thermodynamic analysis; solar collectors and storage systems for solar refrigeration and air-conditioning; Solar desiccant cooling systems; SPV based systems | 10 |

## References:


1) S. P. Sukhatme and J.K. Nayak, Solar Energy - Principles of thermal collection and storage; Tata McGraw-Hill, New Delhi
2) Solar Energy, Fundamentals and Applications, Garg, Prakash, Tata McGraw Hill
3) J.A. Duffie and W.A. Beckmann, Solar Engineering of Thermal Processes, John Wiley, London, 1991.
4) M. S. Sodha, N. K. Bansal, P. K. Bansal, A. Kumar and M. A. S. Malik, Solar Passive Building: science and design, Pergamon Press, New York, 1986
5) M. A. S. Malik, G. N. Tiwari, A. Kumar and M.S. Sodha, Solar Distillation. Pergamon Press, New York, 1982.
6) Kreith F and Kreider J.F., 'Principles of Solar Engineering', McGraw Hill Book Co.,
7) A. Rabl, Active Solar Collectors and Their Applications, Oxford University Press, New York, 1985
8) Gilbert M. Masters, Renewable and efficient electric power systems, Prentice-Hall


## Assessment:

**Internal:** Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

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

| Subject Code | Subject Name | Credits |
|---|---|---|
| **EGE1021** | **COMPUTATIONAL FLUID DYNAMICS[%]** | **04** |

| **Module** | **Detailed Content** | **Hours** |
|---|---|---|
| 1 | Definition and overview of CFD, Advantages and applications, CFD methodology | 04 |
| 2 | GOVERNING DIFFERENTIAL EQUATIONs :<br>Governing equations for mass, momentum and energy; Navier-Stokes equations; Mathematical behaviour of PDE's viz. parabolic, elliptic and hyperbolic, Initial and boundary conditions, Initial and Boundary value problems. | 10 |
| 3 | DISCRETIZATION TECHNIQUES:<br>Introduction to Finite difference Method, Finite Volume method and Finite Element method<br>Finite difference methods; Finite difference representation of PDE's; Solutions to Finite Difference Equations; Implicit, semi-implicit and explicit methods; Errors and stability criteria | 12 |
| 4 | FINITE VOLUME METHODS:<br>FVM solutions to steady one, two and three dimensional diffusion problems and unsteady one and two dimensional diffusion problems<br>FVM solutions to convection-diffusion problems - one and two dimensional, steady and unsteady; Advection schemes; Pressure velocity coupling; SIMPLE family of algorithms | 14 |
| 5 | GRID GENERATION :<br>Structured and Unstructured Grids; General transformations of the equations; body fitted coordinate systems; Algebraic and Elliptic Methods; multi block structured grids; adaptive grids | 10 |
| 6 | TURBULENCE MODELING:<br>Effect of turbulence on governing equations; RANS, LES and DNS Models | 10 |

**% Common for Machine Design, Automobile Engineering, CAD/CAM and Robotics and Energy Engineering**

## References:


1) Muralidhar, K., Sundararajan, T., " Computational fluid flow and heat transfer", NArosa Publishing House, New Delhi1995
2) Ghosdhasdidar, P.S., " Computer simulation of flow and heat transfer" Tata Mc Graw-Hill Publishing company Ltd., 1998.
3) Subas, V.Patankar, "Numerical heat transfer fluid flow" , Hemisphere publishing Corporation.
4) Taylor, C and Hughes J.B., Finite Element Programming of the Navier Stokes Equation, Pineridge Press Ltd., U.K , 1981.
5) Anderson, D.A., Tannehill , I.I., and Pletcher, R.H., Computational fluid Mechanics and Heat Transfer, Hemisphere Publishing Corporation, New York , USA, 1984.
6) Fletcher, C.A.J., " Computational Techniques for Fluid Dynamics 1" Fundamental and General Techniques, Springer- Verlag , 1987


## Assessment:

**Internal:** Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

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

| Subject Code | Subject Name | Credits |
|---|---|---|
| **EGE1022** | **NUCLEAR REACTOR THEORY** | **04** |

| Module | Detailed Content | Hours |
|---|---|---|
| 1 | RADIOACTIVITY:<br>Types of nuclear radiation, Interaction oalpha, beta & gamma rays with matter. Interaction of neutron with matter. Production of neutron, elastic and inelastic scattering. Structural changes caused by neutron interaction. Thermal reactor, homogeneous and heterogeneous reactor. Conversion and breeding | 12 |
| 2 | CROSS SECTIONS FOR NUCLEAR REACTIONS:<br>significance of cross section, macroscopic and microscopic cross section, rates of reaction, variation of cross section with neutron energy. Nuclear fission, Power from fission, prompt neutron & delayed neutron, amount and activities of fission products, heat generation after shutdown | 12 |
| 3 | NEUTRON TRANSPORT EQUATION:<br>Diffusion theory approximation, diffusion coefficient, diffusion length, Fick's law, Solutions to diffusion equation for point source, Planar source, etc. Infinite and effective multiplying factor. | 12 |
| 4 | Slowing down of neutrons, Energy loss in elastic collisions, Collision and slowing down densities, Moderation in hydrogen, Lethargy concept, Moderation in heavy nucleus. Moderation with absorption, Resonance absorption, NR and NRIM approximations. Multi-region reactors, Multigroup diffusion methods | 08 |
| 5 | REACTOR KINETICS.<br>Four factor formula. One group model for bare reactor, prompt neutron lifetime, one group delayed neutron, reactivity & period, In-hour equation, prompt critical condition, Coefficients of reactivity, Control | 10 |
| 6 | Fission product poisoning, effect of poisons on reactivity, Xenon & Samarium poisoning . Perturbation theory | 06 |

## Texts / References:


1) J.R. Lamarsh, Introduction to Nuclear Reactor Theory, Wesley, 1966
2) J.J. Duderstadt and L.J. Hamilton, Nuclear Reactor Analysis, John Wiley, 1976


