SEMESTER I

21SE01 APPLIED NUMERICAL METHODS

Vide Engineering Design 21MD01

21SE02 DESIGN OF RENEWABLE ENERGY SYSTEMS

3 1 0 4

SOLAR THERMAL CONVERSION: Properties of solar radiation, absorption of light by the atmosphere, spectral distribution of sunlight, thermo-dynamical description of solar collectors, optical properties of solar collectors, technologies for fabrication of solar collectors, design of solar thermal systems for different applications. (12+4)

WIND AND WIND RESOURCE: The nature of the wind, geographical variation in the wind resource, long-term wind-speed variations, annual and seasonal variations, Synoptic and Diurnal variations; Turbulence - the boundary layer; Wind-speed prediction and forecasting. (11+4)

WIND POWER CONVERSION: Aerodynamic concepts, Betz's law of maximum power, rotor blade theory, design of blade Geometry and rotor diameter, performance curves, wind turbine siting and issues. (11+4)

BIOFUELS: Concepts and systems, sources, energy plantations; Design: pyrolysis, gasification and liquefaction systems; biogas, fermentation and wet processes, chemicals from biomass and biotechnology, biofuels. (11+3)

Total L: 45 +T: 15 = 60

REFERENCES:

1. Frank Kreith and Yogi Goswami D, “Handbook of Energy Efficiency and Renewable Energy”, CRC Press, 2017.
2. Kothari P, Singal K C and Rakesh Ranjan, “Renewable Energy Sources and Emerging Technologies”, PHI Pvt. Ltd., 2011.
3. Sukhatme S P and Nayak J K, “Solar Energy - Principles of Thermal Collection and Storage”, Tata McGraw Hill, 2017.
4. Rai G D, "Non Conventional Sources of Energy", Khanna Publishers, 2009.
5. Bent Sorensen, “Renewable Energy”, Academic Press, 2011.
6. Tony Burton, David Sharpe, Nick Jenkins, Ervin Bossanyi, “Wind Energy Handbook”, John Wiley and Sons, 2011.

21SE03 ENERGY CONSERVATION AND MANAGEMENT

3 1 0 4

ENERGY MANAGEMENT: Scope of energy audit, types of energy audit, detailed energy audit methodology, role of energy managers in industries; Energy Management System (EnMS): ISO standards, implementing energy efficiency measures, detailed project report, energy monitoring and targeting, identification of energy conservation measures / technologies, economic and cost benefit analysis, ESCOS. (11+2)

ENERGY EFFICIENCY IN THERMAL UTILITIES: Steam engineering in thermal and cogeneration plants- steam traps and various energy conservation measures; Boilers- losses and efficiency calculation methods, controls. Furnaces- heat balance in furnaces, furnace efficiency calculations, energy conservation opportunities in furnaces, Insulation and Refractories. (11+ 4)

ENERGY EFFICIENCY IN ELECTRICAL UTILITIES: Electrical system, motor, harmonics, diesel generator, centrifugal pumps, fans and blowers, air compressor, lighting system – energy consumption and energy saving potentials, design considerations. (12+4)

PERFORMANCE ASSESSMENT: Industrial case studies – assessment of energy generation/consumption in thermal station, steel industry, cement industry, textile industry, etc. (11+5)

Total L: 45 +T: 15 = 60

REFERENCES:

1. Energy Audit Manual The Practitioner’s Guide, EMC-Kerala and NPC 2017.
2. Bureau of Energy Efficiency - Energy Management Series, 2006.
3. Eastop T.D and Croft D.R, “Energy Efficiency for Engineers and Technologists”, Logman Scientific and Technical, 1990.
4. Reay D.A, “Industrial Energy Conservation”, Pergamon Press, 1979.
5. Openshaw Taylor E, "Utilisation of Electric Energy", Orient Longman Ltd, 2003.
6. Donald R Wulfinghoff, “Energy Efficiency Manual”, Energy Institute Press, 1999.

21SE04 ENERGY RESOURCES, ECONOMICS AND ENVIRONMENT

3 1 0 4

ENERGY RESOURCES: Current trends in energy production and consumption, world energy flows, energy and economic growth, supply and availability; Electric utilities and regulations, cost structure analysis, economics of energy use in agriculture, transport, building, Industry and energy substitution, cost benefit analysis – carbon credit and footprint. (12+4)

ENERGY MODELING AND FORECASTING: Modeling concepts 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, methodology for energy demand analysis including regression, econometric energy demand modeling, end-use method of energy demand analysis, time series method, techno-economic approach to forecasting, case studies on forecasting energy needs. (10+4)

ENERGY ECONOMICS: Simple payback period, time value of money, IRR, NPV, life cycle costing, cost of saved energy, and cost of energy generated, examples from energy generation and conservation, energy chain, primary energy analysis, life cycle assessment, net energy analysis, case studies on life cycle costing. (11+4)

ENVIRONMENTAL IMPACTS OF ENERGY USE: Global warming - sources of emissions, CO_2 emissions, impacts, mitigation and sustainability; carbon capture and storage. Air pollution - SOx, NOx, CO, particulates, formation of pollutants, measurement and controls; Effect of operating and design parameters on emission, control methods, exhaust emission test and procedures. (12+3)

Total L: 45 +T: 15 = 60

REFERENCES:

1. Energy and the Challenge of Sustainability, World energy assessment, UNDP New York, 2004.
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, 1999.
4. Fowler, J.M ., “Energy and the environment”, McGraw Hill,1984.
5. Robert Ristirer, and Jack P. Kraushaar., “Energy and the environment”, Willey, 2005.

