SEMESTER I

15SE01 APPLIED NUMERICAL ANALYSIS

2 2 0 3

REVISION: Error analysis

SYSTEM OF EQUATIONS AND EIGENVALUE PROBLEMS: Solving set of equations - Gauss elimination method, LU - Choleski method, successive over relaxation method, system of non-linear equations - Newton Raphson method, power method and inverse power method. (8+8)

CURVE FITTING AND APPROXIMATION OF FUNCTIONS: Concept of least square approximations, linear regression, non-linear regression, error and standard deviation, multiple linear regression, applications of cubic splines - Bezier curves and B-splines.(6+6)

BOUNDARY VALUE PROBLEMS: Shooting method, solution through a set of equations, derivative boundary conditions, Rayleigh-Ritz method. (4+4)

ELLIPTIC PARTIAL DIFFERENTIAL EQUATIONS: Laplace's equation, Poisson equation - difference equation, Liebmann method - derivative boundary conditions, alternating direct implicit method, irregular and non-rectangular grids, matrix patterns, sparseness, applications to steady heat flow problems. (4+4)

PARABOLIC PARTIAL DIFFERENTIAL EQUATIONS: Explicit method, Crank-Nicholson method, derivative boundary condition, stability and convergence criteria, parabolic equations in two or more dimensions, applications to heat flow problems. (4+4)

HYPERBOLIC PARTIAL DIFFERENTIAL EQUATIONS: Solving wave equation by finite differences, stability of the solution, wave equation in two dimensions. (4+4)

Note: Exposure to softwares. Design problems will be given to the students and they have to submit assignments/term papers using programs.

Total L: 30 + T: 30 = 60

REFERENCES:

1. Curtis F Gerald and Patrick O Wheatley, “Applied Numerical Analysis”, Pearson Education, New Delhi, 2011.
2. Steven C Chapra and Raymond P Canale, “Numerical Methods for Engineers”, Tata Mcgraw Hill, New Delhi, 2007.
3. John H Mathews and Kurtis D Fink, “Numerical Methods using MATLAB”, Prentice Hall, New Delhi, 2005.
4. Ward Cheney and David Kincaid “Numerical Mathematics and Computing”, Cengage Learning, New Delhi, 2013.
5. Richard T Burden and Douglas Faires J, “Numerical Analysis”, Cengage Learning, New Delhi, 2012.

15SE02 CONCEPTS OF ENERGY ENGINEERING

3 0 0 3

THERMODYNAMICS: First law and its application, second law and its application, Irreversibility and energy, basic power generation cycles. (8)

FLUID MECHANICS: Properties of fluids, mass and momentum balance, flow through pipe, backed bed, pressure drop, continuity equation, Bernoulli’s equation, Navier stokes equation, Euler’s equation and examples. (10)

FLUID MACHINES: Principles of operation and selection of turbine, Pumps, fans, blowers and Compressors. (8)

HEAT TRANSFER: CONDUCTION – One dimensional steady state heat conduction: Composite walls – Critical thickness – Effect of variation of thermal Conductivity, Lumped System, Transient; CONVECTION Free convection –Forced convection. Boiling and condensation heat transfer, RADIATION- Physical mechanism – Radiation properties – Radiation shape factors – Heat exchange between non – black bodies – Radiation shields. (12)

ELECTRICAL SYSTEMS: Transformer, Induction motor and generators, speed control techniques, DC machines. Power systems: generation, distribution and transmission. (7)

Total L: 45

REFERENCES:

1. Zemansky M W, “Heat and Thermodynamics” 4th Edn. McGraw Hill, 1968.
2. Prasuhn L, “Fundamentals of Fluid Mechanics”, Prentice Hall, 1980

3. Sukhatme S P, “A Text book on Heat Transfer”, Orient Longman, 1979.
4. Sen P C, “Modern Power Electronics”, Wheeler, New Delhi, 1998.
5. Balbanian N and Bickart T A, “Electrical network theory”, John Wiley, New York, 1969

15SE03 THERMODYNAMICS AND COMBUSTION SYSTEMS

3 2 0 4

INTRODUCTION: First law and second law, systems, energy balance and conversion, properties of pure substances and mixtures. (6+6)

CYCLE ANALYSIS: Second law analysis, gas, steam and combined power cycles, refrigeration and air conditioning cycles, energy and exergy analysis of cycles. (8+6)

FUELS AND COMBUSTION: Fuels and types, fuel analysis, combustion calculations, theoretical and excess air requirements, excess air control, flue gas analysis and measurement, types of draught, draught calculations, chimney size calculations, F.D and I.D fan power requirements, furnace pressure requirements. (10+6)

COMBUSTION THEORY: Fuels and combustion process, combustion mechanism, adiabatic flame temperature, flame propagation, stability, kinetics, combustion aerodynamics, gaseous detonations, flame ignition and extinction and condensed phase combustion, combustion in SI and CI engines, ignition and burning rate analysis. (13+6)

DESIGN OF COMBUSTION SYSTEMS: Design of combustion systems for boilers, furnaces, gas turbines and internal combustion engines, combustion chamber, types and performance evaluation. (8+6)

Total L: 45+ T: 30=75

REFERENCES:

1. Kenneth Kuan-yunKuo, “Principles of Combustion”, Wiley - Interscience, 2005.
2. Colin R Ferguson and Allan T Kirk Patrick, “Internal Combustion Engines”, John Wiley and Sons. Inc. 2000.
3. Stephen R Turns, “Introduction to Combustion: Concepts and Applications”, McGraw Hill, 2000.
4. Gary L Borman and Kenneth W Ragland, “Combustion Engineering”, McGraw Hill, 1998.
5. Winterbone D and Elesaier, “Advanced Thermodynamics for Engineers”, 1996.