## Assessment:

**Internal:** Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

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

| Subject Code | Subject Name | Credits |
|---|---|---|
| **EGE1023** | **POWER GENERATION , TRANSMISSION AND UTILISATION** | **04** |

| **Module** | **Detailed Content** | **Hours** |
|---|---|---|
| 1 | CONVENTIONAL POWER GENERATION :<br>Steam power plant, Selection of site, Layout ,coal and Ash Handling, Steam Generating Plants, Feed Circuit, Cooling Towers, Turbine Governing<br>Hydro Power Plant: Selection of Site ,Classification, Layout, Governing of Turbines Nuclear Power Plants: Selection of Site, Nuclear Fuels, nuclear reactors, nuclear disposal Gas Turbine Plants | 10 |
| 2 | NON-CONVENTIONAL POWER GENERATION:<br>Wind power generation, characteristics of wind power, design of wind mills, Tidal power generation, Single and two basin systems, Turbines for tidal power ,Solar power generation, Energy from biomass | 12 |
| 3 | ECONOMICS OF POWER GENERATION:<br>Daily load curves-load factor-diversity factor-load deviation curve, load management, number and size of generating unit, cost of electrical energy, tariff, power factor improvement | 10 |
| 4 | ELECTRICAL POWER TRANSMISSION:<br>Online diagram of transmission-sub transmission and distribution systems, comparison of systems(DC and AC), EHVAC and HVDC transmission, layout of substations and bus bar arrangements, Equivalents circuit of short, medium and large lines, Transmission efficiency, regulation, reactive power, compensation, transmission-loss minimization | 12 |
| 5 | UTILISATION OF ELECTRICAL ENERGY:<br>Selection of Electrical Drives, Electrical characteristics and mechanical considerations, size, rating and cost,<br>Transformer characteristics | 08 |
| 6 | Illumination, laws of illumination, polar curve, incandascent-fluoroscent and vapour lamps, Design of OLTC, lighting Scheme of industry, energy efficient aspects of devices | 08 |

## References:


1. C.L.Wadhwa; Generation, Distribution and utilization of Electrical Energy, Wiley Eastern Ltd., India(1989)
2. V.A.Venikov and B.V. Put Yatin, Introduction of Energy Technology, Electric power Engineering, MIR Publishers, Moscow(1984)
3. M.L.Soni, P.VGupta and V.S.A.Bhatnagar, Course in Electrical Power, Dhanpat Rai &
1) Sons, New Delhi(1983)
4. J.W.Twidell and A.D.Weir; Renewable Energy Sources, ELBS Edition(1986)
5. A.J.Wood and B.F. Wallenberg(1986):Power Generation, Operation and Control,2nd Edition, John Wiley &Sons, Newyork


## Assessment:

**Internal:** Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

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

| Subject Code | Subject Name | Credits |
|---|---|---|
| **EGE1024** | **ENERGY CONSERVATION IN BUILDINGS AND HVAC** | **04** |

| **Module** | **Detailed Content** | **Hours** |
|---|---|---|
| 1 | CLIMATES AND BUILDINGS<br>Thermal Properties and Energy content of Building materials - Psychrometry-Comfort conditions – Air-conditioning Systems | 08 |
| 2 | ESTIMATION OF BUILDING LOADS:<br>Steady state method-Network method- Numerical method-correlations-computer packages for carrying out thermal design of buildings and predicting performance | 12 |
| 3 | EFFICIENT LIGHTING AND DAY LIGHTING:<br>Lighting and Visual ability-Light sources and Luminaries - Lighting System Design-Daylighting-Lighting Economics and aesthetics-Impacts of Lighting efficiency | 10 |
| 4 | INDOOR ENVIRONMENTAL REQUIREMENT AND MANAGEMENT :<br>Thermal comfort-Ventilation and air quality-Air conditioning requirement- visual perception – illumination requirement-Auditory requirement-Energy Management Options-Energy Audit and Energy Targeting-Technological Options for Energy Management | 16 |
| 5 | ENERGY CONSERVATION IN AIR-CONDITIONING SYSTEMS:<br>Cycles-Energy Conservation in pumps/fan/blowers-Refrigerating machines -Heat Rejection Equipment-Energy efficient motors-insulation | 12 |

## Reference Books:


1. J.Krieder and A.Rabi (1994): Heating and Cooling of Buildings: Design for Efficiency McGraw-Hill.
2. 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).
3. J.R. Williams, Passive Solar Heating, Ann Arbar Science (1983).
4. R.W. Jones, J.D. Balcomb, C.E. Kosiewiez, G.S. Lazarus, R.D.Mc Farland and W.O. Waray (1982),Passive Solar Design Handbook,Vol 3,Report of U.S. Department of Energy (DOE/CS-0127/3)
5. J.L.Thrikeld, Thermal Environmental Engineering, Prentice Hall (1976).
6. (1993):IES Lighting Handbook, Reference and Application Volume, IESNA.
7. Thumann (1992): Lighting Efficiency Applications, Fairmont Press.


## Assessment:

**Internal:** Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

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

| Subject Code | Subject Name | Credits |
|---|---|---|
| **EGE1025** | **BIOMASS ENERGY TECHNOLOGIES** | **04** |

| **Module** | **Detailed Content** | **Hours** |
|---|---|---|
| 1 | INTRODUCTION:-<br>Production of biomass, photosynthesis; Broad classification- Agro and forestry residues, industrial and municipal solid and liquid wastes; Biomass resources in India; MNRE Biomass energy schemes; Environmental benefits of using biomass as a fuel; energy plantations- wood, oil seeds | 10 |
| 2 | BIOMASS COMBUSTION & PYROLYSIS:<br>Calorific value, proximate and CHN analysis of biomass; Combustion: Grate combustion, fluidized bed combustion, combustion of pulverized biomass, cyclone furnace;<br>Pyrolysis techniques- for charcoal production, medium CV gas, and bio-oil production | 10 |
| 3 | THERMOCHEMICAL GASIFICATION OF BIOMASS:-<br>Chemistry of air gasification, equilibrium model; down-draft (throat type and throatless), updraft, cross-draft, fluidized bed (bubbling bed and CFB), entrained and cyclone gasifiers; design of Imbert down-draft gasifier; Introduction to thermal and engine applications of producer gas | 11 |
| 4 | BIOCHEMICAL CONVERSION:-<br>Biogas: substrates used (cow dung, human, agricultural waste, municipal & industrial liquid effluents; aerobic and anaerobic processes; Applications- rural domestic and community plants; industrial and urban power production<br>Ethanol: Fermentation of biomass to ethanol;<br>Fuel properties of biogas and ethanol | 10 |
| 5 | MUNICIPAL AND INDUSTRIAL WASTE:-<br>Production of municipal solid wastes- contents, quantities, disposal by landfill; recovery of energy by biomethanation, incineration, pelletisation and combustion; municipal sewage- and biogas production for treatment and energy recovery;<br>Industrial wastes- liquid organic effluents; biomethanation; supercritical water gasification; wastewater treatment plant sludges- energy recovery by combustion | 09 |
| 6 | LIQUID BIOFUELS AND DENSIFICATION:<br>Extraction of straight vegetable oils and use in diesel engines<br>Production of bio-diesel – raw materials, basic process, properties of biodiesel in comparison to diesel, use of biodiesel-diesel blends in diesel engines<br>Biomass densification- Pelletisation and briquetting- techniques ; benefits and applications | 10 |

