

**DEPARTMENT OF MECHANICAL ENGINEERING
MANIPAL UNIVERSITY JAIPUR**

M. Tech. in ENERGY SCIENCE AND TECHNOLOGY (EST)

MA6101: APPLIED NUMERICAL ANALYSIS [3 1 0 4]

Mathematical modeling and engineering problem solving: simple mathematical model, conservation laws and engineering. Approximations and round of errors: Accuracy and precision, error definitions, round off errors, truncation errors and Taylor's series. Roots of equations: Bracketing methods, open methods, roots of polynomials applied to engineering problems. Linear algebraic equations: LU decomposition and matrix inversion, special matrices and Gauss Seidel applied to engineering problems. Numerical Differentiation and Integration: Newton Cotes Integration formulas, integration of equations, numerical differentiation applied to engineering problems. Ordinary Differential Equations: RK methods, Boundary value and Eigen value problems. Partial Differential Equations: Finite difference method for elliptic and parabolic equation applied to engineering problems.

References:

1. S.C. Chapra and R.P. Canale, *Numerical Methods for Engineers*, McGraw Hill Publication, 1998.
2. S.S. Sastry, *Numerical Analysis for Engineers*, McGraw Hill Publication, 2002

ME6170: RESEARCH METHODOLOGY [3 0 0 3]

Mathematical tools for analysis, statistical analysis of data, regression analysis, correlation, concept of best fit and exact fit – Lagrange interpolation, Newton divided difference, least square regression. Design of experiment definition, objective, factorial design, designing engineering experiments, ANOVA, Fractional, Full and Orthogonal Experiments, Taguchi methods for robust design, response surface methodology. Engineering Optimization definition, basics of nonlinear optimization, formulation of optimization problems-examples, Calculus techniques- Lagrange multiplier method – examples, nature inspired optimization techniques i.e. GA, PSO, SA etc., neural network-based optimization, optimization using fuzzy systems. Sampling Techniques: basic terms, Importance of sampling in research, essentials of a good sample, sampling error, standard error of the mean (Standard Deviation), Estimation of parameters, accuracy & precision of estimation, sampling procedure, types/methods of sampling, Central limit theorem, sample size determination, confidence interval and Confidence level. Measurement & Scaling Techniques: - types of data: Primary & Secondary, Types of Scales: Ratio, Interval, Ordinal Nominal. Mapping rules, characteristics of a good measurement, sources of error in measurement. Mathematical modeling of Engineering systems Basic concepts of modeling of Engineering systems – Static and dynamic model – Model for prediction and its limitations, system simulation using tools like MATLAB, SPSS, Minitab, COMSOL, Ansys etc.- validation, use of optimization techniques – Genetic Algorithm, Simulated Annealing. Design of Experiments: Basic principles, Study of completely randomized and randomized block design.

Reference:

1. C R Kothari, *Research Methodology: methods and techniques*, New Age International Publication Ltd
2. J W Creswell, *Research Design*, Sage South Asia Edition
3. D G Montgomery, *Design and analysis of Experiments*, John Willy India Edition
4. Stuart Melville and Wayne guddard, *Research Methodology an introduction for Science & Engineering Students*.
5. Ganesen MJP Publishers, *Research Methodology for Engineers*, Chennai, 201.

ME6107: NON-CONVENTIONAL ENERGY SOURCES [3 1 0 4]

Introduction: Concepts of pollution and climate change, Sources of environmental pollution. Renewable energy sources: Solar energy, Calculation of solar radiation on horizontal and inclined surfaces, Measurement of solar radiation, Low temperature applications. Solar distillation, Heat pump, Solar refrigerator, Passive space conditioning, Solar thermal power generation, Photovoltaic. Wind energy, Physical and thermo-chemical methods of bioconversion, Biological methods. Hydropower Energy: Present status of hydro power, magneto-hydro-dynamic (MHD) energy conversion. Ocean energy resources, Ocean wave energy conversion and tidal energy conversion. Geothermal Energy: Types of

geothermal energy sites, Geothermal power plants. Nuclear Energy. Conversion of energy: Thermal, chemical, and electromagnetic energy into electricity. Renewable energy economics.