STREAM SPECIFIC CORE I - Mechanical

21SE05 INDUSTRIAL COMBUSTION SYSTEMS

3 0 0 3

COMBUSTION THEORY: Stoichiometry, lean and rich mixture, basic reaction chemistry, chemistry of combustion, energetics, types of flame, pre mixed, diffusion, laminar and turbulent flames, adiabatic flame temperature, burners and types. (12)

FURNACE: Furnace types and classification, aerodynamic and heat transfer in furnaces, the single gas-zone model, the "long" furnace and other multi-zone models, effect of operating variables, reduction of furnace-wall losses, temperature control in industrial furnaces, oxygen enrichment in combustion processes. (11)

INDUSTRIAL BOILERS: Sectional, shell and water-tube boilers, design features of shell boilers, boiler water treatment and conditioning, gas-side corrosion and fouling problems, oil and gas-firing of boilers, coal firing, wastes as boiler fuel, boiler efficiency and part-load operation, condensing boilers. (11)

FLUE GAS ANALYSIS: Formation of unburnt combustibles, NOx, SOx, particulates; Thermal oxidizer, scrubber, thermo-gravity analyzer, Fourier-transform infrared spectroscopy (FTIR), cyclone separator, precipitator (11)

Total L: 45

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. 2015.
3. Stephen R Turns, “Introduction to Combustion: Concepts and Applications”, McGraw Hill, 2011.
4. Gary L Borman and Kenneth W Ragland, “Combustion Engineering”, McGraw Hill, 2011.
5. Winterbone D and Elesaier, “Advanced Thermodynamics for Engineers”, 2015.

STREAM SPECIFIC CORE I – Electrical

21SE09 MODELING AND ANALYSIS OF ELECTRICAL MACHINES

Vide 21ED03 MODELING AND ANALYSIS OF ELECTRICAL MACHINES

21SE06 Research Methodology and IPR

vide Automotive Engineering 21AE06

21SE72 AUDIT COURSE I

vide Automotive Engineering 21AE72

21SE51 ENERGY ENGINEERING LABORATORY

0 0 4 2

In this course, students will be provided with an orientation programme on the following equipment/software. After this orientation, each student is expected to formulate and complete an activity of interest which has to be derived from the orientation programme under the guidance of a faculty. The details like background, problem definition, 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 ORIENTATION

1. Performance evaluation of solar thermal system.
2. Performance evaluation of biomass digester.
3. Energy consumption and lumen measurement of lights and ballasts.
4. Power quality measurements of electrical power systems.
5. Performance evaluation of wind energy systems.
6. Aerodynamic performance of bluff and streamlined bodies.

Total P: 60

REFERENCES:

1. Energy engineering lab manual, Department of mechanical engineering, PSG College of Technology.
2. Solar concentrator training system, Experimental manual, Ecosense world, New Delhi.
3. Wind energy training system, Experimental manual, Ecosense World, New Delhi.

21SE52 ENERGY AUDIT LABORATORY

0 0 4 2

In this course, students will be provided with an orientation on the following topics for duration of 12-16 hours. Each student is expected to perform a case study by formulating and completing an activity of interest derived from the orientation under the guidance of faculty. The details expected in the final report to be submitted at the end of the semester are: literature review, objectives, methodology, error analysis and interpretation of results and conclusions.

TOPICS FOR ORIENTATION

1. Demo of Audit Instruments and Field Trial
2. Field Trial Studies of Electrical Utilities Energy Audit Instruments
3. Field Trial Studies of Thermal Utilities Energy Audit Instruments
4. Water Energy Audit Instruments
5. Building Energy Audit Instruments

Total P: 60

REFERENCES:

1. Energy Audit laboratory manual, Department of Mechanical Engineering, PSG College of Technology.
2. BEE materials
3. https://www.npcindia.gov.in/NPC/User/
4. https://pec.ac.in/sites/default/files/uploads/ENERGY%20AUDIT%20LAB%20final

SEMESTER II

21SE07 COMPUTATIONAL FLUID DYNAMICS

3 0 0 3

CFD AND THERMO-FLUIDS: Review on the physics of thermo-fluids, governing equations -continuity, momentum, and energy conservation - modeling, grid generation, simulation, and high-performance computing. (10)

COMPUTATIONAL APPROACH: Finite difference method, forward, backward and central difference schemes, explicit and implicit methods, properties of numerical solution methods, stability analysis, and error estimation, difference between FDM and FVM, approximation of surface integrals, approximation of volume integrals, interpolation practices, implementation of boundary conditions, specification for a CFD simulation, requirements for accurate analysis and validation for multi scale problems. (12)

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. (12)

TURBULENCE MODELING AND CFD APPLICATIONS: Turbulence energy equation, one-equation model, two-equation models (k-ω and k- ε models), review on advanced turbulence models, applications to fluid flow and heat transfer problems. (11)

Total L: 45

REFERENCES:

1. Muralidhar K and Sundararajan T, "Computational Fluid Flow and Heat Transfer", Narosa Publications, 2009.
2. Chung T J, "Computational Fluid Dynamics", Cambridge University Press, 2010.
3. Joel H Ferziger and MilovanPeric, "Computational Methods for Fluid Dynamics", Springer Publications, 2002.
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, 2007.