## References:


1. V. V. N. Kishore (Editor), Renewable Energy Engineering And Technology: Principles And Practice, Earthscan Publications (Apr 2009)
2. Biomass: Renegerable Energy – D.O. Hall and R.P. Overend (John Wiley and Sons, New York, 1987)
3. Biomass for energy in the developing countries – D.O.Hall, G.W.barnard and P.A.Moss (Pergamon Press Ltd. 1982)
4. Thermo chemical processing of Biomass, Bridgwater A V.
5. Biomass as Fuel – L.P.White (Academic press1981)
6. Biomass Gasification Principles and Technology, Energy technology review No. 67,- T.B. Reed (Noyes Data Corp. , 1981)
7. Fundamentals of combustion – D.P.Mishra, PHI Pvt. Ltd , new delhi
8. Introduction to I C Engines – Mathur and Sharma
9. J. Twidell and T. Weir, Renewable Energy Resources, Taylor and Francis (special Indian edition) 2006
10. T.B. Reed and Agua Das; Handbook of biomass downdraft gasifier engine systems; Biomass Energy Foundation Press, USA
11. The Energy and Resources Institute, Bioenergy in India, 2010
12. Caye M. Drapcho, Nghiem Phu Nhuan, Terry H. Walker, Biofuels Engineering Process Technology; McGraw Hill, 2008
13. P.D. Grover, S.K. Mishra; Biomass Briquetting: Technology and Practices; FAO, Bangkok, 1996


## Assessment:

**Internal:** Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

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

| Subject Code | Subject Name | Credits |
|---|---|---|
| **EGL101** | **RENEWABLE ENERGY SOURCES LAB** | **01** |

| **Module** | **Detailed Content** | **Hours** |
|---|---|---|
| 1 | Performance evaluation of any one solar unit and any one wind unit (Solar units like solar heater, solar distillation unit, solar concentrators, etc.<br>Wind energy units like wind mills, wind turbines, Savonius rotors, etc.) | 06 |
| 2 | Measurement of IV curve of solar PV panel and evaluation of performance with tracking | 02 |
| 3 | Modeling and Simulation of solar and wind systems like solar refrigerators, solar air conditioning units, etc. | 04 |
| 4 | Experimental comparison of performance of solar and wind devices with conventional devices eg. Solar and wind pumps vs. conventional pumps | 04 |
| 5 | Determine aerodynamic characteristics of wind turbine blades by experiments or simulation | 04 |
| 6 | Demonstration of production of bio-diesel, evaluation of its properties and its use in diesel engine | 04 |
| 7 | Production of hydrogen using renewable energy source, its storage and use in a fuel cell | 04 |
| 8 | Performance evaluation of biomass gasifier with or without producer gas S.I. or dual-fuel engine | 04 |
| 9 | Production of ethanol by fermentation from biomass feedstock; evaluation of properties | 04 |

Note:
At least 6 experiments to be performed from the list of which at least 2 experiments each will be on solar, wind and biomass

The experiments will focus on the following:

1. Ability to select and install the measuring instruments
2. Take accurate readings
3. Analyse the data
4. Interpret the results
5. Carry out an error analysis

## Assessment:

**End Semester Examination:** Practical/Oral examination is to be conducted by pair of internal and external examiners

| Subject Code | Subject Name | Credits |
|---|---|---|
| **EGL102** | **COMPUTATIONAL FLUID DYNAMICS LAB** | **01** |

| **Module** | **Detailed Content** | **Hours** |
|---|---|---|
| 1 | Simulate and solve 2-d and 3-d steady and unsteady flows using any commercial CFD package like Ansys-FLUENT, STAR CCM, FLUIDYNE, Ansys-CFX, etc. | 12 |
| 2 | Write codes for 1-d and 2-d steady conduction with and without source and do the post processing to verify with analytical results | 6 |
| 3 | Write codes for steady, 2-d conduction-advection problems and do the post processing to verify with analytical results | 6 |

Note: The laboratory will focus on the following:

1. Give adequate exposure to commercially available analysis packages
2. Train students to write simple codes in MATLAB, C, C++ for control volume analysis
3. Give students an understanding of the working of a complete code through exercises on simple flows

## Assessment:

**End Semester Examination:** Practical/Oral examination is to be conducted by pair of internal and external examiners

| Subject Code | Subject Name | Credits |
|---|---|---|
| **EGC201** | **FUEL CELL AND HYDROGEN TECHNOLOGY** | **04** |

| **Module** | **Detailed Content** | **Hours** |
|---|---|---|
| 1 | Hydrogen energy : Hydrogen: Its merit as a fuel; Applications | 06 |
| 2 | Hydrogen production methods : Production of hydrogen from fossil fuels, electrolysis, thermal decomposition, photochemical and photo-catalytic methods ,Hydrogen storage methods - Metal hydrides, metallic alloy hydrides, carbon nano-tubes, sea as source of deuterium | 08 |
| 3 | Fuel cell BASICS - Fuel cell definition, Difference between batteries and fuel cells, fuel cell history, components of fuel cells, principle of working of fuel cells Fuel cell thermodynamics - second law analysis of fuel cells, efficiency of fuel cells, fuel cell electrochemistry - Nernst equation, Electrochemical kinetics, Butler-Volmer equation Fuel cell types - Classification by operating temperature/electrolyte type | 14 |
| 4 | Fuel Cell Performance: Activation, Ohmic and Concentration over potential<br>Fuel cell design and components: Cell components, stack components, system components | 12 |
| 5 | Overview of intermediate/high temperature fuel cells :Solid oxide fuel cells (SOFC), Molten carbonate fuel cells (MCFC), Phosphoric acid fuel cells (PAFC) Polymer Electrolyte fuel cells (pefc) - Heat and mass transfer in polymer electrolyte fuel cells, water management in PEFCs, Current issues in PEFCs | 10 |
| 6 | Direct methanol fuel cells (DMFC) – Electrochemical kinetics methanol oxidation, Current issues in DMFCs, Fuel crossover in DMFCs, Water management in DMFCs, high methanol concentration operation, limiting current density | 10 |