References:

1. S. P. Sukatme and J. Nayak, *Solar Energy Principles of Thermal Collection and Storage*, (3e), Tata Mc Graw Hill, 2008.
2. G. D. Rai, *Non-Conventional Energy Sources*, Khanna Publications, 2011.
3. H. P. Garg and J. Prakash, *Solar Energy: Fundamentals and Applications*, (1e) McGraw Hill Education, 2017.
4. S. Rao and Dr. B B Parulekar, *Energy Technology*, Khanna Publishers, 2004.
5. B. H. Khan, *Non-Conventional Energy Resources*, (3e), McGraw Hill Education India Private Limited, 2017.

ME6108: THERMAL SCIENCE AND ENGINEERING [3 1 0 4]

Introduction: Energy and entropy balances, Equilibrium criteria. Laws of thermodynamics and cycles: Entropy, Thermodynamics power cycles. Conduction heat transfer: Basic concepts of Conduction, Heat diffusion equations, Heat transfer laws, Heat transfer through wall, cylinder, sphere, Optimum thickness of insulation, Conduction with heat source, Unsteady state heat transfer. Convection heat transfer: Boundary layers concept, Dimensionless numbers, Various equations related to heat transfer during laminar and turbulent flow for flat plate as well as pipe flow, Convection with phase change. Condensation and boiling. Radiation heat transfer: Radiation heat transfer basic laws, Shape factor, Shape factor calculations for different bodies, Radiations exchange between surfaces. Heat exchangers and evaporators: LMTD, Effectiveness-NTU methods.

References:

1. P.K. Nag PK, *Engineering Thermodynamics*, (6e), McGraw Hill Education, 2008.
2. Boles M. A. and Cengel Y. A., *Thermodynamics: An Engineering Approach*, (8e) McGraw-Hill Education, 2017.
3. White F. M., *Fluid Mechanics*, (8e), McGraw-Hill Education, 2015.
4. F. P. Incropera, D. P. Dewitt, T. I. Bergman and A. S. Lavine, *Fundamentals of Heat and Mass Transfer*, (6e), John Wiley & Sons, 2006.

ME6109: ENERGY STORAGE [3 1 0 4]

Need for energy storage, Different modes of energy storage. Potential energy, Pumped hydro storage, KE and Compressed gas system, Flywheel storage, Compressed air energy storage, Electrical and magnetic energy storage, Capacitors, Electromagnets, and Battery storage systems. Chemical Energy storage, Thermo-chemical, Photochemical, Bio-chemical, Electrochemical, Fossil fuels and Synthetic fuels and Hydrogen storage. Laid Acid Battery, Proton exchange membrane Fuel cell/Microbial Fuel cell. SHS mediums, Stratified storage systems, Rock-bed storage systems, Thermal storage in buildings, Earth storage, Energy storage in aquifers, Heat storage in SHS systems, Aquifers storage Phase Change Materials (PCMs), Selection criteria of PCMs, Stefan problem, Solar thermal LHTES systems, Energy conservation through LHTES systems, LHTES systems in refrigeration and air-conditioning systems. Enthalpy formulation, Numerical heat transfer in melting and freezing process. Food preservation, Waste heat recovery, Solar energy storage.

References:

1. L.F. Cabeza, *Advances in Thermal Energy Storage Systems: Methods and Applications*, (2e), Woodhead Publishing, UK, 2020.
2. S. Kalaiselvam, and R. Parameshwaram, *Thermal Energy Storage for Sustainability-Systems Design, Assessment and Applications*, Academic Press Inc. 2014.
3. S. P. Sukhame and J P Nayak, *Solar Energy: Principles of Thermal Collection and Storage*, (3e) Tata McGraw Hill, 2008.
4. Harald Mehling and Luisa F. Cabeza, *Heat and Cold Storage with PCM*, Springer-Verlag Berlin Heidelberg, 2008.