STREAM SPECIFIC CORE II - Mechanical

21SE09 THERMAL SYSTEMS DESIGN

3 1 0 4

THERMAL SYSTEMS: Energy systems, heat exchangers – classification, review of different design methodologies, pressure drop analysis, thin fin analysis, fouling, corrosion, and erosion, design and operational issues, exergy analysis, surface comparisons, size and weight relationships. (12+4)

MODELLING OF ENERGY SYSTEMS: Design of energy systems- mathematical analysis - thermodynamic modeling and analysis of energy conversion equipments - heat exchangers, motors, fans, pumps, compressors, turbines, piping, ducts, etc. and efficiency analysis. (12+4)

HEAT TRANSFER ENHANCEMENT TECHNIQUES: Flow maldistribution and header design, reduction of non-uniform heat transfer in heat exchangers, reduction of fouling, role of pitch analysis in a thermal system. (11+3)

WASTE HEAT RECOVERY SYSTEMS: Sources of waste heat, selection of waste heat recovery technologies and financial considerations, design aspects of waste heat recovery systems. (10+4)

Total L: 45 +T: 15 = 60

REFERENCES:

1. Stoecker W G, "Design of Thermal Systems", McGraw Hill, 2011.
2. Robert F Boehm, "Developments in the Design of Thermal Systems", Cambridge University Press, 2016.
3. Ramesh K Shah and Dusan P Sekulic, "Fundamentals of Heat Exchanger Design", Wiley Publications, 2007.
4. SadikKakac and Hongtanliu, "Heat Transfer Enhancement of Heat Exchangers", Kluwer academic publishers, 1998.
5. Ralph L WebbandNae – Hywn Kim, "Principles of Enhanced Heat Transfer", Taylor and Francis, 2005.

STREAM SPECIFIC CORE II - Electrical

21SE10 ELECTRIC DRIVES AND CONTROL

Vide 21ED07 ELECTRIC DRIVES AND CONTROL

3 1 0 4

21SE82 AUDIT COURSE II

vide Automotive Engineering 21AE82

21SE61 COMPUTATIONAL FLUID DYNAMICS LABORATORY

0 0 4 2

In this course, students will be provided with an orientation programme on the following equipment/software. After this orientation, each student is expected to formulate and complete an activity of interest which has to be derived from the orientation programme under the guidance of a faculty. The details like background, problem definition, 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 ORIENTATION
1. Flow simulation - Internal flow – Laminar region.
2. Flow simulation - External flow – Laminar region.
3. Flow simulation - Internal flow – Turbulence region.
4. Flow simulation - External flow – Turbulence region.
5. Flow simulation - Internal flow with heat transfer.
6. Flow simulation - External flow with heat transfer.

MINI PROJECT: Simulation of fluid flow/ heat transfer-based systems.

Total P: 60

REFERENCES:
1. CFD lab manual, Department of mechanical engineering, PSG College of Technology.

21SE62 ENERGY SIMULATION LABORATORY

0 0 4 2

In this course, students will be provided with an orientation programme on the following equipment/software. After this orientation, each student is expected to formulate and complete an activity of interest which has to be derived from the orientation programme under the guidance of a faculty. The details like background, problem definition, 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 ORIENTATION
1. Performance evaluation of solar systems using ray tracing tool.
2. Time series forecasting of wind speed using numerical tool.
3. Load resource analysis for the optimization of hybrid solar-wind systems using numerical tool.
4. Scheduled Heat Gain estimation using building energy management software.
5. Windows and daylight estimation using building energy management software.
6. Air movement and green features simulation using HVAC simulator.
7. Performance evaluation and parameter study of power plant systems using numerical tool.

MINI PROJECT: Modeling and simulation of energy systems using application software.

Total P: 60

REFERENCES:
1. Energy simulation lab manual, Department of mechanical engineering, PSG College of Technology.