15SE04 THERMAL ENERGY CONSERVATION AND MANAGEMENT

3 0 0 3

INDUSTRIAL BOILERS: Introduction to thermal energy system, types and characteristics of industrial boilers, heat balance in boilers, draught and excess air controls, efficiency trials in boilers, energy conservation opportunities in boilers, operation and maintenance, water treatment requirements, soot blowing requirements, super heaters and superheat controls, waste heat recovery systems, ultra super critical boilers, CFB and FBC boiler types and their advantages. (10)

STEAM: Distribution requirement of steam and streamlines, efficient utilisation of steam, steam trapping and air venting, flash steam recovery, condensate recovery, thermal insulation for systems, steam balance calculations. Cogeneration - Types of cogeneration processes, topping cycle plant, bottoming cycle plant, combined cycle plant, application and economics. (10)

INDUSTRIAL FURNACES: Furnace types and characteristics, heat balance in furnaces, furnace efficiency calculations, energy conservation opportunities in furnaces, refractories, types and properties, waste heat recovery systems, insulating refractories, ceramic fibers, wall and stored heat loss reductions. (9)

EVAPORATION AND DRYING: Principle of evaporation and types of evaporators, mass and heat balance, single and multiple effect evaporators, capacity and steam economy calculations, vapour recompression system, energy conservation in evaporators, Principle of drying and types of driers, mass and heat balance in driers, energy conservation opportunities in drying operations. (9)

ENERGY AUDIT AND APPLICATIONS: Types, methodology, questionnaire development, specific energy consumption (unit wise/section wise), identification of energy conservation measures / technologies, economic and cost benefit analysis, energy benchmarking and targeting, case studies, ESCOS and energy service providers. Energy Conservation Act 2001, ISO standards. (7)

Total L:45

REFERENCES:

1. Trinks W and Mawhinney M H, “Industrial Furnaces”, John Wiley Publications, 2004.

2. PrabirBasu, Cen Kefa and Louis Jestin, “Boilers and Burners: Design and Theory”, Springer Publications, 1999.
3. Lyle O, “Efficient Use of Steam”, Heritage Publishers, 1963.
4. “Efficient Use of Fuel”, Her Majesty’s Stationary Office, UK, 1954.

15SE05 RENEWABLE ENERGY SYSTEMS

3 0 0 3

SOLAR ENERGY: Basic concepts, solar radiation, potential of solar energy, environmental aspects of solar energy, technologies overview - Photon-to-electric energy conversion, photon-to-thermal-to-electric energy conversion, photon-to-chemical energy conversion, semi-conductors, solar cell, batteries, satellite solar power systems, design of low power solar system. (10)

WIND ENERGY: Principles of wind power, wind turbine operation, site characteristics, horizontal and vertical axis types, aerodynamics of wind turbine, performance and wake analysis, design principles of wind turbine, tower design, new developments, small and large machines, magnus effect, storage systems. (10)

BIOMASS AND BIOGAS: Concepts and systems, biomass production, energy plantations, short rotation species, forestry system, biomass resource agro forestry wastes, municipal solid wastes and agro processing industrial residues, environmental factors and biomass energy development, combustion, pyrolysis, gasification and liquefaction, modeling, appliances and latest development. Bioconversion: biogas, fermentation and wet processes, chemicals from biomass and biotechnology. Biodiesel, ethanol, methanol, manufacture and properties. (10)

OTHER ENERGY SOURCES: Geothermal energy, types, systems and application, ocean thermal energy, systems and applications. Wave energy - systems and applications. Tidal energy - systems and applications. Magneto Hydrodynamic system (MHD), thermionic and thermo electric generator, fuel cells – types and applications, hydrogen technologies, micro-hydel systems. Hybrid systems and applications. (10)

RENEWABLE ENERGY PERFORMANCE ASSESSMENT : estimation of power generation in solar, wind, biomass, biogas, geothermal and OTEC (5)

Total L:45

REFERENCES:

1. Frank Kreith and Yogi Goswami D, “Handbook of Energy Efficiency and Renewable Energy”, CRC Press, 2007.
2. Kothari P, Singal K C and RakeshRanjan, “Renewable Energy Sources and Emerging Technologies”, PHI Pvt. Ltd., New Delhi, 2008.
3. Sukhatme S P and Nayak J K, “Solar Energy - Principles of Thermal Collection and Storage”, Tata McGraw Hill, 2008.
4. Rai G D, "Non Conventional Sources of Energy", Khanna Publishers, 2006.
5. Bent Sorensen, “Renewable Energy”, Academic Press, 2004.
6. Abbasi S A and Naseema Abbasi, “Renewable Energy Sources and their Environmental Impact”, PHI Private Limited, 2001.
7. Wakil M M H, “Power Plant Technology”, McGraw Hill, 1984.

15SE51 HEAT POWER LABORATORY

0 0 4 2

Each student shall design his/her own experiment by suitably modifying one of the existing experimental set ups in any of the laboratories of Thermal Stream under the supervision of Faculty-in-Charge of the Class and Staff-in-Charge, concerned Laboratory. He/she shall conduct the planned experiment and submit a detailed report on the experimental results obtained. The report shall also contain the detailed study carried out prior to designing the experiment. Grade will be awarded on the basis of the quality of the experiment conducted, the final report submitted, and oral examination conducted towards the end of the semester…

TOPICS FOR THE ORIENTATION PROGRAMME

1. Heat Transfer from Pin-Fin
2. Thermal Conductivity measurements by line and plane source Method
3. Forced Convection inside tube
4. Effectiveness of Parallel / Counter Flow Heat Exchanger
5. Thermal Conductivity of pipe insulation using lagged pipe apparatus
6. Determination of Emissivity of a Grey surface
7. Performance test on Spark Ignition engines using Alternate fuels such as ethanol and LPG.

8. Performance test on constant speed 4-stroke diesel engine and compare using PC interface
9. Heat balance test on 4-stroke diesel engine
6. Performance test on high pressure two stage reciprocating air compressor
10. Experiment of heating, ventilation and air conditioning unit
11. Experiment on Refrigeration tutor

Total P: 60

15SE61 INDUSTRIAL VISIT & TECHNICAL SEMINAR 1 0 3 2

The student will be required to visit atleast two industries and observe the industry functions.

The student will be required to present at least two technical presentations during this course on current topics related to his or her specialization. The same will be assessed by a committee appointed by the department. The student is expected to submit atleast two reports based on the above guidelines.