ME6207: ENERGY AUDIT [3 1 0 4]

Energy audit concepts: Energy needs of growing economy, Long term energy scenario, Energy pricing, Energy sector reforms. Energy security, Energy strategy for the future, Energy conservation Act-2001 and its features. Energy Codes And Standards. Measurements: Mass and energy balances: Facility as an energy system, Methods for preparing process flow, Material, and energy balance diagrams. Financial Management: Investment-need, Appraisal and criteria, Financial analysis techniques- Simple payback period, Return on investment, Net present value, Internal rate of return, Cash flows, Risk and sensitivity analysis, Financing options, Energy performance contracts and role of ESCOs. Electricity tariff, Load management, Power factor improvement, Distribution, and transformer losses. Losses in induction motors, Motor efficiency, Factors affecting motor performance, Rewinding and motor replacement issues, Energy efficient motors, Light source, Choice of lighting, Luminance requirements, and Energy conservation avenues. Compressed air system: Types of air compressors, Compressor efficiency, Efficient compressor operation.

References:

1. Y.P. Abbi, and S. Jain, *Handbook on Energy Audit and Environment Management*, The Energy and Resources Institute, 2009.
2. Frank Kreith and D. Yogi Goswami, *Introduction to Energy Conservation and Management*, CRC Press, 2017.
3. Paul O'Callaghan, *Energy Management*, McGraw-Hill Education.
4. Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, *Energy Management Handbook*, (7e), CRC Press, 2011.

ME6208: MEASUREMENT & CONTROL IN ENERGY SYSTEMS [3 1 0 4]

Introduction: Basic measurement concepts, Measurement errors, Calibration, Uncertainty analysis. Thermo-flow measurement: Pressure, Velocity, Force, Temperature, Thermal radiation, Heat flux, Humidity. Measurement of Flow: Flow visualization techniques, Shadowgraph, Schlieren and interferometer. Temperature Measurement: Different principles of temperature measurement, Measurement of heat flux, Calibration of temperature measuring instruments. Air pollution sampling and measurement of particulates, SO_x, NO_x, CO, O₃, Hydrocarbons. Measurement of wind speed, Wind direction. Solar irradiance, Controls of solar and wind energy systems.

References:

1. S.P. Venkatesan, *Mechanical Measurement*, (2e), Ane Books Pvt. Ltd, 2015.
2. Karl B. Schnelle, Jr., Russell F. Dunn, Mary Ellen Terne, *Air Pollution Control Technology Handbook*, CRC Press, 2002 (Indian Reprint: 2014).
3. J.P. Holman, *Experimental Methods for Engineers*, 8th Edition, McGraw-Hill Education, (2011).
4. J. Billingsley, *Essentials of Control Techniques and Theory*, CRC Press, 2009.

ME6209: ENERGY ECONOMICS [3 1 0 4]

System economics: Sector wise consumption of energy resources, Electricity-fuel-transportation, Energy Scenario and supply position of different energy sectors: Indian and international Level – Coal, Oil, Natural Gas, RE, Hydro, Nuclear, Simple payback period, IRR, NPV, Life cycle costing, Cost of saved energy, Cost of energy generated. Energy demand forecasting: Forecasting, Simple and advanced techniques, Econometric approach to energy demand forecasting, Input-output model, Scenario based approach, ANN based approach, Hybrid approach, Energy demand analysis. Economics of demand/load management: Demand side management, cost effectiveness of DSM, Introduction to DSM, concept of DSM, Benefits of DSM, different techniques of DSM, Methods of DSM Load control, DSM planning.

References:

1. Subhes C. Bhattacharyya. *Energy Economics: Concepts, Issues, Markets and Governance*. Springer Science & Business Media, 2011.

2. T.C. Kandpal, *Financial Evaluation of Renewable Energy Technologies*, Macmillan Publishers India, 2003.
3. Peter Zweifel, Aaron Praktiknjo, and Georg Erdmann, *Energy Economics: Theory and Applications*, Springer-Verlag Berlin Heidelberg, 2017.
4. Aris Spanos, *Statistical Foundations of Econometric Modelling*, Cambridge University Press. 2011.

