Course Curriculum for
M. Tech. Programme in Green Energy Technology
(School of Engineering)

SEMESTER-I

CODE	SUBJECTS	Teaching Scheme			Credits
		L	T	P	
MHS101	Research and Publication Ethics	2	0	0	2
MGE101	Introduction to Green Energy Technology	3	0	0	3
MGE102	Applied Electronics and Instrumentation in Energy Harvesting	2	1	0	3
MGE103	Electric Vehicle Technology	3	0	0	3
MGE****	Elective-I	3	0	0	3
MGE****	Elective-II	3	0	0	3
MGE171	Energy Lab I	0	0	6	3
Total		16	1	6	20

Lists of Electives: First Semester

Elective I/II

CODE	SUBJECTS	Teaching Scheme			Credits
		L	T	P	
MGE111	Solar Cell Technology	3	0	0	3
MGE112	Heat and Mass Transfer	2	1	0	3
MGE113	Hydrogen Energy & Fuel Cells	3	0	0	3
MGE114	Nuclear Power Systems	3	0	0	3
MGE115	AI & ML in Energy Systems	3	0	0	3
MGE116	Waste to Energy Conversion	3	0	0	3
MGE117	Energy Efficiency & Performance of Electrical Equipment	2	1	0	3
MGE118	Engines Technologies	3	0	0	3

DETAILS OF SYLLABUS:

MGE101: INTRODUCTION TO GREEN ENERGY TECHNOLOGY: L-T-P:3-0-0 (Credit:3)

Green energy sources, their utilities and limitations, Current energy requirements, growth in future energy requirements, Review of conventional energy resources- Coal, gas and oil reserves and resources, Tar sands and Oil Shale, Nuclear energy Option.

Solar energy: Radiation measuring instrument, Basics of Flat plate collectors, Concentrators Solar Principle of photovoltaic conversion of solar energy. Applications of solar energy.

Wind energy: Characteristics and measurement, Principles of wind energy conversion system (WECS), Types and classification of WECS.

Biomass Energy: Classification of biomass. Physicochemical characteristics of biomass as fuel. Biomass conversion routes.

Small Hydropower: Overview of micro, mini and small hydro system, types of hydro turbine; Ocean Energy, Principle of ocean thermal energy conversion system, Principles of Wave and Tidal energy conversion.

Geothermal energy: Origin of geothermal resources, type of geothermal energy deposits.

Hydrogen as a source of energy. Types of fuel cell, fuel cell system.

Text Books:

1. D.Y. Goswami, F. Kreith and J. F. Kreider, Principles of Solar Engineering, Taylor and Francis, Philadelphia, 2000.
2. C.S. Solanki, "Solar Photovoltaics: Fundamental Applications and Technologies, Prentice Hall of India, 2009.
3. L.L. Freris, Wind Energy Conversion Systems, Prentice Hall, 1990.
4. D.A. Spera, Wind Turbine Technology: Fundamental concepts of Wind Turbine engineering, ASME Press.

Reference books:

1. Renewable Energy by Godfrey Boyle

2. Renewable Energy Resources by John Twidell and Tony Weir.
3. S.P. Sukhatme, Solar Energy: principles of Thermal Collection and Storage, Tata McGraw-Hill(1984).

MGE102: Applied Electronics and Instrumentation in Energy Harvesting L-T-P: 2-1-0 (Credit: 3)

Module 1: Electronic instruments and their characteristics:

Electronic ammeter, voltmeter, wattmeter, and energymeters, Advantages of electronic instruments over its counterparts viz., electrical and mechanical, Loading effects, Signal conditioning, and signal processing. Measuring systems - classification, static and dynamic characteristics, errors, calibration and standards.

Module 2: Signal Generators and Analysers

Signal generators: Oscillators, VCO, PLL, sine wave generator, frequency synthesized sine wave generator, sweep frequency generator, pulse generator, Schmitt trigger and function generator. Audio frequency and noise generator. Signal analyzers: Harmonic distortion analyzer, signal and spectrum analyzer.