21SE63 INDUSTRIAL VISIT AND TECHNICAL SEMINAR
vide Automotive Engineering 21AE63

SEMESTER – III

21SE71 PROJECT WORK – I
vide Automotive Engineering 21AE71

SEMESTER – IV

21SE81 PROJECT WORK – II
Vide Automotive Engineering 21AE81

PROFESSIONAL ELECTIVE THEORY COURSES (Four to be opted)

COMMON FOR MECHANICAL AND ELECTRICAL ENGINEERING STREAMS

21SE21 ADVANCED POWER PLANT ENGINEERING

3 0 0 3

INTRODUCTION: Energy scenario: India Vs. World - Load curves and – Thermodynamic analysis of Conventional Power Plants (Coal, Gas Turbine and Diesel) - Advanced Power Cycles - Kalina Cycle, IGCC-Integrated gasification combined cycle (9)

COAL BASED THERMAL POWER PLANTS: Basics of typical power plant utilities – Boilers, Nozzles, Turbines, Condensers, Cooling Towers, Water Treatment and Piping system – steam rate and heat rate – mean temperature of heat addition - Rankine cycle improvements – Superheat, Reheat, Regeneration, Super critical, ultracritical AFBC/PFBC – computation of per unit cost of power generation from coal/biomass (9)

GAS TURBINE AND DIESEL POWER PLANTS: Brayton cycle – Open and Closed – Improvements - Intercooler, Reheating and Regeneration. Diesel power plant – Layout - Performance analysis and improvement – Techniques for starting, cooling and lubrication of diesel engines - computation of per unit cost of power generation (9)

CHP AND MHD POWER PLANTS: Cogeneration systems – types - heat to power ratio - Thermodynamic performance of steam turbine, gas turbine and IC engine-based cogeneration systems – Polygeneration - Binary Cycle - Combined cycle. MHD-magneto hydrodynamic power plants – Open cycle and closed cycle- Hybrid MHD& steam power plants (9)

HYDROELECTRIC & NUCLEAR POWER PLANTS: Hydroelectric Power plants – classifications - essential elements – pumped storage systems – micro and mini hydel power plants. General aspects of Nuclear Engineering – Components of nuclear power plants - Nuclear reactors & types – PWR, BWR, CANDU, Gas Cooled, Liquid Metal Cooled and Breeder reactor - nuclear safety – Environmental issues - Computation of per unit cost of power generation (9)

Total L: 45

REFERENCES:
1. Nag, P.K., Power Plant Engineering, Tata McGraw Hill Publishing Co Ltd, New Delhi, 2017.
2. Haywood, R.W., Analysis of Engineering Cycles, 4th Edition, Pergamon Press, Oxford, 1991.
3. Wood, A.J., Wollenberg, B.F., Power Generation, operation and control, John Wiley, New York, 2013.
4. Gill, A.B., Power Plant Performance, Butterworths, 2016.
5. Lamarsh, J.R., “Introduction to Nuclear Engineering”, Pearson, 2001

21SE22 GREEN BUILDINGS

3 0 0 3

GREEN BUILDING CONCEPTS: High-performance green buildings - Impacts of building construction, operation, and disposal - Methods and tools for building assessment, LEED, Green Globes, Living Building Challenge, Green Building Coalition. (10)

BUILDING ASSESSMENT AND THE GREEN BUILDING PROCESS: Design and construction relationships -project management- BREEAM, CASBEE, green star, DGNB - site and landscape strategies, building energy system strategies, low energy buildings, renewable energy systems, building hydrologic cycle strategies, case studies on energy assessment. (11)

GREEN MATERIALS AND STRATEGIES: Materials selection strategies - multi-attribute standards (MAS) - life cycle assessment - indoor environmental quality (IEQ) analysis and strategies - construction team responsibilities and controls - building commissioning strategies - site operations. (12)

COST ANALYSIS AND STANDARDS: Carbon Accounting - economic issues and analysis - life cycle costing - business case for green buildings - green building codes and standards - International Green Construction Code ASHRAE 189P, ANSI/GG 01 - green building specifications - future directions in green high performance building technologies. (12)

Total L: 45

REFERENCES:
1. Abe Kruger, Carl Seville, “Green Building: Principles and Practices in Residential Construction”, Wiley, 2012.
2. Francis D. K. Ching, Ian M. Shapiro, “Green Building Illustrated” Wiley-2014.
3. Charles J. Kibert,” Sustainable Construction: Green Building Design and Delivery” John Wiley and Sons 2016.
4. The World Business Council on Sustainable Development (WBCSD) website: http://www.wbcsd.org.

21SE23 DESIGN OF SOLAR SYSTEMS

3 0 0 3

DESIGN OF SOLAR COLLECTORS: Solar constant, penetration depth, characteristics of radiation, 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)

SELECTION OF 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, performance analyzer and applications. (11)

ANALYSIS OF SOLAR THERMAL SYSTEMS: Steady state and dynamic analysis, solar pond, modeling of solar thermal systems and simulations in process design of active systems by f-chart and utilization methods. Water heating systems: active and passive, passive heating and cooling of buildings, solar distillation, solar drying. (10)

SOLAR ENERGY UTILIZATION: Solar powered vapor absorption air condition system, solar cooler, solar power station, water pump, chimney, dryer, dehumidifier, still, desalination, furnaces, cooker, swimming pool, and solar energy economic analysis, performance analysis and system design. (12)

Total L: 45

REFERENCES:

1. Sukhatme S. P., “Solar Energy - Principles of thermal collection and storage” Tata McGraw-Hil, 2017.
2. Duffie J. A. and Beckman W. A., “Solar Engineering of Thermal Processes”, John Wiley, 2013.
3. Goswami D. Y., Kreith F. and Kreider J. F., “Principles of Solar Engineering”, Taylor and Francis, 2000.
4. Sodha M. S., Bansal N. K., Bansal P. K., and Malik M. A. S., “Solar Passive Building: science and design”, Pergamon Press, 2012.
5. Malik M. A. S., Tiwari G. N., Kumar A. and Sodha M.S., “Solar Distillation”, Pergamon Press, 1982.