PROGRAM ELECTIVES:

ME6144: ALTERNATIVE FUELS [3 0 0 3]

Introduction: Estimation of conventional fuels, Advantages, and disadvantages of conventional fuels. Need for Alternative fuel, Availability and Comparative properties of Alternative fuels, classification of alternative fuels. Biofuels: Vegetable oil, Biodiesel and ethanol. Engine design modifications required & effects of design parameters on engine behaviour. Alcohols: Methods of using alcohols in CI and SI engines. Legal aspects of blending alternative fuels into conventional liquid fuels. Gaseous Fuels: Production of biogas, Factors affecting biogas formation and Usage of Biogas in SI engine & CI engine. Producer gas and their characteristics. Properties of LPG & CNG as engine fuels, Fuel metering systems, Combustion characteristics, Effect on performance, storage, Emission, Cost and safety. Other alternative fuels: Di-Methyl Ether (DME), Pyrolysis gas/oil, Synthetic gas/oil from plastic, rubber, coal, wood etc., Eco Friendly Plastic fuels (EPF).

References:

1. S.S. Thipse, *Alternative Fuels*, Jaico Publishing House, 2010.
2. Gerhard Knothe Jürgen Krahl Jon Gerpen, *The Biodiesel Handbook*, (2e) Academic Press and AOCS Press, 2010.
3. Richard L Bechtold, *Alternative Fuels Guidebook R-180*, Society of Automotive Engineers Published by SAE International, 1997.
4. G. D. Rai, *Non-Conventional Energy Sources*, Khanna Publications, 2011.

ME6145: CARBON AUDIT AND MANAGEMENT [3 0 0 3]

Greenhouse gas emissions from the energy sector and their time trend, Climate change and Other potential impacts of enhanced greenhouse effect caused by anthropogenic emissions primarily from extraction, conversion, transport, storage, and utilization of energy carriers. Carbon footprint, Carbon audit, Carbon management tools and accounting techniques. Life cycle assessment, Policies, Regulations, Protocols and Standards, Carbon credits and Carbon economics the concept of carbon sequestration. Clean development mechanism (CDM) and Its operationalization, Modalities and Procedures for CDM Project. Renewable energy certifications, Renewable purchase obligations, Automobile Emissions, Indian scenario, Impact of automobile pollutants and its abatement.

References:

1. S.M. Subramanian, *The Carbon Footprint Handbook*, CRC Pres, 2015.
2. *Carbon Handbook*, United Nations Development Programme, UNDP, 2014.
3. R Emmanuel and B. Keith, *Carbon Management in the Built Environment*, Routledge 2012.

ME6146: SOLAR ENERGY APPLICATIONS [3 0 0 3]

Solar Radiation: Extra-terrestrial and terrestrial, Radiation measuring instrument, Radiation measurement and Predictions. Solar thermal conversion: Basics, Flat plate collectors-liquid and air type. Classifications of solar thermal collectors. Theory of flat plate collectors, Selective coating, Advanced collectors. Concentrators: Optical design of concentrators, Solar water heater, Solar dryers, Solar stills, Solar ponds, Solar cooling and Refrigeration. Solar thermal power generation and Sterling engine. Solar photovoltaic: Principle of photovoltaic conversion of solar energy. Integration of thermal energy systems with various end use applications. Application of solar thermal technologies: Power generation, Industrial process heating, Water distillation, Refrigeration, Building heating and Cooling, Cooking, Drying Solar cells, Home lighting systems, Solar lanterns, Solar PV pumps, Solar energy storage options. Economic analyses of solar thermal energy systems, Life cycle assessment of solar thermal energy systems.

References:

1. Peter Heller, *The Performance of Concentrated Solar Power (CSP) Systems: Modelling, Measurement and Assessment*, Woodhead Publishing, 2017.