Module 3: Instrumentation in Energy harvesting

Transducers and their classifications, PLC: architecture, programming, ladder diagram, communications and networking, selection and installation. Control and instrumentation for extracting maximum power from sources, Communication Technologies: wired, wireless. RF -Zigbee, Bluetooth, WiFi, Ethernet, GSM, GPRS. Data acquisition systems, data loggers, internet of things.

Module 4: Signal Conditioning and signal processing:

Active and passive electrical filters, Modulated signals, sampling circuits, angle modulation counters, encoders and decoders, D-A and A-D converters, voltage to frequency counters, digital multiplexers and demultiplexers, envelope detection, fast Fourier and wavelet transform.

TEXT BOOKS

1. D.V.S.Murty, “Transducers and Instrumentation”, Second Edition, Prentice-Hall of India Private Limited, 2008.

2. Arun K.Ghosh, “Introduction to Measurements and Instrumentation”, Third Edition, PHI Learning Private Limited, 2009.

3. S. K. Singh, “Computer Aided Process Control”, Prentice-Hall of India Private Limited, 2003.

4. William Stallings, “Wireless Communications and Networks”, Second Edition, Pearson Education, 2005.

REFERENCE BOOKS:

1. Fabio Sauli, “Instrumentation and high energy physics” World Scientific, 1992
2. Kapil Khurana, “Digital Revolution: Guide to succeed with Technology Integration Industry 4.0 Industrial IoT” Technoviz Automation, 2024.

MGE103: Electric Vehicle Technology L-T-P:3-0-0 (Credit:3)

Module 1: Overview of electric vehicle (EV)

EV industry, automation in vehicle and electrical modeling, mechanics in vehicle, architecture, electrical motors, different types of motors used in electric vehicles.

Module 2: Electrochemical Cells

Operation of Cells and Batteries; Oxidation and Reduction; Lead-acid, Ni-based and lithium ion batteries, Battery Performance factors, metals and the treatment of lead poisoning.

Module 3: Battery characteristics

Charging and discharging, Inductive and conductive charging, fast charging techniques, safety from overcharging, public charging infrastructure.

Module 4: Vehicle dynamics

Particle and rigid body dynamics, concepts of control and damping, friction, mechanical modeling of tyre, vibrations, spring, mass and damper system, study of aerodynamics in vehicles, steering performance.

Module 5: Power Electronics in EV

Introduction to power electronics for electric mobility, switched mode power supply, PWM controlled power electronic converter, electric drives, safety measures in electric vehicle, digital controller design, improvement in power efficiency.

Text/Reference Books:

1. C.C Chan, K.T. Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York, 2001.
2. I. Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.

3. M. Ehsani, Y. Gao, S. E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.

4. J. Larminie, J. Lowry, Electric Vehicle Technology Explained, Wiley, 2003.

MGE111: Solar Cell Technology L-T-P: 3-0-0 (Credit:3)

Module 1: Solar Cell Basics and Materials: Properties of Semiconductor: Intrinsic, extrinsic and compound semiconductor; Energy levels; Electrical conductivity; Determination of Fermi energy level; Probability of occupation of allowed states; Dynamics of energy density of allowed states; Density of electrons and holes; Carrier transport: Drift, diffusion, continuity equations; Absorption of light; Recombination process; Basic equations of semiconductor devices physics. Introduction to organic Solar Cells

Module 2: Solar Cell Physics: p-n junction: homo and hetro junctions, Metal-semiconductor interface; Dark and illumination characteristics; Figure of merits of solar cell; Efficiency limits; Variation of efficiency with band-gap and temperature; Efficiency measurements; High efficiency cells, Tandem structure. Junctions in Organic Solar Cells; Working and Efficiency limits.

Module 3: Solar Cell Fabrication Technology: Preparation of metallurgical, electronic and solar grade Silicon; Production of single crystal Silicon: Czokralski (CZ) and Float Zone (FZ) method: Procedure of masking, photolithography and etching; Design of a complete silicon, GaAs, InP solar cell; High efficiency III-V, II-VI multijunction solar cell; a-Si-H based solar cells; Quantum well solar cell, Thermophotovoltaics. Organic PV cell materials

Module 4: Solar Photovoltaic System Design: Solar cell array system analysis and performance prediction; Shadow analysis: Reliability; Solar cell array design concepts; PV system design; Design process and optimization; Detailed array design; Storage autonomy; Voltage regulation; Maximum tracking; Use of computers in array design; Quick sizing method; Array protection and trouble shooting.