21SE24 DESIGN AND ANALYSIS OF TURBO MACHINES

3 0 0 3

TURBO MACHINERY FUNDAMENTALS: Recap of basic terminologies and fluid theory, Fundamental governing principles, Performance calculations. (12)

DESIGN PROCESS: An overview of different conventional design methodologies, Modules of design guidelines for each process, Discussion on the empirical relations and the new methodologies to overcome the assumptions. (11)

ENERGY CONSERVATIONS METHODS: Detailed theoretical performance study, Analyze the energy recovery methods by design principles, Introduction to optimization techniques (10)

SIMULATION TECHNIQUES AND EXPERIMENTAL METHODS: Basics of blade modeling and meshing using CAD tools, Geometry Similarity, Simulation Techniques Moving Mesh, Dynamic meshes, Multiple frame of references, Introduction to measurement instruments related to fluid machinery, Experimental methods and uncertainty analysis. (12)

Total L: 45

REFERENCES:

1. H. I.H. Saravanamuttoo, G. F. C. Rogers and H. Cohen, “Gas Turbine Theory”, Prentice Hall,7th Edition, 2017
2. S. L. Dixon, “Fluid Mechanics and Thermodynamics of Turbomachinery”, Pergamon Press, 6th Edition, 2010
3. R. I. Lewis and Arnold, “Turbomachinery Performance Analysis”, 1996
4. R. K. Turton, “Principles of Turbomachinery” , Chapman and Hall, 1995
5. Murty V D, “Turbomachinery”, Concepts Applications And Design, Taylor and Francis Ltd, 2018

21SE25 HYDROGEN ENERGY AND FUEL CELLS

3 0 0 3

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, strategies for sustainability, energy and climate change. (11)

HYDROGEN ENERGY: Introduction to hydrogen economy, production, storage and transportation systems, hydrogen from fossil fuels, electrolysis of water, thermo chemical cycles, transmission and infrastructure requirements, safety and environmental impacts, economics of transition to hydrogen systems. (11)

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. (11)

FUEL CELL DESIGN AND PERFORMANCE: 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. (12)

Total L: 45

REFERENCES:

1. John Wiley and sons., “Fuel cell fundamentals”, Willey 2016.
2. Viswanathan B and Aulice Scibioh, “Fuel cells: Principles and Applications”, University Press, 2008.
3. Peter Hoffman, “Tomorrow’s Energy – Hydrogen Fuel Cells and the Prospects for Cleaner Planet”, MIT, 2012.
4. Prashukumar G P, “Hydrogen – A fuel for Automatic Engines”, ISTE, 2013.
5. Hart A B and Womack G J, “Fuel Cells: Theory and Applications”, Chapman and Hall, 1967.

21SE26 BIO-ENERGY CONVERSION TECHNOLOGIES

3 0 0 3

ANALYSIS OF BIOMASS: Biomass resources and biomass properties, biomass classification, availability, estimation of availability, consumption and surplus biomass; energy plantations, proximate analysis, ultimate analysis, thermo gravimetric analysis and summative analysis of biomass and briquetting. (12)

PYROLYSIS: A pyrolysis plant, pyrolysis products, pyrolyser types, pyrolysis product yields and its influencing factors, pyrolysis kinetics, kinetic models. (10)

GASIFICATION: Biomass gasification plant, 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, gasifier product yields and its influencing factors. (12)

COMBUSTION: Biomass combustion, fixed bed combustors, inclined grate combustors fluidized bed combustors, design, construction and operation and operation of all the above biomass combustors, biomass stoves, improved challahs, types. (11)

Total L: 45

REFERENCES:

1. Prabir Basu, “Biomass Gasification and pyrolysis, a practical guide”, Academic press, 2018.
2. Desai and Ashok V, “Non Conventional Energy”, Wiley Eastern Ltd., 2008.
3. Khandelwal K C and Mahdi S S, “Biogas Technology - A Practical Hand Book - Vol. I and II”, Tata McGraw Hill Publishing Co. Ltd., 2002.
4. Challal D S, “Food, Feed and Fuel from Biomass”, IBH Publishing Co. Pvt. Ltd., 2010.
5. WereKo-Brobby C Y and Hagan E B, “Biomass Conversion and Technology”, John Wiley and Sons, 1996.