2. H.P. Garg and J. Prakash, *Solar Energy: Fundamentals and Applications*, McGraw Hill Education, 2017.
3. J.A. Duffie and W.A. Beckman, *Solar Engineering of Thermal Processes*, (4e), John Wiley and Sons, 2013.
4. S.A. Kalogirou, *Solar Energy Engineering: Processes and Systems*, (2e), Academic Press, 2013.
5. S. Sukhatme and J Nayak, *Solar Energy: Principles of Thermal Collection and Storage*, (3e), McGraw Hill Education, 2008.

ME6147: ENERGY CONVERSION & STORAGE [3 0 0 3]

Introduction and basic definitions, Types and forms of energy, Energy balances, Energy production via cyclic processes, Energy conversion emphasizing on thermal efficiency of the conversion processes, Energy storage techniques including thermal energy storage by sensible and latent heats, Energy Conservation, Energy coupling.

References:

1. Yasar Demirel, *Energy, Production, Conversion, Storage, Conservation and Coupling*, Springer, 2012.
2. D. Yogi Goswami and Frank Kreith, *Energy Conversion*, (2e), CRC press, 2017.

ME6247: ELECTRICAL ENERGY TECHNOLOGY & MANAGEMENT [3 0 0 3]

Transformers: Parallel operation, Auto transformers DC machines, Generator characteristics, Motor characteristics applications. Synchronous machines, Permanent magnet alternators, Induction machines. Power factor correction: Concept of power factor and reactive power, Causes and effects of low power factor, Advantages of improved power factor, Energy saving by power factor. Transmission line: Power flow study, power factor improvement, faults on power systems, Symmetrical components, Introduction to HVDC systems. Controlled rectifiers, Choppers, Inverters, Voltage regulators and Cyclo converters. Speed control of dc motors, converter, fed and chopper fed control. Speed control of AC motors, Inverter fed and AC voltage controller, fed schemes. Wind-driven induction generators, Grid connected photo-voltaic systems, Steady state performance, Integration issues, Principles of energy auditing.

References:

1. John F. Walker and N. Jenkins, *Wind Energy Technology*, John Wiley and Sons, 1997.
2. Syed A Nasar, *Electric Energy Conversion and Transmission*, Macmillan Publishing Company, New York, 1985.
3. K. V. Sharma and P. Venkateshaiah, *Energy Management and Conservation*, I K International Publishing House Pvt. Ltd, 2011.
4. A. Garg, A.K. Bhoi, P. Sanjeevikumar, and K.K. Kamani, *Advances in Power Systems and Energy Management*. Springer Singapore, 2018.

ME6248: FUNDAMENTALS OF SOLAR PHOTOVOLTAICS [3 0 0 3]

Quantum mechanics, Crystals structures, Atomic bonding, Types of semiconductors, Energy band diagram, p-type and n-type semiconductors, Doping and Carrier concentration, Diffusion and Drift of carriers, Continuity equation, P-N junction and Its properties, Dark I-V equation of P-N junction, Junction under illumination, Solar cell and Solar PV modules, Issues with solar PV modules, Bypass diode and Blocking diode, Applications of solar PV systems, Electronic circuits in PV, Design of solar PV systems, Battery sizing, PV panel sizing, Inverter sizing, Solar lanterns, Water pumping application, Home lighting application, Cathodic protection, Remote lighting. Applications of Photovoltaic for power generation from few watts to megawatts.

References:

1. Roger A. Messenger and Amir Abtahi, *Photovoltaic Systems Engineering*, CRC Press, 2020.

2. Martin A. Green, *Solar Cells: Operating Principles, Technology and System Applications*, Longman Higher Education, 1982.
3. J. Nelson, *The Physics of Solar Cells*, Imperial College Press, 2006.
4. R. Brendel, *Thin-Film Crystalline Silicon Solar Cells: Physics and Technology*, Wiley-VCH, Weinheim, 2003.
5. Mary D Archer and Martin A Green, *Clean Electricity from Photovoltaics*, Imperial College Press, 2014.