Module 5: SPV Applications: Centralized and decentralized SPV systems; Stand alone, hybrid and, grid connected system, System installation, operation and maintenances; Field experience; PV market analysis and economics of SPV systems.
Module 6: Solar Photocatalytic Detoxification: Mechanism; Advantages; Kinetic model; Nanoparticle Catalyst: Physical properties, sensitization; System design methodology; Performance parameters; Application for liquid and gas phase organic pollutant mitigation and disinfection.

Textbooks:

1. **Sukhatme, S. P. (2000)**: "Solar Energy: Principles of Thermal Collection and Storage," Tata McGraw-Hill.
2. **Duffie, J. A., and Beckman, W. A. (2006)**: "Solar Engineering of Thermal Processes," John Wiley & Sons.
3. **Green, M. A. (2005)**: "Third Generation Photovoltaics: Advanced Solar Energy," Springer.
4. **Tiwari, G. N. (2002)**: "Solar Energy: Fundamentals, Design, Modeling and Applications," Narosa, New Delhi.

References:

1. **Kreith, F., and Kreider, J. F. (1978)**: "Principles of Solar Engineering," McGraw-Hill.
2. **Kreider, J. F., and Kreith, F. (1981)**: "Solar Energy Handbook," McGraw-Hill.
3. **Garg, H. P., and Prakash, J. (1997)**: "Solar Energy: Fundamentals & Applications," Tata McGraw-Hill, New Delhi.
4. **Goswami, D. Yogi (1995)**: "Engineering of Solar Photocatalytic Detoxification and Disinfection Process," Advances in Solar Energy, 13, 208.

MGE112: Heat and Mass Transfer L-T-P: 3-0-0 (Credit:3)

Flow classifications, mass, momentum and energy relations in differential form.

Exact and approximate solutions to forced convection in laminar and turbulent, internal and external flow. Solution to natural convection problems.

Heat transfer at high velocity and incompressible fluid. Liquid metal heat transfer.

Convective mass transfer. Reacting flows. Mass transfer. Transport equations. Mass transfer across interface. Heat and mass transfer in separated flows.

Reference Books:
1. W.M. Rays, Convective Heat and Mass Transfer, McGraw Hill, 1966. E.R.G.
2. Eckert R.M. Drake Jr., Analysis of Heat Transfer, McGraw-Hill, 1972

MGE113: HYDROGEN ENERGY AND FUEL CELLS: L-T-P: 3-0-0 (Credit:3)

Fuel cells: Introduction and overview, operating principle, polarization curves, components, types of fuel cell, low and high temperature fuel cells, fuel cell stacks.

Thermodynamics of fuel cell: application of the first and second law to fuel cells, significance of the Gibbs free energy, concept of electrochemical potential and emf, Nernst equation, thermodynamic efficiencies of fuel cell in comparison to Carnot efficiencies, thermodynamic advantage of electrochemical energy conversion

Electrochemistry of fuel cell: electrochemical cells, oxidation and reduction processes, half cell potentials and the electrochemical series, Faraday's law, faradaic and non faradaic processes, current and reaction rate, Butler–Volmer theory for electrode kinetics, exchange current, polarization and over potential, cell resistance, mass transport in electrochemical cells

Fuel cell technology: Types of Fuel Cells, Fuel Cell systems and sub-systems, system and subsystem integration; Power management, Thermal management; Pinch analysis
Fuel cell electrolytes: different types of electrolytes used, ionomeric membrane in PEFC, mechanism of ion transfer in ionomeric membranes, relation between proton conductivity and water content, alternative membranes

Fuel cell electrocatalysts: types of catalysts, synthesis and characterization, HOR and ORR kinetics of catalysts, half-cell and full cell reaction, and effect of impurities
Fuel cell characterization: In-situ and Ex-situ; System and components' characterization modeling a Fuel Cell

Hydrogen Production: fossil fuels, electrolysis, thermal decomposition, nuclear, photochemical, photocatalytic, hybrid; Hydrogen Storage: Metal hydrides, chemical hydrides, Carbon nano-tubes; sea as the source of Deuterium, methane hydrate, etc.