Total L: 15 + P: 45 = 60

SEMESTER II

15SE06 ENERGY ECONOMICS, FORECASTING AND MODELLING

3 0 0 3

ENERGY SCENARIO: Current trends in energy production and consumption, world energy flows, energy and economic growth. Primary energy industries, energy conversion processes, electric utilities and regulations, cost structure analysis, supply and availability, economics of energy use in agriculture, transport, building, Industry and energy substitution, cost benefit analysis. (10)
ENERGY MODELLING: Modeling concepts, different models like simulation, equilibrium, optimization, concept of energy multipliers and implications of energy multipliers for analysis of regional, national energy policy, energy and environmental input – output analysis including I - O model, interfile substitution models, SIMA model, MARKAL model for energy policy analysis. (14)

ENERGY COSTING: Evaluation of energy alternatives, time value of money, present and future worth methods, present worth comparison, IRR, and cost benefit analysis, replacement analysis, life cycle analysis, life cycle costing and management, case examples, energy project feasibilities. (10)

ENERGY DEMAND FORECASTING: Methodology for energy demand analysis including regression, econometric energy demand modeling, end-use method of energy demand analysis, other energy demand energy analysis methods, time series method, techno-economic approach to forecasting, sectoral energy demand forecasting, micro and macro forecasts. (11)

Total L: 45

REFERENCES:

1. William G Sullivan et. al, “Engineering Economy”, Pearson Education Inc., Delhi, 2001.
2. Fred Baseman, Jim Rossi and Jacqueline Weaver, “Energy, Economics and the Environment”, Foundation Press, 2000.
3. John A White et. al, “Principles of Engineering Economic Analysis”, John Wiley and Sons, New York, 1998.
4. Leland T Blank and Anthony J Tarquinii, “Engineering Economy”, McGraw Hill, 1998.
5. Cassedy, Edward S and peter Z Grossman, “Introduction to Energy: Resources Technology and Society”, Cambridge University Press, 1998.

15SE07 ENERGY AND THERMAL SYSTEMS DESIGN

3 0 0 3

THERMAL DESIGN: Basics of fluid flow and heat transfer required for design of energy systems, mathematical analysis, and regression analysis and equation fitting. (6)

MODELLING OF THERMAL SYSTEMS: Thermodynamics modeling and analysis of energy conversion equipments**,** Development of design philosophy and governing relations for thermal configurations to heat exchangers, motors, fans, pumps, compressors, turbines, piping, ducts, etc. and efficiency analysis. (6)

OPTIMIZATION: Optimization of energy systems using search methods, geometric programming, dynamic programming, linear

programming, search methods, genetic algorithms and neural network, particle swam optimization and Caslime algorithm. (6)

HEAT EXCHANGERS DESIGN: Classification - processes, number of fluids, surface compactness, construction features, flow arrangements and heat transfer mechanisms. Over view of heat exchanger design methodology, Finned and plate heat exchanger**:** Construction and operation, industrial application, pressure drop, thin fin analysis, fouling, corrosion, and erosion, design and operational issues. Compact heat exchanger**:** Industrial compact heat exchanger, fire tube heat exchanger, energetic analysis, surface comparisons, size, shape and weight relationships. (10)

HEAT TRANSFER ENHANCEMENT: Multiphase heat exchangers, multi-phase heat transfer analysis, fouling on enhanced surfaces, pool boiling, pitch analysis, non-uniform overall heat transfer, length effect, pressure drop analysis, flow maldistribution and header design, vapor space condensation, convective condensation. (10)

WASTE HEAT RECOVERY AND ECONOMICS: Sources of waste heat, recuperates, regenerators, economizers, waste heat boilers, fluidized bed heat exchangers, heat pipe exchangers, heat pumps, thermic fluid heaters, selection of waste heat recovery technologies and financial considerations. (7)

Total L: 45

REFERENCES:

1. Stoecker W G, “Design of Thermal Systems”, McGraw Hill, 2001.
2. Robert F Boehm, “Developments in the Design of Thermal Systems”, Cambridge University Press, 2005.
3. Ramesh K Shah and Dusan P Sekulic, “Fundamentals of Heat Exchanger Design”, Wiley Publications, 2003.
4. SadikKakac and Hongtanliu, “Heat Transfer Enhancement of Heat Exchangers”, Kluwer academic publishers, 1998.
5. Ralph L Webb and Nae – Hywn Kim, “Principles of Enhanced Heat Transfer”, Taylor & Francis, 2005.

15SE08 COMPUTATIONAL FLUID DYNAMICS

3 0 0 3

CONCEPT: Basic principles of fluid flow, derivation of the governing equations, conservation of mass, momentum and energy, numerical methods related to CFD. (8)

GRID GENERATION: Choice of grid, grid oriented velocity components, Cartesian velocity components, staggered and collocated arrangements, adaptive grids. (4)

DISCRETISATION: Finite difference method, forward, backward and central difference schemes, explicit and implicit methods, properties of numerical solution methods, stability analysis, and error estimation. (8)

CFD TECHNIQUES: Mathematical classification of flow, hyperbolic, parabolic, elliptic and mixed flow types, Lax - Wendroff technique, MacCormack’s technique, relaxation technique, artificial viscosity, ADI technique, pressure correction technique, SIMPLE algorithm, upwind schemes, flux vector splitting. (9)

FINITE VOLUME METHOD: Introduction, difference between FDM and FVM, approximation of surface integrals, approximation of volume integrals, interpolation practices, implementation of boundary conditions. (7)

TURBULENCE MODELING: Turbulence energy equation, one-equation model, k-ω model, R k- ε models. (3)

APPLICATIONS: Fluid flow and heat transfer problems, piping, burners and furnace. (6)

Total L: 45

REFERENCES:

1. Muralidhar K and Sundararajan T, “Computational Fluid Flow and Heat Transfer”, Narosa Publications, 2003.
2. Chung T J, “Computational Fluid Dynamics”, Cambridge University Press, 2002.
3. Joel H Ferziger and MilovanPeric, “Computational Methods for Fluid Dynamics”, Springer Publications, 1999.
4. John D Anderson, “Computational Fluid Dynamics – The Basics with Applications”, McGraw Hill, 1995.
5. Versteeg H K and Malalasekara W, “An Introduction to Computational Fluid Dynamics - The Finite Volume Method', Longman, 1995.