21SE27 INSTRUMENTATION FOR ENERGY SYSTEMS

3 0 0 3

INSTRUMENTATION SYSTEM AND ELECTRICAL ENERGY MEASUREMENT: Measurement terminologies, precision, range, accuracy, span, linearity, sensitivity, resolution, random errors, systematic errors, relative and absolute errors, uncertainty analysis of single and multiple measurements – calibration of instruments – range –resolution – span – linearity, sensitivity- signal conditioning system; Electrical Energy Measurement: Power factor, load factor, harmonic analyzer, lighting and lamination measurement, digital data processing and data acquisition system. (12)

TEMPERATURE AND PRESSURE MEASUREMENT: Working principle of various temperature devices, thermocouples, thermistor, RTD, measurement analysis, infrared camera; Working principle of pressure transducers and laser induced fluorescence (LIF), quantification, basics of algorithm used for quantification- calibration of Pressure measuring equipment, principles and operation of various vacuum pumps and gauges. (12)

FLOW MEASUREMENT: Variable head flow meters- rota meters-working principle of hot wire/film anemometry and particle image velocimetry, quantification, electromagnetic flow meters, ultrasonic flow meters. (11)

AIR QUALITY MEASUREMENT: 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. (10)

Total L: 45

REFERENCES:

1. Sawhney A K and Puneet Sawhney, “A Course in Mechanical Measurements and Instrumentation”Dhanpat Raiand Co 2017.
2. Doebelin EO, “Measurement Systems - Application and Design”, McGraw-Hill, 2017.
3. Rangan C S, Sharma G R and Mani V S V, “Instrumentation Devices and Systems”, Tata McGraw-Hill, 2016.
4. Holman JP, “Experimental methods for engineers”, McGraw-Hill, 2011.
5. Bechwith, Marangoni and Lienhard, “Mechanical Measurements” Addison-Wesley, 2009.

21SE28 ENERGY STORAGE DEVICES AND SYSTEMS

3 0 0 3

BATTERY PRINCIPLES: Introduction, battery types, Electrochemical reaction thermodynamics, Battery reaction kinetics, Charge transfer, Mass transport, Battery modeling, Battery characterization. (8)

FUEL CELL PRINCIPLES: Introduction, fuel cell types, Fuel cell thermodynamics, Fuel cell reaction kinetics, Charge transfer in fuel cells, Mass transport in fuel cells, Fuel cell modeling, Fuel cell characterization. (7)

BATTERY ENGINEERING: Overview of battery types, Lead acid battery systems, Nickel-Cadmium battery systems, Zinc battery systems, Ni-MH battery systems, Li-metal battery systems, Li-Ion battery systems, Li-polymer battery systems, Battery safety. (10)

FUEL CELL ENGINEERING: Overview of fuel cell types, Proton exchange membrane and solid oxide fuel cell materials, Overview of fuel cell systems, Fuel processing subsystem design, Thermal management, Fuel cell system design, Environmental impact of fuel cells (10)

APPLICATIONS AND CHALLENGES: Capacitor and super capacitor, Fuel cells and fuel cell application for electric vehicles, Energy storage systems for electric vehicles (design criteria, retention, cooling and management, battery management system), challenges infuel cell engineering (performance, durability and cost), Application of nanostructured materials in fuel cells, Micro-fuel cells, Modeling of catalyst design, Anion exchange membrane fuel cells. (10)

Total L: 45

REFERENCES:

1. Thomas Reddy, "Linden's Handbook of Batteries", 4th Edition, 2015
2. Ryan O'Hayre, Suk-Won-Cha, Whitney Colella and Fritz B. Prinz, "Fuel Cell Fundamentals", John Wiley, 2006.
3. Christopher D. Rahn and Chao-Yang Wang, "Battery System Engineering", Wiley, 2013
4. Robert A. Huggins, "Energy Storage", 1st Edition, 2012
5. D.A.J. Rand, "Batteries for Electric Vehicles", 1st Edition, 2014
6. Karl Kordesch and Gunter Simander, "Fuel Cells and Their Applications", VCH Publishers Inc, 2001.

MECHANICAL ENGINEERING STREAM

21SE29 FUNDAMENTALS OF TURBULENCE AND BOUNDARY LAYER THEORY

3 0 0 3

BOUNDARY LAYER THEORY: Boundary layer concept, displacement thickness, momentum thickness, laminar boundary layer on a flat plate, turbulent boundary layer on a flat plate, boundary layer thickness using Blasius solution and Von Karman approach, effect of pressure gradient and separation, Flow past bluff bodies and airfoil, concept of lift and drag. (11)

TURBULENT BOUNDARY LAYERS: Fully developed turbulent flow in a pipe, turbulent shear stress, turbulent velocity profile, internal flows – couette flow – two-layer structure of the velocity field – universal laws of the wall– friction law – channel flow, couette – poiseuille flows. (11)

TURBULENCE AND TURBULENCE MODELS: Nature of turbulence – averaging procedures – characteristics of turbulent flows – scales of turbulence, integral length scale, energy spectra, Kolmogorov's theory, Kolmogorov's scales, eddy viscosity and Prandtl's mixing length, Reynolds Average Navier Stokes equation (RANS), Two-equation models, low – reynolds number models, large eddy simulation. (11)

STATISTICAL THEORY OF TURBULENCE AND TURBULENT FLOWS: Ensemble average – isotropic turbulence and homogeneous turbulence – kinematics of isotropic turbulence – Taylor's hypothesis – dynamics of isotropic turbulence –grid turbulence and decay – turbulence in stirred tanks.