Hydrogen Economy: Hydrogen as an alternative fuel in IC engines; Suitability of Hydrogen as a fuel, and techno-economic aspects of fuel cell as energy conversion device; Hydrogen fuel for transport

Text Books:

1. O' Hayre R.P., Cha S.W., Colella W.,and Prinz F.B.,(2008); Fuel cell fundamentals, John Wiley
2. Larminie J., Dicks A.and McDonald M. S.(2003);Fuel cell systems explained. Vol. 2, Wiley

Reference Books:

1. Zhang J. (2008); PEM Fuel Cell Electrocatalysts and Catalyst Layers: Fundamentals andApplications, Springer
2. Spiegel C.(2011);PEM Fuel Cell Modeling and Simulation Using Matlab, Elsevier Science.
3. Vielstich W., Lamm A.,and Gasteiger H. A.(2003); Handbook of Fuel Cells: Fundamentals, Technology, Applications, Vol (1-4), Wiley
4. Gupta R. B.(2008);Hydrogen Fuel: Production, Transport and Storage, CRC Press

MGE114: NUCLEAR POWER SYSTEMS: L-T-P: 3-0-0(Credit:3)

Introduction to Nuclear Engineering:

Introduction, Why Nuclear Power for Developing Countries, Atomic Nuclei, Atomic Number and Mass Number, Isotopes, Atomic Mass Unit, Radioactivity and Radioactive Change Rate of Radioactive Decay, Mass – Energy Equivalence, Binding Energy, Release of Energy by Nuclear Reaction, types of Nuclear Reactions, Initiation of Nuclear Reaction, Nuclear Cross – section, Nuclear Fission, The Fission Chain Reaction, moderation, Fertile Materials and Breeding.

Nuclear Reactors:

Introduction, General Components of Nuclear Reactor, General Problems of Reactor Operation, DifferentTypesofReactors,PressurisedWaterReactors(PWR),BoilingWaterReactors(BWR), Heavy Water – cooled and Moderated CANDU (Canadian Deuterium Uranium) Type Reactors, Gas-cooled Reactors, Breeder Reactors, Reactor Containment Design, Location of Nuclear Power Plant, Nuclear Power Station in India, India's 3-stage Programme for Nuclear Power Development, Comparison Nuclear Plants with Thermal Plants.

Nuclear Materials:
Introduction, Fuels, Cladding and Structural Materials Coolants, Moderating and Reflecting Materials, Control Rod Materials, Shielding Materials.

Nuclear Waste & Its Disposal:
Introduction, Unit of Nuclear Radiation, Types of Nuclear Waste, Effects of Nuclear Radiation, Radioactive Waste Disposal System, Gas Disposal System.

Safety Rules:
Personal Monitoring, Radiation Protection (Radiation Workers, Non-Radiation Workers, Public at large), Radiation Dose (Early effect, Late effect hereditary effect)

Text Books:

1. S. Glasstone and A. Sesonske "Nuclear Reactor Engineering" Third Edition, 1994, Springer Science & Business Media.
2. P.K. Nag "Power Plant Engineering",TataMcGrawHill
3. M. Fulcher, Handbook of Nuclear Power Plants, Clanrye International, 16th Edition, 2015.
4. Combined Power Plants by J.H. Horlock, Pergamon Press, 2001.

References:

1. Black/Veatch,"Power Plant Engineering", CBS Published & Distributors.
2. Gas Turbine Theory–by Sh.H. Cohen,G. F.C. Rogers.H.I.H. Saravanamuttoo, Pearson publishing, 7th edition, 2017.