ME6249: WASTE TO ENERGY [3 0 0 3]

Impact of waste on environment and classification of pollution. Types and sources of solid and hazardous wastes, Need for solid and hazardous waste management, Recycling and reuse, handling and Segregation of wastes. Energy from waste: Production, characterisation, and classification of waste as fuel– Biomass, Industrial waste, Municipal solid waste. Comparison of properties with conventional fuels. Power generation using waste to energy technologies. Waste to energy options: Type of thermo chemical conversion route of biomass, Direct combustion, Liquefaction, Gasification, Pyrolysis. Biochemical Conversion process, Anaerobic digestion, Fermentation, Composting. Briquetting technology: Production of solid recovered fuel (SRF) from waste and briquetted fuel. Comparison of properties of fuels derived from waste to energy technology with conventional fuels.

References:

1. Kanti L. Shah, *Basics of Solid & Hazardous Waste Management Technology*, Pearson, 1999.
2. Colin Parker, and T. Roberts, *Energy from Waste: Evaluation of Conversion Technologies*, Spon Press, 1985
3. D. O. Hall and R. P. Overend, *Biomass - Regenerable Energy*, John Willy and Sons Ltd. New York, 1987.
4. J. Pichtel, *Waste Management Practices: Municipal, Hazardous, and Industrial*, (2e), CRC Press , 2014
5. Marc J. Rogoff, and Francois Screve, *Waste-to-Energy: Technologies and Project Implementation*, (3e), Academic Press, 2019.

ME6250: ENERGY, ENVIRONMENT AND CLIMATE CHANGE [3 0 0 3]

Role of energy in economic development and social transformation. Energy and GDP, GNP and its dynamics, Impact of energy on economy, Energy sources and overall energy demand and availability. Future energy options: Sustainable development, Energy crisis, Transition from carbon rich and Nuclear to carbon free technologies. Environmental impacts of energy technologies: Limitations of traditional energy technologies, Criteria for the selection of new energy sources, Environmental degradation due to energy production and utilization, Fallout from nuclear explosions, Fuel processing and Radioactive waste. Global climate change: Causes and consequences of global warming, Ozone hole and consequence of ozone depletion, Montreal protocol, Kyoto protocol and Recent conventions. Climatic considerations in industrial locations, City planning, Landscape architecture and Abatement/mitigation of pollution, Strategies for conservation of environmental changes induced by CO₂ rise.

References:

1. C.E. Brown, *World Energy Resources*, Springer-Verlag Berlin Heidelberg, 2002.
2. G.N. Tiwari and M. K. Ghosal, *Renewable Energy Resources: Basic Principles and Applications*, Alpha Science International, Limited, 2004.
3. M. Dayal, *Renewable Energy Environment and Development*, Konark Publishers Pvt. Ltd, 1991.

ME6251: BIOMASS GASIFICATION & PYROLYSIS [3 0 0 3]

Historical background to solid waste conversion and motivation, Biomass characteristics, biomass handling, Pyrolysis and torrefaction, Tar production and destruction. Gasification theory and Modeling of gasifiers, Design of biomass gasifiers, Hydrothermal gasification of biomass. Production of synthetic fuels and chemicals from biomass. Current development and new frontiers and challenges in gasification and pyrolysis technologies.

References:

1. Prabir Basu, *Biomass Gasification, Pyrolysis and Torrefaction*, Academic Press, Elsevier, 2013.
2. Petr A. Nikrityuk and Bernd Meyer, *Gasification Processes-Modeling and Simulation*, Wiley-VCH Verlag GmbH & Co, 2014.
3. A.A. Vertes, N. Qureshi, H.P. Blaschek, H. Yukawa, *Biomass to Biofuels: Strategies for Global Industries*, Wiley, 2010.
4. S. Yang, H.A. El-Enshasy and N. Thongchul, *Bioprocessing Technologies in Biorefinery for Sustainable Production of Fuels, Chemicals and Polymers*, Wiley, 2013.
5. Shang-Tian Yang, *Bioprocessing for Value Added Products from Renewable Resources*, Elsevier, 2006.

ME6252: BIOMASS CONVERSION AND BIOREFINERY [3 0 0 3]

Introduction to biorefinery concept, Biomass characterization and pre-treatment, Physical & Thermochemical conversion processes, Review of biochemical conversion technologies, Biodiesel, Bioethanol and Biobutanol, Organic commodity chemicals from biomass, Integrated biorefinery concept.