## References:


1. J. Larminie and A. Dicks, Fuel Cell Systems Explained, 2nd Edition, Wiley (2003)
2. Xianguo Li, Principles of Fuel Cells, Taylor and Francis (2005)
3. S. Srinivasan, Fuel Cells: From Fundamentals to Applications, Springer (2006)
4. O'Hayre, S. W. Cha, W. Colella and F. B. Prinz, Fuel Cell Fundamentals, Wiley (2005)
5. J. Bard and L. R. Faulkner, Electrochemical Methods: Fundamentals and Applications, 2nd Edition, Wiley 2000
6. Faghri and Y. Zhang, Transport Phenomena in Multiphase Systems, Elsevier 2006
7. Fuel Cell System, edited by Leo J.M.J. Blomen and Michael N. Mugerwa, New York, Plenum Press, 1993.
8. Fuel Cell Handbook, by A. J. Appleby and F. R. Foulkers, Van Nostrand, 1989


## Assessment:

**Internal:** Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

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

| Subject Code | Subject Name | Credits |
|---|---|---|
| **EGC202** | **MATERIALS AND DEVICES FOR ENERGY APPLICATION** | **04** |

| **Module** | **Detailed Content** | **Hours** |
|---|---|---|
| 1 | Device fabrication technologies: diffusion, oxidation, photolithography, sputtering, physical vapor deposition, chemical vapor deposition (CVD), plasma enhanced CVD (PECVD), hot wire CVD (HWCVD), etc. | 08 |
| 2 | Introduction to material characterization: Scanning electron microscopy (SEM), Transmission electro microscopy (TEM), X-ray diffraction (XRD), Raman spectroscopy, Atomic force microscopy (AFM), Spectral response of solar cells, quantum efficiency analysis, dark conductivity, I-V characterization. | 08 |
| 3 | Basics of solar cells: High efficiency solar cells, PERL Si solar cell, III-V high efficiency solar cells, GaAs solar cells, tandem and multi-junction solar cells, solar PV concentrator cells and systems, III-V, II-VI thin-film solar cells (GaAs, Cu(In,Ga)Se2, CdTe ) Nano-, micro- and poly-crystalline Si for solar cells,. | 12 |
| 4 | Introduction to physics of semiconductor devices: mono-micro silicon composite structure, crystalline silicon deposition techniques, material and solar cell characterization, advanced solar cell concepts and technologies (Porous Si layer transfer, Metal induced crystalization, etc.). Amorphous silicon thin-film (and/or flexible) technologies, multi-junction (tandem) solar cells, stacked solar cells. Conjugated polymers, organic/plastic/flexible solar cells, polymer composites for solar cells, device fabrication and characterization | 12 |
| 5 | Materials and devices for energy storage: Batteries, Carbon Nano-Tubes (CNT), fabrication of CNTs, CNTs for hydrogen storage, CNT-polymer composites, ultra-capacitors etc. Polymer membranes for fuel cells, PEM fuel cell, Acid/alkaline fuel cells. | 08 |

## Texts/References:


1. Solar cells: Operating principles, technology and system applications, by Martin A. Green, Prentice-Hall Inc, Englewood Cliffs, NJ, USA, 1981.
2. Seminconductors for solar cells, H. J. Moller, Artech House Inc, MA, USA, 1993. Solid State electronic devices, Ben G. Streetman, , Prentice-Hall of India Pvt. Ltd., New delhi 1995.
3. Carbon nanotubes and related structures: New material for twenty-first century, P. J. F. Harris, Cambridge University Press, 1999.

4. Thin-film crystalline silicon solar cells: Physics and technology, R. Brendel, Wiley-VCH, Weinheim, 2003.
5. Clean electricity from photovoltaics, M. D. Archer, R. Hill, Imperial college press, 2001.
6. Organic photovoltaics: Concepts and realization, C. Barbec, V. Dyakonov, J. Parisi, N. S. Sariciftci, Springer-Verlag 2003.
7. Fuel cell and their applications, K. Kordesch, G. Simader, VCH, Weinheim, Germany, 1996.
8. Battery technology handbook, edited by H.A. Kiehne, Marcel Dekker, New York, 1989

## Assessment:

**Internal:** Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

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

| Subject Code | Subject Name | Credits |
|---|---|---|
| **EGC203** | **ENERGY CONSERVATION AND MANAGEMENT** | **04** |

| Module | Detailed Content | Hours |
|---|---|---|
| 1 | INTRODUCTION: Energy Scenario- Principles and Imperatives of Energy Conservations- Energy Consumption Patters- Resource Availability-Role of Energy Managers in Industries | 06 |
| 2 | ENERGY AUDITING: Purpose, Methodology with respect to process industries- Power plants , Boilers etc.,Characteristic Method Employed in certain Energy Intensive Industries- Various Energy Conservation Measures in Steam Systems- Losses in Boiler, Methodology of Upgrading Boiler Performance, Steam Traps- Types, Function, Necessity | 10 |
| 3 | Energy Conservation in Pumps, Fans and Compressors, Air Conditioning and Refrigeration Systems | 08 |
| 4 | TOTAL ENERGY SYSTEMS: Concept of Total Energy- Advantages and Limitations- Total energy systems and Applications- Various possible Schemes employing steam turbine movers used in Total Energy Systems, Potential and Economics of Total Energy Systems | 08 |
| 5 | ELECTRICAL ENERGY AUDITING: Potential Areas for Electrical Energy Conservation in Various Industries- Energy Management Opportunities in Electrical Heating lighting System, Cable Selection - Energy Efficient Motors- Factor involved, Determination of Motor Efficiency, Adjustable AC Drivers- Applications & its use, variable speed drivers/ belt drivers. | 16 |
| 6 | ENERGY MANAGEMENT: Importance of Energy Management, Energy Economics- Discount Rate , Payback Period, Internal rate of Return, Life cycle Costing. | 12 |

## References:


1. CB Smith, Energy Management Principles, Pergamon Press, New York, 1981.
2. Hamies, Eney Auditing and Conservation; Methods, Measurements, Management and Case study, Hemisphere, Washington, 1980.
3. Trivedi. PR, Jolka KR, Energy Management, Commonwealth Publication, New Delhi, 1997.
4. Witte, Larry C, Industrial Energy Management and Utilization, Hemispheres Publishers, Washington, 1988.
5. Diamant, RME, Total Energy, Pergamon, Oxford, 1970.