MGE115: AI & ML in Energy Systems: L-T-P: 3-0-0 (Credit: 3)

Module 1:

Basics of linear algebra, concepts of vectors and matrices; background of probability and statistics.

Module 2:

Efficiency in energy systems: Know-what of efficiency in Electrical Motor, Transformer, pumps, blowers etc., factor affecting performance in various machines/systems, Introduction to terminologies: artificial intelligence (AI), machine learning (ML) and deep learning (DL); Feature selection and dimensionality reduction; Regression and classification, .

Module 3:

Types of machine learning algorithms: Supervised, unsupervised and reinforcement machine learning algorithms; Concepts of bias and variance; Concepts of overfitting and underfitting; Importance of Cross-validation.

Module 4:

AI and ML in the improvement of energy efficiency, Role of AI and ML in the Energy forecasting,
Supervised learning algorithms: naïve Bayes, nearest-neighbors, support vector machine, linear discriminant analysis, linear regression, bagging and boosting techniques, Unsupervised learning algorithms:K-means/Kernel K-means clustering, density-based clustering, hierarchical clustering, independent component analysis, singular value decomposition, Reinforcement learning algorithms: Q-learning, Genetic algorithm and SARSA reinforcement learning.

Module 5:
Neural network, concepts of perceptron, multilayer perceptron, back propagation, Deep learning: convolutional neural network, LSTM, adversarial networks.

Text/ References:

1. C. Bishop, Pattern Recognition and Machine Learning (Information Science and Statistics), Springer, 2006.
2. Frank, Kreith, Ronald E West Hand Book of Energy Efficiency, CRC Press
3. S. Russel, P. Norvig, Artificial Intelligence: A Modern Approach (Prentice Hall Series), 2010.
4. T. Hastie, R.Tibshirani, and J. Friedman, The Elements Of Statistical Learning: Data Mining, Inference, And Prediction, Springer, 2001.

MGE116: WASTE TO ENERGY CONVERSION: L-T-P: 3-0-0 (Credit:3)

Solid Waste : Definitions: Sources, types, compositions; Properties of Solid Waste; Municipal Solid Waste: Physical, chemical and biological property; Collection, transfer stations; Waste minimization and recycling of municipal waste

WasteTreatment&Disposal:SizeReduction:Aerobiccomposting,incineration;Furnacetype& design; Medical / Pharmaceutical waste incineration; Environmental impacts; Measures of mitigate environmental effects due to incineration; Land Fill method of solid waste disposal; Land fill classification; Types, methods & siting consideration; Layout & preliminary design of land fills: Composition, characteristics, generation; Movement and control of landfill leachate & gases; Environmental monitoring system for land fill gases

Energy Generation Form Waste: Types: Biochemical Conversion: Sources of energy generation, Industrial waste, agro residues; Anaerobic Digestion: Biogas production; Types of biogas plants; Thermochemical conversion: Sources of energy generation, Gasification; Types of gasifiers; Briquetting; Industrial applications of gasifiers; Utilization and advantages of briquetting; Environment benefits of biochemical and thermochemical conversion

References:

1. Municipal Solid Waste to Energy Conversion Processes: Economic, Technical, and Renewable Comparisons, by Gary C. Young, ISBN:9780470539675, Publisher: John Wiley & Sons, Publication Date: June 2010.
2. Recovering Energy from Waste Various Aspects Editors: Velma I.Grover and Vaneeta Grover, ISBN978-1-57808-200-1; 2002
3. Shah, Kanti L., Basics of Solid & Hazardous Waste Management Technology, Prentice Hall, 2000.
4. Waste-to-Energy by Marc J. Rogoff, DEC-1987, Elsiever, ISBN-13: 978-0-8155-1132-8, ISBN-10: 0-8155-1132-9.

MGE117:Energy Efficiency And Performance Of Electrical Equipments:

L-T-P:2-1-0(Credit:3)

Energy Efficiency: Energy Conservation, Need for Energy Efficiency , Indian Energy Conservation Act 2001 and its Features, Energy Star Rating of buildings and Equipments, Bureau of Energy Efficiency Guidelines and Programmes

National Energy Building Code: Energy Building Code, Guidelines: Thermal Insulation, Heating, Ventilation and Air Conditioning System, Building Lighting Design: Lighting levels, light efficient options, CFL, LEDs, Fixtures, Day lighting timers, Building Energy Management Energy Efficiency Improvement in Electrical Systems: Improving Energy Efficiency in Electrical Systems, Electrical load management, maximum demand control.