15SE09 INSTRUMENTATION FOR ENERGY SYSTEMS 3 0 0 3

GENERALIZED INSTRUMENTATION SYSTEM: Error theory – Calibration of instruments – Range – resolution – Span – Linearity, Sensitivity- Signal conditioning systems. (5)

PRESSURE AND TEMPERATURE MEASUREMENT: Bimaterials, Pressure thermometers, Thermocouples, RTD, Thermisters, and Pyrometry, pyrometers- Calibration of Pressure measuring equipment, principles and operation of various vacuum pumps and gauges. (12)

FLOW MEASUREMENT: Variable head flow meters- Rota meters, Electromagnetic flow meters, Hot wire anemometers, Hot film transducers, Ultrasonic flow meters. (8)

AIR POLLUTION AND ENERGY MEASUREMENTS: Particulate sampling techniques, SO_2, Combustion Products, Opacity , odour measurements - Measurement of liquid level, Humidity, O_2, CO_2 in flue gases- pH measurement, moisture analyzer. (8)

ELECTRICAL ENERGY MEASUREMENT: power factor, load factor, harmonic analyzer, lighting and lamination measurement, Digital data processing and Data acquisition system. (4)

ADVANCE MEASURMENT TECHNIQUES: Shadowgraph, Schlieren, Interferometer, Laser Doppler Anemometer, Hot wire, Anemometer, heat flux sensors, Telemetry in measurement. (8)

Total L: 45

REFERENCES:

1. Sawhney A K and PuneetSawney, “A course in Mechanical Measurements and Instrumentation” DhanpatRai & Co 2002.
2. Doebelin E O, “Measurement Systems - Application and Design”, McGraw-Hill, 2004.
3. Bechwith, Marangoni and Lienhard, “Mechanical Measurements” Addison-Wesley, 2000.
4. Holman J P, “Experimental methods for engineer’s”, McGraw-Hill, 1994.
5. Rangan C S, Sharma G R and Mani V S V, “Instrumentation Devices and Systems”, Tata McGraw-Hill, 1983.

15SE10 ELECTRICAL ENERGY CONSERVATION AND MANAGEMENT

3 0 0 3

ELECTRICAL ENERGY AUDIT: Electrical energy use and electrical energy audit, tariff and billing system, energy and demand charges, electrical demand and load factor improvement, power factor correction, power demand control, demand shifting, maximum demand controllers, transmission and distribution losses. (4)

ELECTRICAL MACHINES: Motors performance characteristics, duties and ratings of motors, motor selection, factors affecting motor performance, efficiency at part load, idle running, VSD drives and applications, load reduction, effect of rewinding on motors performance, energy efficient motors, generators, energy efficient transformers. (8)

ELECTRICAL ENERGY CONSERVATION IN DRIVEN EQUIPMENTS: Input electrical energy requirements in pumps, fans, and compressors, load factor estimation in the equipments, Energy conservation in pumps, fan and compressors, electrical energy conservation in refrigeration and A/C system, operation and maintenance practices for electrical energy conservation, soft starter with energy saver, case examples.Energy efficiency of industrial DG Sets, maintenance practices, load matching, PF improvement and parallel operation. (8)

INDUSTRIAL LIGHTING: Choice of lighting, energy saving, control of lighting, lighting standards, lighting audit, use of different lighting technologies, electronic ballast. (6)

DEMAND SIDE MANAGEMENT: Basic concepts, load research, importance of demand side management, types of DSM, efficiency gains, estimation of energy efficiency potential, barriers for energy efficiency and DSM, measurement and verification protocols, smart grids. (5)

Total L: 31

LABORATORY COMPONENTS:

1. Performance study of Stator Voltage Controlled Induction Motor Drive.
2. Modelling and Simulation of Electric Drives using MATLAB.
3. Modelling and Simulation of Electric Drives using PSIM.
4. Variable speed drive (VSP)

REFERENCES:

1. Openshaw Taylor E, "Utilisation of Electric Energy", Orient Longman Ltd., 2003.
2. Donald R Wulfinghoff, “Energy Efficiency Manual”, Energy Institute Press, 1999.
3. Awasthi S K, “Energy Conservation”, ISTE Publication, 1999.

4. Daniel and Hunt V, "Wind Power - A Handbook of WECS", Van Nostrend Co., New York, 1998.
5. Thomas Markvart and Luis Castaser, “Practical Handbook of Photovoltaics”, Elsevier Publications, UK, 2003.

15SE52 COMPUTATIONAL FLUID DYNAMICS LABORATORY

0 0 4 2

In this course, students will be provided with an orientation programme on the following equipment/software for duration of 15 hours. 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, state 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 will 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. Expected hours needed for this work is 45 hours.

TOPICS FOR THE ORIENTATION PROGRAMME

1. Single Phase Flow simulation.
2. Two Phase Flow Simulation.
3. Heat Transfer Studies.
4. Combustion Simulation in SI Engine.
5. Combustion Simulation in CI Engine.
6. Mass Transfer Studies.
7. Simulation of condensation.
8. Simulation of Evaporation.
9. Simulation of Drying.

Total P: 60

SEMESTER III

15SE53 ENERGY ENGINEERING LABORATORY 0 0 4 2

In this course, students will be provided with an orientation programme on the following equipment/software for duration of 15 hours. 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, state 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 will 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. Expected hours needed for this work is 45 hours.

TOPICS FOR THE ORIENTATION PROGRAMME

1. Experimental study of solar water heating systems.
2. Experimental study of solar PV pump.
3. Experimental study of solar lighting systems and optimization of lighting.
4. Evaluation study of biomass gasifier based power plant.
5. Evaluation study of DG plant.
6. Performance evaluation of Air-conditioning system.
7. Design of a 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 for a room.
14. Wind farm analysis using WASP software.

Total P: 60

13SE71 PROJECT WORK I

0 0 6 3

1. Identification of problem
2. Literature survey
3. Scope and objectives
4. Experimental / simulation set up and analysis
5. Results and discussion
6. Conclusion

IV SEMESTER

13SE72 PROJECT WORK II 0 0 28 14

Same as listed in Project Work I or New project with same contents as in Project Work I.