## Assessment:

**Internal:** Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

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

| Subject Code | Subject Name | Credits |
|---|---|---|
| **EGE2031** | **POWER GENERATION AND SYSTEMS PLANNING** | **04** |

| Module | Detailed Content | Hours |
|---|---|---|
| 1 | Overview of the Indian power sector, Thermodynamic analysis of Conventional Power Plants. Advanced Power Cycles, Kalina (Cheng) Cycle, IGCC, AFBC/PFBC | 10 |
| 2 | Power Plant types :Steam Turbine - Superheater, reheater and partial condenser vacuum. Combined Feed heating and Reheating. Regenerative Heat Exchangers, Reheaters and Intercoolers in Gas Turbine power plants. Hydro power plants - turbine characteristics. Auxiliaries - Water Treatment Systems, Electrostatic Precipitator / Flue gas Desulphurisation, Coal crushing / Preparation - Ball mills / Pulverisers, ID/FD Fans, Chimney, Cooling Towers. | 12 |
| 3 | Power plant control systems- Review of control principles, Combustion control, pulveriser control, control of air flow, Furnace pressure and feed water, steam temperature control, Safety provisions / Interlocks | 10 |
| 4 | Analysis of System load curve -plant load factor, availability, Loss of load Probability calculations for a power system, Maintenance Scheduling<br>Load Forecasting - Time series, Econometric, end use techniques | 12 |
| 5 | Pricing of Power - Project cost components, Analysis of Power Purchase Agreements (PPA), Debt/Equity Ratio and effect on Return on Investment. Least Cost Power Planning - Integration of DSM, Renewable into supply | 08 |
| 6 | Environmental Legislations/Government Policies Optimal Dispatch - Scheduling of Hydro-Thermal plants | 08 |

## Texts/References:


1. R.W.Haywood, Analysis of Engineering Cycles, 4th Edition, Pergamon Press, Oxford, 1991.
2. D. Lindsay, Boiler Control Systems, Mcgraw Hill International, London, 1992.
3. H.G. Stoll, Least Cost Electrical Utility / Planning, John Wiley & Sons, 1989.
4. T.M. O' Donovan, Short Term Forecasting: An introduction to the Box Jenkins Approach, Wiley, Chichester, 1983.
5. A.B.Gill, Power Plant Performance, Butterworths, 1984.
6. Wood, A.J., Wollenberg, B.F., Power Generation, operation & control, John Wiley, New York, 1984.


## Assessment:

**Internal:** Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

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

| Subject Code | Subject Name | Credits |
|---|---|---|
| **EGE2032** | **ENERGY AND CLIMATE** | **04** |

| Module | Detailed Content | Hours |
|---|---|---|
| 1 | Energy and us: Energy terms; Current energy scenario (World, US, India); Fossil energy Vs renewable sources; Electricity; Future projections; Externalities of energy use. | 08 |
| 2 | Carbon Cycle: Natural systems – autotrophs, heterotrophs, energy flows, pre-industrial humanity; Photosynthesis- efficiency of natural ecosystems, forests and various crops; Respiration, combustion and other oxidation processes; Biomethanation | 10 |
| 3 | Climate Science Research: Climate history; Greenhouse gas effect; Anthropogenic climate change; Role of different gases; Global problem; Integrated assessment models; Impacts and adaptation; Uncertainties; Precautionary principle. | 12 |
| 4 | Carbon Sequestration: Biological pathways; Physico-chemical methods; CO2 capture from large point sources; Pre-, post- and oxy-combustion technology; Transport, storage and monitoring; Feasibility, economics and public perceptions; Case studies | 10 |
| 5 | Climate Policy: Kyoto protocol; UNFCCC; IPCC; Geopolitics of GHG control; Carbon market - CDM and other emission trading mechanisms; Non-CO2 GHGs; Relevance for India<br>Landfills: Gas generation and collection in land fills, Introduction to transfer stations | 12 |
| 6 | Power generation using waste to energy technologies: CI and SI engines. IGCC and IPCC concepts | 08 |

## Texts/References:


1. Energies: V Smil, MIT Press, Cambridge, 1999..
2. Global Warming: J Houghton, Cambridge University Press, New York, 1997
3. Various reports published by IPCC: http://www.ipcc.ch/, 1990 onwards
4. IPCC Special Report on Carbon Dioxide Capture and Storage: B Metz et al (Eds), Cambridge University Press, NY, 2005.
5. CDM Country Guide for INDIA: Institute for Global Environmental Strategies (Ed), Ministry of the Environment, Japan, 2005.

6. Global Environmental Issues:F Harris (Ed),John Wiley,Chichester, 2004.
7. “Carbon Capture and Sequestration: Integrating Technology, Monitoring, and Regulation” edited by E J Wilson and D Gerard, Blackwell Publishing, Ames, Iowa, USA, 2007
8. Energy and the environment: J A Fay and D S Golomb, Oxford University Press, New York, 2002.
9. Introduction to Engineering and the Environment: E S Rubin, McGraw Hill, New York, 2001

## Assessment:

**Internal:** Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

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

| Subject Code | Subject Name | Credits |
|---|---|---|
| **EGE2033** | **WASTE TO ENERGY** | **04** |

| Module | Detailed Content | Hours |
|---|---|---|
| 1 | Introduction to energy from waste: characterisation and classification of waste as fuel – agrobased, forest residues, industrial waste, Municipal solid waste. | 08 |
| 2 | Waste to energy options: combustion (unprocessed and processed fuel), gasification, anaerobic digestion, fermentation, pyrolysis<br>Landfills: Gas generation and collection in land fills, Introduction to transfer stations | 12 |
| 3 | Conversion devices: combustors (Spreader Stokes, Moving grate type, fluidized bed), gasifier, digesters. | 12 |
| 4 | Briqueting technology: Production of RDF and briquetted fuel. | 08 |
| 5 | Properties of fuels derived from waste to energy technology: Producer gas, Biogas, Ethanol and Briquettes, Comparison of properties with conventional fuels. | 12 |
| 6 | Power generation using waste to energy technologies: CI and SI engines. IGCC and IPCC concepts | 08 |

## Texts/References:


1. M.M. EL-Halwagi, Biogas Technology- Transfer and diffusion, Elsevier Applied science Publisher, New York, 1984.
2. D.O Hall and R.P. Overeed, Biomass – regenerable energy, John Willy and Sons Ltd. New York. 1987.