Power Factor: Power factor, power factor correction, selection and location of capacitors, performance assessment of PF capacitors and energy conservation opportunities

Electric Motors: motor efficiency, factor affecting motor performance, Energy saving opportunities in motors, energy efficient motors, soft starter with energy savers, motor efficiency measurements.

Transformers: Energy efficient transformers, factor affecting the performance of transformers
Electric Distribution: Energy conservation opportunities, cables, switch gears, distribution losses, and energy conservation in house electrical distribution system

Compressed Air Systems: compressor efficiency, efficient compressor operation, leakage test, factors affecting the performance and energy savings
Pumps and Pumping System: Energy conservation opportunities, Agricultural pumps, Solar PV Pumps

Fans and Blowers: Energy Efficient system operation, flow control strategies and energy conservation opportunities, Solar PV fans, Energy Conservation in Boilers, Steam Turbines and Industrial heating Systems

Energy Audit: Energy Management in Buildings and Industry, Energy Audit: Methodology, Data Collection, Techno-economic Analysis, Energy Audit Measurements: Energy Audit Instruments, Combustion Analysis, Temperature , Pressure Flow, Humidity, Energy, Power, Light Level measurements, HVAC, Furnaces and Ovens, Boilers and Steam Lines, Air Compressor and Compressed Air Distribution Lines, Chillers and Chilled Water Distribution Lines, Process Water Generation and Distribution Lines, Electrical Distribution, Transformers and Lines, Pumps, Fans and Blowers, Cooling Towers, Electrical Motors, Waste Heat Sources, Material Transport, Peak Load Equipments, Duties and responsibilities of Energy managers and Auditors ,Case Studies of Energy Audit.

Text Books/References:

1. L. C. Witte, PS Schmidt, D.R. Brown, Industrial Energy Management and Utilization, Hemisphere Publication, Washington, 1988
2. Industrial Energy Conservation Manuals, MIT Press, Mass, 1982
3. I.G.C. Dryden, Butterworths (Ed), The Efficient Use of Energy, London, 1982.
4. W.C. Turner (Ed),Energy Management Handbook,Wiley,NewYork,1982
5. Frank, Kreith, Ronald E West Hand Book of Energy Efficiency, CRC Press

MGE118:ENGINES TECHNOLOGY: L-T-P:3-0-0 (Credit:3)

Working of I.C. Engines, Combustion in IC Engines;
Engine parameters affecting combustion, Homogeneous Charge Compression Ignition Engine, Ultra Lean Burn Engines,
Fuel Injection in SI Engines, Multi valve engines, Variable valve timing. Direct and Indirect injection systems, Combustion chambers, Turbo charging, Formation and control of NOX , HC/CO and Particulate emissions,
Alternative fuels; Combustion and Emission Characteristics of SI and CIEngines using alternate fuels.

Text books:

1. Heywood, J., Internal Combustion Engine Fundamentals, McGraw Hill Publication
2. J.G. Speight, Synthetic Fuels Handbook: Properties, Process, and Performance, McGraw-Hill, 2008
3. Ayhan Demirbas, Biodiesel: A Realistic Fuel Alternative for Diesel Engines, Springer,
4. John B Heywood, "Internal Combustion Engine Fundamentals", Tata McGraw-Hill 1988
5. Gupta H.N, "Fundamentals of Internal Combustion Engines",Prentice Hall of India, 2006

Reference:

1. Ferguseaon, Internal Combustion Engines, John Wiley & Sons,1986.
2. Ganesan,V.,InternalCombustionEngines,TataMcGrawHill,NewDelhi,2001.
3. James G. Speight, Sudarshan K. Loyalka , Handbook of Alternative Fuel Technologies, CRC Press, 2007