ELECTIVE THEORY COURSES

(Six to be opted-out of which two may be an open elective from other M.E/M.Tech programmes)

15SE21 CLEANER PRODUCTION AND CDM

3 0 0 3

CLEANER PRODUCTION: Industrial and commercial sector development and related energy and environmental issues, energy economy interactions in stabilizing green house gases emission, long term strategies for reducing GHG emission, CP in industrial and commercial sectors, sustainability, life cycle analysis, pollution prevention and control, overview, approaches and technologies, industrial waste evaluation, sankey diagram for CP processes and case studies. (12)

PROCESS INTEGRATION: Process optimization by integrating energy and environmental aspects, energy management concepts and measures to improve energy efficiency. Energy and water pinch as waste minimization tool, occupational health and safety, quality of product, and other aspects of CP. (8)

CLEAN DEVELOPMENT MECHANISM (CDM): Carbon Credit, CER, Baselines in CDM, its context, key elements and concepts, additionality assessment, investment analysis, barrier analysis, common practice analysis, impact of CDM registration, baseline for small scale CDM projects, small scale CDM project criteria and types, project categories and approved methodologies. (12)

CDM PROJECTS AND EVALUATION: Establishing baselines for large scale CDM projects, procedures for the submission and approval of new methodologies. Baselines for a forestation and reforestation projects, sequestration projects, determining eligibility and establishing the baseline tools and models for estimating baseline emissions, estimation of energy savings and GHG emissions reductions, carbon credit, case examples. Green energy concept. (13)

Total L: 45

REFERENCES:

1. Tapas K Das, “Toward Zero Discharge: Innovative Methodology and Technologies for Process Pollution Prevention”, Wiley, 2005.
2. Paul L Bishop, “Pollution Prevention: Fundamentals and Practice”, McGraw Hill, 2000.
3. “Cleaner Production Training Manual”, United Nations Environment Programme, 1996.

4. Rossiter A P, “Waste Minimization through Process Design”, McGraw Hill, 1995.
5. www.epa.gov

15SE22 BUILDING ENERGY CONSERVATION AND GREEN BUILDINGS

3 0 0 3

BUILDING LOADS: Solar radiation, sun earth relationship and energy balance on the earth's surface, climate, wind, solar radiation, and sol-air temperature, sun shading and solar radiation on surfaces, energy impact on the shape and orientation of buildings, thermal properties of building materials. Steady state method, network method, numerical method, correlations, computer packages for carrying out thermal design of buildings and predicting performance, Zero energy buildings. (14)

ENERGY EFFICIENT TECHNOLOGIES FOR BUILDINGS: Passive cooling and day lighting, active solar and photovoltaic, building energy analysis methods, building energy simulation, building energy efficiency standards, energy management options, building energy audit and energy targeting, technological options for energy management. (8)

INDOOR ENVIRONMENTAL QUALITY REQUIREMENT AND MANAGEMENT: Psychrometry, comfort conditions, thermal comfort, ventilation and air quality, air conditioning requirement, visual perception, illumination requirement, lighting system design, lighting economics and aesthetics, impacts of lighting efficiency, auditory requirement. (8)

ENERGY CONSERVATION IN AIR CONDITIONING SYSTEMS: Cycles, air conditioning systems, energy conservation in pumps, fans and blowers, refrigerating machines, heat rejection equipment, energy efficient motors, insulation. (7)

GREEN BUILDINGS: Ecological sustainable design, life cycle analysis, barriers to green buildings, green building rating tools, material selection, embodied energy, operating energy, façade systems, ventilation systems, transportation, water treatment systems, water efficiency, building economics, LEED and IGBC codes. (8)

Total L: 45

REFERENCES:

1. Edward G Pita, “An Energy Approach- Air-Conditioning Principles and Systems”, Pearson Education, 2003.
2. Colin Porteous, “The New Eco-Architecture”, Spon Press, 2002.
3. Lever More G J, “Building Energy Management Systems”, E and FN Spon, London, 2000.
4. Ganesan T P, “Energy Conservation in Buildings”, ISTE Professional Center, Chennai, 1999.
5. John Littler and Randall Thomas, “Design with Energy: The Conservation and Use of Energy in Buildings”, Cambridge University Press, 1984.

15SE23 SOLAR ENERGY TECHNOLOGIES

3 0 0 3

SOLAR RADIATION: Solar constant, solar charts, measurement of diffuse, global and direct solar radiation: pyrheliometer, sunshine recorders, Green house effect. (10)

SOLAR COLLECTORS: Classification - air, liquid heating collectors, testing of flat plate collectors, analysis of concentric tube collector, Concentrator Collectors – Classification, concentrator mounting, focusing solar concentrators, heliostats, parabolic and dish. (12)

PHOTO-VOLTAIC SYSTEMS: Physics, material, characteristics, cell arrays, power electric circuits for output of solar panels, choppers, inverters, batteries, charge regulators, thermoelectric, stand alone, off/on grid, hybrid systems and construction concepts, performances analyzer and applications. (8)

APPLICATIONS: Solar powered absorption A/C system, solar cooler, solar power station, water pump, chimney, dryer, dehumidifier, still, desalination, furnaces, cooker, swimming pool, solar ponds, and solar energy economic analysis, performances analysis and system design. (15)

Total L:45

REFERENCES:

1. Sukhatmae S P and Nayak J P, “Solar Energy- Principles of thermal collection and storage”, TATA McGraw-hill 2008.
2. Yogi Goswami D, Frank Kreith and Jan F Kreider, “Principles of Solar Engineering”, Taylor & Francis, 2003.
3. Edward E Anderson, “Fundamentals for solar energy conversion”, Addison Wesley Publ. Co., 1983.
4. Duffie J A and Beckman W A, “Solar Engineering of Thermal Process”, John Wiley, 1991.