## Assessment:

**Internal:** Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

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

| Subject Code | Subject Name | Credits |
|---|---|---|
| **EGE2034** | **THERMODYNAMIC ANALYSIS OF INDUSTRIAL SYSTEMS** | **04** |

| **Module** | **Detailed Content** | **Hours** |
|---|---|---|
| 1 | Thermodynamic systems and postulates, thermodynamic equilibrium, thermodynamic relations, stability and phase transition. | 14 |
| 2 | Entropy generation and exergy analysis, exergy analysis of fluid flow systems, | 08 |
| 3 | Heat transfer and heat transfer augmentation, heat exchangers. | 08 |
| 4 | Heat recovery systems, pinch analysis, energy targeting, heat exchanger networks, area/unit/shell targeting, capital-energy trade-off, multiple utilities, network evolution and evaluation, retrofitting, crude preheat train.. | 16 |
| 5 | Plant utility systems, cogeneration, steam-power balance and optimisation, Thermo economic optimization | 14 |

## References:


1. Bejan, Entropy Generation Minimization, CRC Press, 1996
2. U. V. Shenoy, Heat Exchanger Network Synthesis: Process Optimization by Energy and Resource Analysis, Gulf Publishing Co., 1995.
3. Bejan, Advanced Engineering Thermodynamics, Wiley, 1988.
4. H. B. Callen, Thermodynamics and Introduction to Thermostatistics, Wiley, 1985.
5. Bejan, Entropy Generation Through Heat and Fluid Flow, Wiley, 1982.


## Assessment:

**Internal:** Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

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

| Subject Code | Subject Name | Credits |
|---|---|---|
| **EGE2035** | **ADVANCED SOLAR PHOTOVOLTAICS** | **04** |

| **Module** | **Detailed Content** | **Hours** |
|---|---|---|
| 1 | FUNDAMENTALS OF SOLAR CELL:<br>Solar Cell Physics: p-n junction: homo and hetero -junctions, Metal-semiconductor interface; Photovoltaic Effect, Basic Equation, Equivalent Circuit of the Solar Cell, I-V curve, Analysis and modelling of solar cell: Dark and illumination characteristics; Figure of merits of solar cell; Efficiency limits; Variation of efficiency with band-gap and temperature; Efficiency measurements; | 10 |
| 2 | SOLAR CELL FABRICATION TECHNOLOGY :<br>Preparation of metallurgical, electronic and solar grade Silicon; Production of single crystal Silicon; Wafering and doping; Thin-film modules- method of manufacture; Procedure of masking, photolithography and etching; Role of nano -technology in solar cells; Module lamination and fabrication | 10 |
| 3 | HIGH EFFICIENCY SOLAR CELLS**:**<br>CdTe, GaAs, InP solar cell; High efficiency III-V, II-VI multi-junction solar cell; a-Si-H based solar cells; CIGS cells; Quantum well and quantum dot solar cell, Thermo-photovoltaic; organic solar cell | 10 |
| 4 | SYSTEM COMPONENTS**:**<br>PV arrays, MPPT; UPS and grid-connect inverters; Batteries- tubular, SMF and 2V lead-acid batteries, Battery charge-discharge curves, equivalent circuit; wiring for SPV, charge controllers, net power meters; CFL and LED luminaires; PV array installation, operation & maintenance; | 10 |
| 5 | SOLAR PHOTOVOLTAIC SYSTEM DESIGN:<br>Stand-alone systems- home systems, lanterns, street-lights; hybrid, grid connected and building integrated SPV; Solar PV array system analysis and performance prediction; Storage autonomy; Reliability; System sizing; Voltage regulation; Array protection and trouble shooting; | 10 |
| 6 | SPV DESIGN AND APPLICATIONS**:**<br>SPV pump & refrigerator design; Photovoltaic concentrators- Parabolic, CPC, V-trough, refractive lens concentrators; Solar photovoltaic program in India, Jawaharlal Nehru National Solar Mission | 10 |

## References:


1) S. P. Sukhatme and J.K. Nayak, Solar Energy - Principles of thermal collection and storage, Tata McGraw-Hill, New Delhi
2) Gilbert M. Masters, Renewable and efficient electric power systems, Prentice-Hall
3) Solar Energy, Fundamentals and Applications, Garg, Prakash, Tata McGraw Hill
4) J.A. Duffie and W.A. Beckmann, Solar Engineering of Thermal Processes, John Wiley, London, 1991.
5) C.S. Solanki, Solar Photovoltaics: Fundamental, technologies and applications, Prentice Hall of India, 2011
6) Antonio Luque, Steven Hegedus; Handbook of Photovoltaic Science and Engineering; John Wiley and Sons, 2002


## Assessment:

**Internal:** Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

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

| Subject Code | Subject Name | Credits |
|---|---|---|
| **EGE2041** | **HEAT EXCHANGER DESIGN&** | **04** |

| Module | Detailed Content | Hours |
|---|---|---|
| 1 | Constructional Details and Heat Transfer: Types - Shell and Tube Heat Exchangers - Regenerators and Recuperators - Industrial Applications Temperature Distribution and its Implications - LMTD – Effectiveness | 10 |
| 2 | Flow Distribution and Stress Analysis: Effect of Turbulence - Friction Factor - Pressure Loss - Channel Divergence Stresses in Tubes - Heater sheets and Pressure Vessels - Thermal Stresses - Shear Stresses - Types of Failures | 10 |
| 3 | Design Aspects: Heat Transfer and Pressure Loss - Flow Configuration - Effect of Baffles - Effect of Deviations from Ideality - Design of Typical Liquid - Gas-Gas-Liquid Heat Exchangers | 10 |
| 4 | Condensers and Evaporators Design: Design of Surface and Evaporative Condensers - Design of Shell and Tube - Plate Type Evaporators | 10 |
| 5 | Cooling Towers: Packing - Spray Design - Selection of Pumps - Fans and Pipes - Testing and Maintenance, Compact cooling towers | 10 |
| 6 | Design of Special Purpose Heat Exchangers: corrosive environment. Marine/space applications, compact heat exchanger | 10 |

& **Common for Energy Engineering and Thermal Engineering**

## References:


1) T.Taborek, G.F. Hewittand N. Afgan, Heat Exchangers, Theory and Practice, Mac Graw-Hill Book Co., 1980
2) Walker, Industrial Heat Exchangers- A Basic Guide, Mc Graw-Hill Book Co., 1980
3) Arthur P Fraas, Heat Exchanger Design, John Wiley and Sons, 1988