Turbulent flows: Wall Turbulent shear flows – structure of wall flow – turbulence characteristics of boundary layer – free turbulence shear flows – jets and wakes – plane and axi-symmetric flows. kinetic energy budget in a turbulent flow, turbulence production and cascade. (12)

Total L: 45

REFERENCES:

1. Biswas G. and Eswaran E., "Turbulent Flows, Fundamentals, Experiments and Modelling", Narosa Publishing House, 2002.
2. Schlichting H and Klaus Gersten, "Boundary Layer Theory", Springer 2017.
3. Garde R.J. "Turbulent Flow", New Age International (p) Limited, Publishers, 2013.
4. Rajaratnam N. "Turbulent Jets", Elsevier Scientific Publishing Company, 1976.
5. Hinze J.O., "Turbulence", McGraw-Hill Book Company, 1975.
6. Launder B. E. and Spalding D. B., "Mathematical Models of Turbulence", Academic Press, 1972.

21SE30 ENERGY CONSERVATION IN HVACR SYSTEMS

3 0 0 3

REFRIGERATION EQUIPMENT: Refrigerants-refrigeration cycles-refrigeration equipments-reciprocating, rotary, scroll, screw, centrifugal systems –refrigeration system components expansion coils and valves, evaporators, condensers and other auxiliary elements- sizing and selection of components. (12)

AIR CONDITIONING AND AIR SYSTEMS: Psychrometrics -thermal comfort-air conditioning process, classification, systems and sub systems, components selection- air systems, fans, coils, filters and humidifiers, air handling units(AHU),air ducts and space diffusion systems. (13)

HEATING AND VENTILATING SYSTEMS: Heat pumps and heat recovery systems, air-source heat pump, ground water heat pump systems, ground water coupled surface water heat pump, gas cooling and cogeneration, basics and constant-volume systems- variable-air-volume systems, VAV systems- fan combination, system pressure and smoke control- minimum ventilation and VAV systems controls- indoor air quality. (10)

I S STANDARDS, ENERGY MANAGEMENT AND CONTROL: IS code and standards: Air-condition equipments, pipes and fittings, pumps and valves, refrigeration and lubricants, insulation, ventilation, International codes and practices, automatic control systems- control loop and control methods-control modes-sensors and transducers- controllers and actuators-system architecture-interoperability-artificial network-functional controls and fault detection and diagnostics, BMS. (10)

Total L: 45

REFERENCES:

1. Shan.K.Wang, “Handbook of air conditioning and refrigeration” McGraw-Hill,2000.
2. ISHRAE “HVAC Data book” ISHRAE 2017.
3. Arora C.P., “Refrigeration and Air Conditioning”, Tata McGraw Hill Pub. Company, 2010.
4. Plant Engineers and Manager’s Guide to Energy Conservation, Fair Mount Press, 2011.
5. Edward Hartmann, “Maintenance Management, Productivity and Quality Publishing Pvt. Ltd”, 1995.
6. Carrier Air conditioning Co., “Hand Book of Air conditioning System Design”, McGraw-Hill, 2001.

21SE31 AERODYNAMICS OF STREAMLINED AND BLUFF BODIES

3 0 0 3

INVISCID AND INCOMPRESSIBLE FLOW: Lift, Drag, Moment and related coefficients conservation equations, flow lines, velocity functions, boundary layer, Bernoulli's equation, low-speed wind tunnel flows; Governing equations and boundary conditions; Elementary flows (uniform, sources, sinks and vortex); Ideal flow past a cylinder, conformal mapping, Kutta-Joukowski theorem and lift generation; Source panel method for non-lifting flows; D'Alembert's paradox. (13)

INCOMPRESSIBLE FLOW OVER AIRFOILS: Kutta condition; Thin airfoil theory (symmetric, cambered); Aerodynamic centre; Vortex panel method for lifting flows; Effect of viscosity and Stokes’ second problem. (10)

FINITE WING THEORY: Downwash and induced drag; Biot-Savart Law and Helmholtz's theorems; Prandtl's lifting line theory; Numerical lifting-line method. (10)

AERODYNAMICS AND WIND TUNNEL EXPERIMENTATION: Aerodynamics of horizontal-axis wind turbines, aerodynamics of bluff bodies, building aerodynamics, wind tunnel experiments, case studies. (12)

Total L: 45

REFERENCES:

1. Houghton E. L., Carpenter P. W. and Daniel T. Valentine, "Aerodynamics for Engineering students", Elsevier Ltd., 2013.
2. Lawson T, “Builing Aerodynamics”, Imperial College Press, 2010.
3. John D Anderson., "Fundamentals of Aerodynamics", McGraw Hill Book Co., 2011.
4. Hucho W H, “Aerodynamic of Road vehicles ", Butterworth Co. Ltd., 1998.
5. Pope A, “Wind Tunnel Testing ", John Wiley and Sons, 1974.
6. Tom L. Building Aerodynamics, World Scientific; 2010.