5. Tiwari G N and Ghosal M K, “Fundamentals of Renewable Energy Sources”, Narosa Publishing House, New Delhi, 2007.

15SE24 DESIGN OF SOLID AND LIQUID WASTE CONVERSION SYSTEMS

3 0 0 3

WASTE TO ENERGY: Solid and liquid wastes – types, availability, composition, properties. Waste to energy incineration - process, schematics of incineration plants, furnace and boiler in waste incineration plant, environmental considerations. (9)

COGENERATION, FLUIDIZED BED BOILERS, PYROLYSIS AND WOOD GASIFICATION: Cogeneration – fluidized bed combustion boilers for burning solid biomass and fossil fuels. Pyrolysis of solid waste to obtain methane. Wood to oil process. (9)

LANDFILL: Landfills – principle, design, application of landfill gas, composition of landfill gas, gas collection systems. (9)

BIOMETHANATION AND HIGH RATE REACTORS: Biomethanation of liquid wastes – design and application. High rate reactors – types, principle, design and application, environmental consideration. (9)

COMPOSTING: Aerobic composting – process parameters, composting technology, determination of compost stability, environmental impacts of composting. (9)

Total L: 45

REFERENCES:

1. Poulsen G Tjalfe, “Solid waste management compendium”, Aalborg University, Sweden, 2003.
2. Prabhakar V K, “Solid waste management”, Anmol Publications Pvt. Ltd., New Delhi, 2001.
3. Parker C and Robers T, “Energy from waste – AN Evaluation of Conversion Technologies”, Elsevier Applied Science Publishers, London and New York, 1985.
4. Varma A and Behera B, “Green Energy”, Capital Publishing Company, Bangalore, 2003.
5. Anderson L A and Tillman D A, “Fuels from waste”, Academic press, New York, 1977.

15SE25 ADVANCED ENERGY TECHNOLOGIES AND SUSTAINABLE DEVELOPMENT

3 0 0 3

FUEL CELLS: Concept, key components, physical and chemical phenomena in fuel cells, advantages and disadvantages, different types of fuel cells and applications, characteristics, Nernst equation, relation of the fuel consumption versus current output, stoichiometric coefficients and utilization percentages of fuels and oxygen, mass flow rate calculation for fuel and oxygen in single cell and fuel cell stack, total voltage and current for fuel cells in parallel and serial connection, over-potential and polarizations, DMFC operation scheme, general issues-water flooding and water management, polarization in PEMFC. (10)

HYDROGEN: Introduction to hydrogen economy, production, storage and transportation systems, hydrogen from fossil fuels, electrolysis of water, thermo chemical cycles, baseline and alternative thermo chemical cycles and storage systems. (9)

HYDROGEN UTILISATION: Hydrogen for automotive applications, transmission and Infrastructure requirements, safety and environmental impacts, economics of transition to hydrogen systems. (9)

NEED FOR SUSTAINABLE DEVELOPMENT: definition of sustainable development, factors affecting sustainable development like air pollution, water source degradation, population explosion, agriculture and land degradation, global warming and climate change (8)

SUSTAINABILITY ACHIEVEMENT: Strategies for sustainability, Land Use and Urban Planning. Energy and Climate change, Transportation, Balancing Population with Food and Water Resources (9)

Total L: 45

REFERENCES:

1. Viswanathan B and AuliceScibioh “Fuel cells: Principles and Applications”, University Press, 2006.
2. Peter Hoffman, “Tomorrow’s Energy – Hydrogen Fuel Cells and the Prospects for Cleaner Planet”, MIT, 2002.
3. Prashukumar G P, “Hydrogen – A fuel for Automatic Engines”, ISTE, 1999.
4. Hart A B and Womack G J, “Fuel Cells: Theory and Applications”, Chapman and Hall, 1967.
5. Young G J, “Fuel cells”, Rein Hold Publishing Corp., 1960.

15SE26 NANO TECHNOLOGIES AND ENERGY SYSTEMS

3 0 0 3

INTRODUCTION: Size and shape dependence of material properties at the nanoscale, limits to smallness, scaling relations, nanoscale elements in conventional technologies. (4)

MANUFACTURING METHODS: Lithography, etching, ion implantation, thin film deposition, electron beam lithography, soft lithography: nanoimprinting and microcontact printing, solution/plasma-phase nanofabrication, sol-gel methods, template techniques, functional coatings with self assembled monolayers of molecules and nanoparticles, Langmuir-Blodgett films, layer-by-layer growth. (10)

CHARACTERIZATION OF NANOSTRUCTURES: General considerations for imaging, Scanning probe techniques: SEM, STM, AFM, NSOM, Metal and semiconductor nanoparticles: Synthesis, stability, control of size, optical and electronic properties, ultra-sensitive imaging and detection with nanoparticles. (9)

SEMICONDUCTOR AND METAL NANOWIRES: Vapor/liquid/solid growth and other synthesis techniques, nanowire transistors and sensors, carbon nanotubes - structure and synthesis, electronic, vibrational, and mechanical properties. (6)

NANO-MECHANICS: Enhancement of mechanical properties with decreasing size, nano-electro-mechanical systems, nanomachines, nanofluidics, filtration, sorting, molecular motors. (6)

NANO DEVICES AND APPLICATIONS: Pressure sensors, accelerometers, gyroscopes. Applications in factories: IR sensors, fluidic devices, Micro-actuators - electrostatic, magnetic, piezoelectric and thermal actuators. Micro-power sources - micro-fuel cell, micro-reactor, micro-engines. Applications in fuel systems. (10)

Total L: 45

REFERENCES:

1. Paul Holister, “Nanotechnology and the Future of Energy”, John Wiley and Sons, 2007.
2. Mark Wiesner and Jean-Yves Bottero, "Environmental Nanotechnology", Mcgraw Hill, 2007.
3. Louis Theodore, "Nanotechnology: Basic Calculations for Engineers and Scientists", Wiley-Interscience Publishing, 2005.
4. Michael Wilson and Geoff Smith and KamaliKannangara, “Nanotechnology: Basic Science and Emerging Technologies”, Chapman and Hall Publishers, 2002.