## Assessment:

**Internal:** Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

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

| Subject Code | Subject Name | Credits |
|---|---|---|
| **EGE2042** | **INSTRUMENTATION IN THERMAL ENGINEERING** | **04** |

| Module | Detailed Content | Hours |
|---|---|---|
| 1 | Measurement characteristics: Instrument classification, Characteristics of Instruments - Static and dynamic, experimental error analysis, systematic and random errors, Statistical analysis, Uncentainity, Experimental planning and selection of measuring instruments, Reliability of instruments. | 14 |
| 2 | Microprocessors and computers in measurement: Data logging and acquisition, use of intelligent instruments for error reduction, element of micro-computer interfacing, intelligent instruments in use. | 10 |
| 3 | Measurement of physical quantities: Measurement of thermo-physical properties, instruments for measuring temperature, pressure and flow, use of intelligent instruments for the physical variables. | 12 |
| 4 | Flow visualization techniques :shadow graph, Schlieren, interferometer, Laser Doppler anemometer, heat flux measurement,Telemetry in engines | 12 |
| 5 | Measurement analysis: Chemical, thermal, magnetic and optical gas analysers, measurement of smoke, dust and moisture, gas chromatography, spectrometry, measurement of pH, Review of basic measurement techniques | 12 |

## References:


1. Holman, J.P., Experimental methods for engineers, McGraw-Hill, 1988.
2. Barney, Intelligent Instrumentation, Prentice Hall of India, 1988.
3. Prebrashensky, V., Measurements and Instrumentation in Heat Engineering, Vol.1 and 2, MIR Publishers,1980.
4. Raman, C.S., Sharma, G.R., Mani, V.S.V., Instumentation Dervices and systems, Tata McGraw Hill, New Delhi, 1983.
5. Doeblin, Measurements System Application and Design, McGraw Hill, 1978.
6. Morris. A.S, Principles of Measurements and Instrumentation, Prentice Hall of India, 1998.


## Assessment:

**Internal:** Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

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

| Subject Code | Subject Name | Credits |
|---|---|---|
| **EGE2043** | **THERMAL ENERGY SYSTEMS** | **04** |

| Module | Detailed Content | Hours |
|---|---|---|
| 1 | REVIEW OF THERMAL PROCESS AND APPLICATIONS:<br>First and second law of thermodynamics-cycles-ideal gas mixtures and psychometry-Energy analysis and its use in design of energy system-Dead states and energy components-Exergy balance for closed and control volume systems-applications of exergy analysis for selected energy system design | 11 |
| 2 | DESIGN OF WORKABLE SYSTEMS:<br>Methodology of engineering undertakings-distinction between workable and optimum systems-examples-Equation Fitting for characterization of energy Equipments-Applications of equation fitting techniques for characterization of energy processes and techniques | 11 |
| 3 | MODELING OF ENERGY EQUIPMENT BASED UPON PHYSICAL LAWS:<br>Heat Exchanger -Solar collectors-Distillation and Rectifications-Information flow diagrams-Application of successive method and Newton Rhapson Method to Energy Systems | 11 |
| 4 | OPTIMIZATION TECHNIQUES FOR ENERGY SYSTEM:<br>Selection of Mathematical Representation for Optimization Problems in Energy Systems-Applications of Lagrange's Multipliers and Various search methods to Energy Systems, such as Waste Heat Recovery System-Refrigeration Systems, etc., | 11 |
| 5 | OPTIMIZATION TECHNIQUES FOR HEAT EXCHANGER NETWORKS:<br>Basic concepts of pinch technology & Stream Network-composite curves maximum energy recovery-design of energy recovery systems | 08 |
| 6 | ENERGY ECONOMICS : Cost analysis by present worth-annual cost-Evaluating potential Investments-Forecasting Techniques-Economic Factors in Energy Systems-Examples | 08 |

## References:


1. W.F.Stocker(1989):Design of Thermal Systemas,McGraw Hill
2. B.Linhoff et al.(19840,User Guide on process intergration for the efficient use of energy
3. M.J.Moran and H.N.Shapiro(1988):Fundamentals of Enginering Thermodynamics
4. A.Bejan,G.Tsatsaronis and M.Moran (1996):Thermal Design and Optimization John Wiley & Sons


## Assessment:

**Internal:** Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

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

| Subject Code | Subject Name | Credits |
|---|---|---|
| **EGE2044** | **HYDROPOWER SYSTEMS** | **04** |

| Module | Detailed Content | Hours |
|---|---|---|
| 1 | INTRODUCTION:<br>Overview of Hydropower systems-Preliminary Investigation-Determination of Requirements-preparation of Reports and Estimates-Review of World Resources-Cost of Hydroelectric Power-Basic Factors in Economic Analysis of Hydropower projects-Project Feasibility-Load Prediction and Planned Development | 12 |
| 2 | DEVELOPMENT OF PROTOTYPE SYSTEMS:<br>Advances in Planning,Design and Construction of Hydroelectric Power Stations-Trends in Development of Generating Plant and Machinery-Plant Equipment for pumped Storage Schemes-Some aspects of Management and Operations-Uprating and Refurbishing of Turbines | 12 |
| 3 | POWER STATION OPERATION AND MAINTENANCE: Governing of Power Turbines-Functions of Turbine Governor-Condition for Governor Stability-Surge Tank Oscillation and Speed Regulative Problem of Turbine Governing in Future | 12 |
| 4 | RESERVOIRS:<br>Problem of management-Maintenance of Civil Engineering works-Maintenance of Electrical Engineering works | 12 |
| 5 | DEVELOPMENT OF SOFTWARE:<br>Computer aided Hydropower System Analysis-Design-Execution-Testing-Operation and control of Monitoring of Hydropower Services | 12 |

## References:


1. L.Monition,M.Lenir and J.Roux,Micro Hydro Electric Power Station(1984)
2. AlenR. Inversin,Micro Hydro Power Source Book(1986)
3. Tyler G.Hicks(1988),Power Plant Evaluation and Design


## Assessment:

**Internal:** Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

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

| Subject Code | Subject Name | Credits |
|---|---|---|
| **EGE2045** | **EMERGING BIO-FUEL TECHNOLOGIES** | **04** |

| Module | Detailed Content | Hours |
|---|---|---|
| 1 | INTRODUCTION: Liquid fossil fuels- transportation, industrial & domestic fuels; their properties; consumption pattern, prices and future scarcity; scope for biomass derived liquid fuels; use in boilers, I.C. engines, cooking etc. | 10 |
| 2 | OIL DERIVED FUELS: Vegetable oils- extraction methods, properties, suitability as combustion and IC engine fuel; Biodiesel- Base raw materals used, trans-esterification chemistry & processes, properties, use in diesel engines | 10 |
| 3 | ETHANOL FUEL: Fuel properties of ethanol; suitability as thermal and IC engine fuel, current status of use in Brazil, USA, India | 08 |
| 4 | ETHANOL PRODUCTION: 1st generation ethanol production by fermentation route, processes, reactors, applicable biomass sources; Ethanol production from lignocellulosic agro-residues (2nd generation)- potential, problems faced, technologies used | 10 |
| 5 | THERMOCHEMICAL ROUTES: Steam gasification of biomass- chemistry, reactors used- free fall, fluidised bed, entrained; Fischer-Tropsh conversion of synthesis gas to methanol, ethanol, or synthetic diesel - chemistry, operating parameters, catalysts; India's national hydrogen energy program | 10 |
| 6 | THERMOCHEMICAL PYROLYSIS ROUTE: Pyrolysis process- slow and fast, reactors- packed bed, ablative pyrolysis, rotating cone, fluidised bed; properties and use of oil produced<br>BIO-FUELS FROM MICRO-ALGAE: Process description, present status;<br>MICROBIAL FUEL CELLS | 12 |