References:

1. Donald L. Klass, *Biomass for Renewable Energy, Fuels, and Chemicals*, Academic Press, Elsevier, 2006.
2. Prabir Basu, *Biomass Gasification, Pyrolysis and Torrefaction*, Academic Press, Elsevier, 2013.
3. A.A. Vertes, N. Qureshi, H.P. Blaschek and H. Yukawa, *Biomass to Biofuels: Strategies for Global Industries*, Wiley, 2010.
4. S. Yang, H.A. El-Enshasy and N. Thongchul. *Bioprocessing Technologies in Biorefinery for Sustainable Production of Fuels, Chemicals and Polymers*, Wiley, 2013.
5. Shang-Tian Yang, *Bioprocessing for Value Added Products from Renewable Resources*, Elsevier, 2007.

ME6253: WIND AND HYDRO ENERGY SYSTEMS [3 0 0 3]

Wind machine classification, General theories of wind machines, Basic laws and concepts of aerodynamics, Description, and performance of the horizontal-axis wind machines and vertical-axis wind machines. Generation of electricity by wind machines, case studies. Wind energy conversion system (WECS) siting, Rotor selection, Annual energy output (AEO). Synchronous and asynchronous generators and loads, integration of wind energy converters to electrical networks, inverters. Overview of micro mini and small hydro, Site selection and civil works, Penstocks and Turbines, Speed and Voltage regulation, Investment issues, Load management and Tariff collection, Distribution and Marketing issues, Case studies, Wind and Hydro based stand-alone/hybrid power systems, Control of hybrid power systems, Wind diesel hybrid systems.

References:

1. J.F. Manwell, J.G. McGowan and A.L. Rogers, *Wind Energy Explained-Theory, Design and Application*, John Wiley & Sons Ltd., 2002.
2. M. O. L. Hansen, *Aerodynamics of Wind turbines*, Earthscan, 2008.
3. M. Laguna, *Guide on How to Develop a Small Hydropower Plant*, ESHA, 2004.
4. L.L. Freris, *Wind Energy Conversion Systems*, Prentice Hall 1990.
5. D.A. Spera, *Wind Turbine Technology: Fundamental Concepts of Wind Turbine Engineering*, ASME Press, NY 1994.

ME6132: ENERGY LAB-1 [0 0 4 2]

Preparation of biodiesel and determination of its physical properties. Elemental characterization of a fuel using CHNS(O) analyser. Study of performance characteristics of a diesel engine fuelled with different diesel-biodiesel blend. Study of performance characteristics of a spark ignition engine fuelled with alcohol-gasoline blend. Analysis of engine exhaust emission measurement using AVL DIGAS 444 analyser and AVL 437 Smoke meter. Solar radiation measurement.

References:

1. Gerhard Knothe Jürgen Krahl Jon Gerpen, *The Biodiesel Handbook*, (2e) Academic Press and AOCS Press, 2010.
2. S.S. Thipse, *Alternative Fuels*, Jaico Publishing House, 2010.

ME6232 ENERGY LAB-II [0 0 4 2]

Solar Radiation Data Monitoring and Analysis: Sunshine hour duration, Direct solar radiation, Global solar radiation, Diffuse solar radiation, Net radiation [W/m²], Outgoing radiation [W/m²], Infra-red radiation, Diffuse radiation from global and direct radiation at a given zenith angle. Solar Photovoltaic: Current-voltage characteristics of solar cell, Efficiency variation of solar cell, Performance variation of solar photocell at different light intensities, Determination of power produced by a solar photo voltaic system. Performance evaluation of a solar photo voltaic lighting system and its components: inverter, charge controller and battery, Performance evaluation of a solar photovoltaic water pump. Performance testing of solar cooker with and without energy storage system. Experiment on wind turbine generator. Determination of proximate analysis (Moisture content, Ash, Volatile matter & fixed carbon) for a Given Biomass Sample. Determination of Total solids, volatile Solids and calorific value for a given organic Biomass Sample. Determination of elemental analysis (chemical method) for a Given Biomass Sample.