15SE27 DESIGN OF BIO-ENERGY SYSTEMS

3 0 0 3

PROPERTIES: Biomass resources and biomass properties – biomass – definition – classification – availability – estimation of availability, consumption and surplus biomass – energy plantations. Proximate analysis, Ultimate analysis, thermo gravimetric analysis and summative analysis of biomass – briquetting. (9)

PROCESSES: Biomass pyrolysis – pyrolysis – types, slow fast – manufacture of charcoal, methods, yields and application , manufacture of pyrolytic oils and gases, yields and applications. (9)

GASIFICATION: Biomass gasification – gasifiers – fixed bed system – downdraft and updraft gasifiers – fluidized bed gasifiers – design, construction and operation – gasifier burner arrangement for thermal heating – gasifier engine arrangement and electrical power – equilibrium and kinetic consideration in gasifier operation. (9)

COMBUSTION: Biomass combustion – biomass stoves – improved chullahs, types, some exotic designs – fixed bed combustors – types, inclined grate combustors – fluidized bed combustors – design, construction and operation and operation of all the above biomass combustors. (9)

WASTE UTILIZATION: Introduction to Energy from waste - classification of waste as fuel – agro based, forest residue, industrial waste, MSW – conversion devices – incinerators, gasifiers, digestors. (9)

Total L: 45

REFERENCES:

1. Desai and Ashok V, “Non Conventional Energy”, Wiley Eastern Ltd., 1990.
2. Khandelwal K C and Mahdi S S, “Biogas Technology - A Practical Hand Book - Vol. I & II”, Tata McGraw Hill Publishing Co. Ltd.,1983.
3. Challal D S, “Food, Feed and Fuel from Biomass”, IBH Publishing Co. Pvt. Ltd., 1991.
4. WereKo-Brobby C Y and Hagan E B, “Biomass Conversion and Technology”, John Wiley & Sons, 1996.

15SE28 NUCLEAR REACTOR ENGINEERING

3 0 0 3

NUCLEAR REACTOR THEORY: Basic principles, Radioactivity, Nuclear reactions, Cross sections, nuclear fission, Power from fission, Conversion and breeding, Neutron transport equation, Diffusion theory approximation, Fick's law. (8)

NUCLEAR REACTIONS: Mechanism of nuclear fission - nucleides - radioactivity – decay chains – neutron reactions -the fission process - reactors - types of fast breeding reactor - Nuclear Instrumentation. (8)

REACTOR MATERIALS: Nuclear Fuel Cycles - characteristics of nuclear fuels - Uranium - production and purification of Uranium - conversion to UF4 and UF6 - other fuels like Zirconium, Thorium - Berylium. (8)

NUCLEAR POWER PLANTS: Elements of Nuclear power plant, design and construction of nuclear reactors - heat transfer techniques in nuclear reactors - reactor shielding, Current Generation power reactors- Pressurized water reactors- heavy water reactor– Boiling water reactors –Gas-cooled reactors- Fast breeder reactor-nuclear fusion reactor – Advanced Design. (12)

WASTE DISPOSAL AND RADIATION PROTECTION: Types of nuclear wastes - safety control and pollution control and abatement – international convention on safety aspects - Hazards due to Nuclear power plants radiation hazards prevention. (9)

Total L: 45

REFERENCES:

1. Wakil M M El, “Nuclear Power Engineering”, McGraw Hill, 1962.
2. Winterton R H S, “Thermal Design of Nuclear Reactors”, Pergamon Press, 1981.
3. Murray R L “Introduction to Nuclear Engineering”, Prentice Hall, 1961
4. Olander and Donald R, "Fundamental Aspects of Nuclear Reactor Fuel Elements," TID-26711-P1, Technical Information Center, Springfield, Virginia, March 1985
5. Smith and Charles O, “Nuclear Reactor Materials”, Addison-Wesley, Reading, MA, 1967.

15SE29 ENERGY STORAGE SYSTEMS

3 0 0 3

ENERGY STORAGE MODES: Potential energy, Pumped hydro storage; KE and Compressed gas system: Flywheel storage, compressed air energy storage; Electrical and magnetic energy storage: Capacitors, electromagnets; Chemical Energy storage: Thermo-chemical, photo-chemical, bio-chemical, Superconducting Magnet Energy Storage (SMES) systems. (12)

ELECTROCHEMICAL ENERGY STORAGE SYSTEMS: Batteries- Primary, Secondary, Lithium, Solid-state and molten solvent batteries; Lead acid batteries; Nickel Cadmium Batteries; Advanced Batteries. Role of carbon nano-tubes in electrodes. (7)

ELECTRIC ENERGY STORAGE SYSTEMS: Capacitor and Batteries: Comparison and application; Super capacitor: Electrochemical Double Layer Capacitor (EDLC), principle of working, structure, performance and application, role of activated carbon and carbon nano-tube. (7)

SENSIBLE AND LATENT HEAT STORAGE: SHS mediums; Stratified storage systems; Rock-bed storage systems; Thermal storage in buildings; Earth storage; Energy storage in aquifers, Phase Change Materials (PCMs); Selection criteria of PCMs; solar thermal LHTE systems. (9)

APPLICATION: Food preservation; Waste heat recovery; solar energy storage; Green house heating; Power plant applications; Drying and heating for process industries, building systems. (10)

Total L: 45

REFERENCES:

1. Ibrahim Dincer and Mark A Rosen, “Thermal Energy Storage Systems and Applications”, John Wiley & Sons 2002
2. James Larminie and Andrew Dicks, “Fuel cell systems Explained”, Wiley Publications, 2003.
3. “Electrochemical tech ologies for energy storage and conversion”, Ru-shiliu, Leizhang, Xueliang sun, Wiley Publications, 2012 Robert A Huggins”, Energy Storage.
4. Ibrahim Dincer and Marc Rosen, “Thermal Energy Storage: Systems and Applications”.

15SE30 INDUSTRIAL PROCESSES AND ENERGY CONSERVATION

3 0 0 3

PROCESS EQUIPMENTS: Material and energy balances of different processes, major process equipments and their characteristics, performance evaluation, specific energy consumption analysis. Heat transfer principles and coefficient evaluation, evaluation of jacketed pan, heating coils immersed in liquids, refrigeration cycles and refrigerant, mechanical equipments, freezing and cold storage systems. (12)

ABSORPTION: Theory of absorption, extraction and washing equipments, performance evaluation, Energy requirements, Energy efficiency. (7)

ADSORPTION: Desiccant and adsorption systems in vehicles, energy recovery systems, chemical dehumidification, cold storage, Energy balance. (6)

CRYSTALLIZATION: Theory and types of crystallization, membrane separation, chillers, performance evaluation, Energy efficiency. (6)

MECHANICAL SEPARATION: Cyclones, centrifuges, filters, size reduction equipments, mixers, chemical reactors and bio-reactors, performance evaluation. (7)

COOLING TOWERS: Cooling tower system, types, performance parameters – range, approach, cycles of concentration, effectiveness, cooling tower losses, factors affecting performance, flow control strategies, energy saves opportunities, performance improvement. (7)

Total L: 45

REFERENCES:

1. Royce N Brown, “Compressors: Selection and Sizing” Gulf Professional Publishing, 2005.
2. James R Couper, W Roy Penney and James R Fair, “Chemical Process Equipment: Selection and Design”, Stan Walas Gulf Professional Publishing, 2004.
3. Ernest E Ludwig, “Applied Process Design for Chemical and Petrochemical Plants”, Vol. 3, Gulf Professional Publishing, 2001.
4. Ernest E Ludwig, “Applied Process Design for Chemical and Petrochemical Plants”, Vol. 1, Gulf Professional Publishing, 1995.