21SE32 STEAM GENERATION TECHNOLOGY

3 0 0 3

COMBUSTION MECHANISM, EQUIPMENT AND FIRING METHODS: Kinetics of combustion reactions, solid fuel combustion, mechanical stokers, coal firing mechanism, effectiveness of combustion reaction,goal gasification , chimney draught systems, effect of coal quality, pollution formation,Boiler Slagging and Fouling, pulversing mills. (12)

STEAM GENERATORS: Types of steam generators, fire and water tube boilers, energy efficient boilers, boiler optimization,Economisers,superheaters,reheaters, steam generation control,air preheaters, Fluidized bed boilers, thermodynamic design of fire tube boilers, ash handling system, feedwater treatment ,deaeration, evaporation, internal treatment, boiler blowdown and steam purity. (11)

STEAM CYCLES: Properties of steam, Rankine cycle, reheating and regeneration, , feed water heating, optimum degree of regeneration, supercritical pressure boilers, plant appraisal, cogeneration of power and heat. (10)

BOILERS PERFORMANCES: Design of boiler joints,Evaporation capacity, equivalence evaporation, factors of evaporation, heat loss calculations, boiler efficiency, feed water treatment. (12)

Total L: 45

REFERENCES:

1. Amiya Ranjan Mallick, “Practical Boiler Operation Engineering and Power Plant” , PHI Learning, 2015

2. Rayaprolu Kumar,” Boilers for Power and Process” , CRC Press Inc, 2009
3. Ganapathy V,“Steam Generators And Waste Heat Boilers: For Process and Plant Engineers”, Apple Academic Press, 2014
4. Esa Kari Vakkilainen, “Steam Generation From Biomass: Construction and Design of Large Boilers” , Butterworth-Heinemann, 2016
5. Paul Breeze, “Power Generation Technologies”, Newnes (Elsevier), 2019

21SE33 DESIGN OF WIND ENERGY SYSTEMS

3 0 0 3

DESIGN OF WIND TURBINE ROTOR: Basic aerodynamics-wind turbine model-blade element method-airfoil aerodynamics-boundary conditions-aerodynamic design of rotor-numerical simulation of wind turbine flow, rotor blades- polymer materials-processing technology-sandwich materials-material characterization**.** (11)

DESIGN OF MECHANICAL SYSTEMS: Rotor hub, blade pitch mechanism, rotor bearing concepts, rotor brake, gear box, nacelle, yaw system, assembly and performance testing, tower design. (11)

SELECTION OF ELECTRICAL AND CONTROL SYSTEMS: Synchronous and asynchronous generator, assessment criteria for electrical generators, fixed speed generators, variable speed generator systems, directly rotor-driven systems, total electrical system of wind turbine, control systems and operation sequence control, wind measurement system, yaw control, power and speed control by blade pitching, power limiting by aerodynamic stall, supervisory control and operational states, simulation and hardware of control systems. (11)

WIND TURBINE OPERATION, MAINTENANCE AND ECONOMICS: Wind farms, project development, planning, transportations, erection, grid connection, commissioning, operation and monitoring, safety aspects, maintenance and repair offshore wind energy, power optimization, power curve, annual energy yield, environmental impact, economics: factors influencing the wind energy, the present worth approach, cost of wind energy, benefits of wind energy, Case studies; yard sticks and tax advantages, carbon credit. (12)

Total L: 45

REFERENCES:
1. Hau E, von Renouard H, “Wind turbines: fundamentals, technologies, application, economics”. Springer,2003.
2. Burton T, Jenkins N, Sharpe D, Bossanyi E. “Wind energy handbook” John Wiley and Sons,2011 .
3. Mathew S, Philip GS, “Advances in wind energy and conversion technology” Berlin, Springer, 2013.
4. Johnson GL. Wind energy systems, Englewood Cliffs (NJ): Prentice-Hall,1985
5. Hansen MO,”Aerodynamics of wind turbines”, Routledge, 2015.

ELECTRICAL ENGINEERING STREAM

21SE34 // Vide 21ED28 SOFT COMPUTING TECHNIQUES FOR RENEWABLE ENERGY SYSTEMS

21SE35 // Vide 21ED34 OPTIMIZATION TECHNIQUES

21SE36 // Vide 21ED38 HYBRID ELECTRIC VEHICLES

21SE37 // Vide 21ED37 DISTRIBUTED GENERATION AND MICRO GRIDS

21SE38 // Vide 21ED36 SMART GRID TECHNOLOGIES

21SE39 // Vide 21ED29 FLEXIBLE AC TRANSMISSION SYSTEM

OPEN ELECTIVE THEORY COURSES (One to be opted)

21SE91 // Vide 21MC91 BUSINESS ANALYTICS IN PRACTICE

21SE92 // Vide 21MC92 LIFE CYCLE ASSESSMENT AND ECO - DESIGN

21SE93 // Vide 21MC93 SYSTEMS ENGINEERING AND MANAGEMENT