References:

1. David C. Dayton and Thomas D. Foust, *Analytical Methods for Biomass Characterization and Conversion*, Elsevier, 2019.
2. S. P. Sukatme and J. Nayak, *Solar Energy Principles of Thermal Collection and Storage*, (3e), Tata Mc Graw Hill, 2008.

ME6233 ENERGY SIMULATION LAB [0 0 4 2]

Using PVSyst Software: Design and simulate grid-connected solar PV power plant for two sites with different latitudes under fixed tilt, seasonal tilt, and tracking, analyse average monthly performance ratio and energy production, analyse impact of thermal losses for silicon and thin film technologies, Analyse share losses for both the locations. Design and simulate Rooftop PV system for off grid application for a household. Power system simulation for engineering (PSS/E): Create and simulate an entire system in PSS/E, Determining the voltages, currents, and real and reactive power flows in a system under a given load conditions, Perform stability analysis in PSS/E. Using ANSYS FLUENT/COMSOL: Thermal energy storage related simulations. Using Design builder: To model a building. Diesel RK: Simulation of IC engines for alternate fuels.

References:

1. <https://diesel-rk.bmstu.ru/>
2. <https://www.pvsyst.com/software-evaluation/>

OPEN ELECTIVE:

ME6280: LEAN AND AGILE MANUFACTURING [3 0 0 3]

Framework of Toyota production system, Introduction to value stream mapping, Characteristics of lean value stream. Introduction to Kanban, Production smoothing, Shortening production lead time, Multifunction workers, Shortening setup time concepts and Techniques. Organization structure for promoting setup time reduction, Standardization of operations, Yo-i-Don system, One shot setup, Determining the standard quantity of work in progress, Preparing the standard operation sheet. The agile production paradigm, History of agile manufacturing, Agile manufacturing vs mass manufacturing. Agile practices, Agile practice for product development, Manufacturing agile practices, understanding the value of investing in people, Concept models of agile manufacturing, Infusing managerial principles for enabling agility.

References:

1. Y. Monden, *Toyota Production System: An Integrated Approach to Just-In-Time*, CRC Press, 2011.
2. J.M. Gross, K.R. McInnis, *Kanban Made Simple: Demystifying and Applying Toyota's Legendary Manufacturing Process*, AMACOM books, 2003
3. K.W. Dailey, D. Wieckhorst, B. Welch, *The Lean Manufacturing Pocket Handbook*, DW Publishing, 2003.
4. A. Gunasekaran, *Agile Manufacturing 21st Strategy Competitiveness Strategy*, Elsevier Publications, 2001.

ME6281: INDUSTRIAL SAFETY [3 0 0 3]

Industrial revolution, Milestones in the safety movement, Accidents & their effects, Cost of accidents, Theories of accident causation-Domino theory, Human factor theory, Accident/incident theory, Epidemiological theory, System theory, Industrial hazards, Ergonomic hazards, Mechanical hazards, Fall and Impact hazards, Temperature hazards, National Safety Council India (NSCI) and Industrial safety acts: Introduction to NSCI, Mission and Vision, Milestones, Management, NSCI safety award schemes, Safety audits, Risk assessment, NSCI safety rating system, Hazard and operational (HAZOP) studies, Industrial Safety Analysis and Management, Preliminary hazard analysis, Detailed hazard analysis, Failure mode and effect analysis (FMEA), Human error analysis (HEA), Environmental Safety: Safety, health and environment.

References:

1. L.G. David, *Occupational Safety and Health for Technologists Engineers and Managers*, (5e), Pearson-Prentice Hall, 2005.
2. F.R. Spellman, N.E. Whiting, *The Handbook of Safety Engineering: Principles and Applications*, The Scarecrow Press Inc., 2010
3. A.K. Gupta, *Industrial Safety and Environment*, Laxmi Publications (P) Ltd., 2006
4. C.R. Asfahi, D.W. Rieske, *Industrial Safety and Health Management*, (7e), Pearson, 2018.