15SE31 ADVANCED IC ENGINES

3 0 0 3

INTRODUCTION TO IC ENGINES: Introduction to thermodynamic analysis of SI and CI Engine combustion process. Air-fuel ratio requirements, Design of carburetor –fuel jet size and venture size, Direct and Indirect injection systems, Combustion chambers, Turbo charging, Stages of combustion-normal and abnormal combustion, Factors affecting knock, Combustion chambers. (9)

ENGINE EXHAUST EMISSION CONTROL: Formation of NOX, HC/CO mechanism, Smoke and Particulate emissions, Green House Effect, Methods of controlling emissions, Three way catalytic converter and Particulate Trap, Emission (HC, CO, NO and NOX,) measuring equipments, Smoke and Particulate measurement, Indian Driving Cycles and emission norms. (9)

ALTERNATE FUELS: Alcohols, Vegetable oils and bio-diesel, Bio-gas, Natural Gas, Liquefied Petroleum Gas, Hydrogen, Properties, Suitability, Engine Modifications, Performance, Combustion and Emission Characteristics of SI and CI Engines using these alternate fuels. (9)

RECENT TRENDS: Homogeneous Charge Compression Ignition Engine, Lean Burn Engine, Stratified Charge Engine, Surface Ignition Engine, Four Valve and Overhead cam Engines, Electronic Engine Management, Common Rail Direct Injection Diesel Engine, Gasoline Direct Injection Engine, Data Acquisition System –pressure pick up, charge amplifier PC for Combustion and Heat release analysis in Engines.

BIODIESEL APPLICATION IN IC ENGINES: Methods of Biodiesel making from raw oils-Conventional and non- conventional methods, Different fatty acids in biodiesel and their significance in defining bio diesel, Characterization of biodiesel- Cetane number evaluation, Additives used in the case of biodiesel, Cetane improvers, Kinematic Viscosity reducers, Comparison between diesel and biodiesel properties-Viscosity index verification. (9)

Total L: 45

REFERENCES:
1. John B. Heywood, “Internal Combustion Engine Fundamentals”, Tata McGraw-Hill 1988
2. Patterson D.J. and Henein N.A,“Emissions from combustion engines and their control,” Ann Arbor Science publishers Inc, USA, 1978.
3. Gupta H.N, “Fundamentals of Internal Combustion Engines”, Prentice Hall of India, 2006
4. Ultrich Adler , “Automotive Electric / Electronic Systems”, Published by Robert Bosh GmbH,1995

15SE32 EXPERIMENTAL ANALYSIS OF SYSTEMS

3 0 0 3

INTRODUCTION-BASIC CONCEPTS: Introduction-Definition of Terms-Calibration-Standards-Dimension and Units-The Generalized Measurements System-Basic Concepts in Dynamic Measurements-System Response-Distortion-Impedance Matching-Experiment Planning. (9)

ANALYSIS OF EXPERIMENTAL DATA: Introduction – Causes And Types of Experimental Errors-Error Analysis On A Commonsense Basis-Uncertainty Analysis-Evaluation of Uncertainties For A Complicated Data Reduction-Statistical Analysis of Experimental Data-Probability Distributions-The Gaussian Or Normal Error Distribution-Comparison of Data With Normal Distribution-The Chi-Square Test of Goodness of Fit-Method of Least Squares-The Correlation Coefficient-Multivariable Regression-Standard Deviation of The Mean-Students-T-Distribution-Graphical Analysis And Curve Fitting-Choice of Graph Formats-General Consideration In Data Analysis. (9)

THE MEASUREMENT OF TEMPERATURE: Introduction Temperature Scales-The Ideal-Gas Thermometer-Temperature Measurements By Mechanical Effects- Temperature Measurements By Electrical Effects- Temperature Measurements By Radiation-Effect Of Heat Transfer On Temperature Measurements-Transient Response of Thermal Systems-Thermocouple Compensation.Temperature Measurements in High speed flow. (9)

THERMAL-AND TRANSPORT-PROPERTY MEASUREMENTS: Introduction-Thermal Conductivity Measurements-Thermal Conductivity of Liquids and Gases-Measurements of Viscosity-Gas Diffusion-Calorimetry-Convection Heat-Transfer-Measurements-Heat-Flux Meters-Ph Measurements. (9)

DATA ACQUISITION AND PROCESSING: Introduction-The General Data Acquisition System- Signal Conditioning Revisited-Data Transmission-Analog-To-Digital And Digital-To-Analog Conversion-Data Storage And Display-The Program as A Substitute For Wired Logic. (9)

Total: 45

REFERENCES:
1. Holman J P, “Experimental Methods for Engineers”, McGraw-Hill Education private limited, New Delhi, 2007.
2. Principles of Experimental Research Course Packet, F&S Printing Department, 2011.
3. Bevington R P, Robinson D K, “Data Reduction and Error Analysis for the Physical Sciences”, McGraw Hill, 2003
4. Wheeler J A, Ganji A R, “Introduction to Engineering Experimentation”, Prentice Hall, 2003

ONE CREDIT COURSES

For the detailed Syllabi of all the one credit courses offered by Mechanical Engineering department which are listed in this programme scheme refer to the syllabi of M.E Engineering Design programme.

For the detailed syllabi of the electives and one credit courses offered by other departments refer to the syllabi of M.E- Automotive Engineering offered by Automobile Engineering Department.