## References:


1) J. Twidell and T. Weir, Renewable Energy Resources, Taylor and Francis (special Indian edition) 2006
2) G.N. Tiwari, M.K. Ghosal, Fundamentals of Renewable Energy Sources, Alpha Science Intnl. Ltd., 2007
3) *Hans P. Blaschek, Thaddeus Ezeji, Jürgen Scheffran*, Biofuels from Agricultural Wastes and Byproducts, Wiley Blackwell, 2010
4) V. V. N. Kishore (Editor), Renewable Energy Engineering And Technology: Principles And Practice, Earthscan Publications (Apr 2009)
5) Caye M. Drapcho, Nghiem Phu Nhuan, Terry H. Walker, Biofuels Engineering Process Technology; McGraw Hill, 2008
6) Prabir Basu; Biomass gasification and pyrolysis: Practical design and theory; Elsevier, 2010


## Assessment:

**Internal:** Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

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

| Subject Code | Subject Name | Credits |
|---|---|---|
| **EGL203** | **ENERGY AUDIT LAB** | **01** |

| **Module** | **Detailed Content** | **Hours** |
|---|---|---|
| 1 | Calculation of heating and cooling load | 4 |
| 2 | Preparation of energy audit plan and analysing energy audit data | 8 |
| 3 | Preparation of heat balance for a thermal machine | 4 |
| 4 | Determination energy efficiency of different machines | 4 |
| 5 | Preparation process flow diagram and energy utility diagram | 4 |

Note:
The experiments will focus on the following:

1. Ability to select and install the measuring instruments
2. Take accurate readings
3. Analyse the data
4. Interpret the results

## Industrial Training:

To acquaint the students with the methodology of Energy Audit, industrial training shall be arranged for not less than 4 weeks and not more than 8 weeks after completion of Sem-II exams and before commencement of Sem-III. The students are expected to implement energy audit procedures for any utility, system or process in the industry. The student will submit a report on the training which will be assessed by the concerned faculty.

## Assessment:

**End Semester Examination:** Practical/Oral examination is to be conducted by pair of internal and external examiners

| Subject Code | Subject Name | Credits |
|---|---|---|
| **EGL204** | **THERMAL ENERGY LAB** | **01** |

| **Module** | **Detailed Content** | **Hours** |
|---|---|---|
| 1 | Calibration of a temperature / flow measuring instrument | 4 |
| 2 | Performance of heat exchanger | 4 |
| 3 | Performance of compressor/ gas or steam turbine | 2 |
| 4 | Energy balance in boiler/ heat exchanger/ I.C.Engine etc. | 6 |
| 5 | Performance evaluation of commercially available heating/cooling/ drying equipment | 4 |
| 6 | Measurement of calorific value and proximate analysis of a biomass material | 4 |

Note:
The experiments will focus on the following:

1. Ability to select and install the measuring instruments
2. Take accurate readings
3 Analyse the data
5. Interpret the results
6. Carry out an error analysis

## Assessment:

**End Semester Examination:** Practical/Oral examination is to be conducted by pair of internal and external examiners

| Subject Code | Subject Name | Credits |
|---|---|---|
| **EGS 301** | **SEMINAR** | **03** |

**Guidelines for Seminar**

- **Seminar should be based on thrust areas in Mechanical Engineering**
- Students should do literature survey and identify the topic of seminar and finalize in consultation with Guide/Supervisor. Students should use multiple literatures and understand the topic and compile the report in standard format and present in front of Panel of Examiners. (pair of Internal and External examiners appointed by the University of Mumbai)
- **Seminar should be assessed based on following points**
  - Quality of Literature survey and Novelty in the topic
  - Relevance to the specialization
  - Understanding of the topic
  - Quality of Written and Oral Presentation

NOTE :

1. Assessment of Seminar will be carried out by a pair of Internal and External examiner. The external examiner should be selected from approved panel of examiners for Seminar by University of Mumbai, OR faculty from Premier Educational Institutions /Research Organizations such as IIT, NIT, BARC, TIFR, DRDO, etc. OR a person having minimum Post-Graduate qualification with at least five years' experience in Industries.

2. Literature survey in case of seminar is based on the broader area of interest in recent developments and for dissertation it should be focused mainly on identified problem.

3. At least 4-5 hours of course on Research Methodology should be conducted which includes literature survey, identification of problems, analysis and interpretation of results and technical paper writing in the beginning of 3$^{rd}$ semester.

| Subject Code | Subject Name | Credits |
|---|---|---|
| **EGD 301/401** | **DISSERTATION (I AND II)** | **12 +15** |

**Guidelines for Dissertation :**

- Students should do literature survey and identify the problem for Dissertation and finalize in consultation with Guide/Supervisor. Students should use multiple literature and understand the problem. Students should attempt solution to the problem by analytical/simulation/experimental methods. The solution to be validated with proper justification and compile the report in standard format.

**Guidelines for Assessment of Dissertation I :**

- Dissertation I should be assessed based on following points
  - Quality of Literature survey and Novelty in the problem
  - Clarity of Problem definition and Feasibility of problem solution
  - Relevance to the specialization
  - Clarity of objective and scope
- Dissertation I should be assessed through a presentation by a panel of internal examiners appointed by the Head of the Department/Institute of respective Programms.

**Guidelines for Assessment of Dissertation II :**

- Dissertation II should be assessed based on following points
  - Quality of Literature survey and Novelty in the problem
  - Clarity of Problem definition and Feasibility of problem solution
  - Relevance to the specialization or current Research / Industrial trends
  - Clarity of objective and scope
  - Quality of work attempted
  - Validation of results
  - Quality of Written and Oral Presentation
- Dissertation II should be assessed through a presentation jointly by Internal and External Examiners appointed by the University of Mumbai

Students should publish at least one paper based on the work in reputed International / National Conference (desirably in Refereed Journal)