APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Cluster No.10 for PG Programmes

(Engineering Colleges in Kannur, Wayanad & Kasaragod Districts)

Curriculum, Scheme of Examinations and Syllabi for M. Tech.
Degree Programme in ENERGY ENGINEERING
with effect from Academic Year 2020 - 2021

Under Mechanical Engineering

M. Tech.

in

ENERGY ENGINEERING

(Total Credits: 66)

CONTENTS

SEMESTER 1

Slot	Course Number	Name	L-T-P	Internal Marks	End Semester Examination Marks	End Semester Examination Duration (hours)	Total Marks	Credits
A	10ME6101	Computational Methods	3-1-0	40	60	3	100	4
B	10ME6503	Thermodynamic Power Cycles	3-0-0	40	60	3	100	3
C	10EE6505	Electrical Energy Systems	3-0-0	40	60	3	100	3
D	10ME6507	Energy Resources and Utilisation	3-0-0	40	60	3	100	3
E	10ME6xxx/	Elective I	3-0-0	40	60	3	100	3
S	10GN6001	Research Methodology	0-2-0	100			100	2
T	10ME6509	Seminar I	0-0-2	100			100	2
U	10ME6511	Energy Systems Lab	0-0-2	100			100	1
		TOTAL	**15-3-4**	**500**	**300**	**-**	**800**	**21**

<u>Elective I</u>

10ME6513 Advanced Optimisation Techniques
10ME6515 Materials and Instrumentation for Energy Systems
10ME6517 Fluid Dynamics and Heat Transfer
10ME6519 Energy Forecasting and Modelling

SEMESTER 2

Slot	Course Number	Name	L-T-P	Internal Marks	End Semester Examination Marks	End Semester Examination Duration (hours)	Total Marks	Credits
A	10ME6502	Solar Energy Systems	3-1-0	40	60	3	100	4
B	10ME6504	Thermal Energy Conservation Techniques	3-0-0	40	60	3	100	3
C	10EE6126	Energy Management	3-0-0	40	60	3	100	3
D	10ME6xxx/ 10EE6xxx	Elective II	3-0-0	40	60	3	100	3
E	10ME6xxx	Elective III	3-0-0	40	60	3	100	3
U	10ME6512	Energy Simulation Lab	0-0-2	100			100	1
V	10ME6508	Mini Project	0-0-4	100			100	2
		TOTAL	**15-1-6**	**400**	**300**	**-**	**700**	**19**

Elective II

10ME6122	Quality and Reliability Engineering
10ME6516	BioEnergy Technologies
10ME6518	Computational Methods in Fluid Flow
10EE 6116	Power Conversion in Renewable Energy Systems

Elective III

10ME6326	Design of Heat Transfer Equipments
10ME6514	Energy Efficient Buildings
10ME6522	Statistical Methods for Experimental Design
10ME6524	Energy Storage Technologies

SEMESTER 3

Examination Slot	Course Number	Name	L-T-P	Internal Marks	End Semester Examination		Total Marks	Credits
					Marks	Duration (hours)		
A	10ME7xxx/ 10EE7xxx	Elective IV	3-0-0	40	60	3	100	3
B	10ME7xxx/ 10EE6xxx	Elective V	3-0-0	40	60	3	100	3
T	10ME7501	Seminar II	0-0-2	100			100	2
V	10ME7503	Project (Phase I)	0-0-12	50			50	6
		TOTAL	**6-0-14**	**230**	**120**	**-**	**350**	**14**

Elective IV

10ME7505	Wind Energy Technologies
10ME7507	Waste Management and Energy Recovery
10ME7511	Industrial Noise Control
10EE 7107	Electric Vehicle Systems

Elective V

10ME7513	Energy, Environment and Climate Change
10ME7515	Energy Systems Modelling and Analysis
10ME7517	Project Management
10EE7505	Electrical Drives and Control

SEMESTER 4

Examination Slot	Course Number	Name	L-T-P	Internal Marks	End Semester Examination		Total Marks	Credits
					Marks	Duration (hours)		
V	10ME7504	Project (Phase II)	0-0-23	70	30		100	12
		TOTAL	**0-0-23**	**70**	**30**	**-**	**100**	**12**

TOTAL NUMBER OF CREDITS: 66

SEMESTER 1

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6101	**COMPUTATIONAL METHODS**	**3-1-0: 4**	**2015**

Course Prerequisites

Basic knowledge in mathematical methods at the UG level

Course Objectives

1. To be capable of developing a thorough knowledge in computational techniques to aid in the modeling and analysis of energy systems.
2. To lay a sound computational foundation for further independent research in energy engineering

Syllabus

First-order differential equations, Second order differential equations, Nonhomogenous differential equations, Laplace transforms, systems of differential equations, Series solutions, Higher-order differential equations, Boundary value problems and Fourier series, Partial differential equations, Probability, distributions, Moments, Estimation Theory, Correlation, Regression, optimization, Unconstrained optimization Nonlinear programming.

Expected Outcomes

On successful completion of the course, the students will

1. Have a strong foundation in modeling with differential equations and Laplace transforms
2. Be able to solve problems involving probability and probability distributions
3. Be able to model engineering problems as linear programming problems and solve them
4. Gain a good understanding of the formulations and solutions of nonlinear programming problems

References

1. Erwin Kreyzig, Advanced Engineering Mathematics, John Wiley, 2006.
2. Shepley L Ross, Differential Equations, John Wiley & Sons, Third Edition, 2004.
3. Gupta, S.C. and Kapoor, V. K., Fundamentals of Mathematical Statistics, Sultan Chand and Sons, New Delhi, 2001
4. Kalyanmoy Deb, Optimisation for Engineering Design - Algorithms and Examples, Prentice Hall of India,1998
5. S. S. Rao, Engineering Optimization, 3rd Ed., New Age International(P) Ltd, New Delhi, 2007

Course Plan

Module	Contents	Hours	Semester Exam Marks (%)
I	First-order differential equations, modeling with first-order equations, equilibrium solutions, Euler's method, Second order differential equations, fundamental sets of solutions, Wronskian method, Nonhomogenous differential equations, mechanical vibrations, Laplace transforms, inverse Laplace transforms, step function, solving IVP's with Laplace transforms, Dirac delta function, convolution integral.	8	15
II	Systems of differential equations, solutions to systems, phase plane, a solution involving real, complex, repeated Eigenvalues and Laplace transforms, solving nonhomogenous differential	10	15

	equations, Modeling using systems of differential equations, series solutions, series solution about an ordinary point, solutions to Euler differential equations.		
First Internal Examination			
III	Higher-order differential equations, linear homogenous differential equations, solution using undetermined coefficients, the variation of parameters and Laplace transforms, systems of differential equations, series solution, Boundary value problems and Fourier series, Eigenvalues and Eigenfunctions in BVP, periodic functions and orthogonal functions, Fourier sine, cosine and full series, the convergence of Fourier series, Partial differential equations, heat equation, wave equation, solution of the heat equation with non-zero temperature boundaries, Laplace equation, vibrating string.	12	15
IV	Probability, Random variables, Binomial, Poisson, Geometric, Uniform, Normal, Exponential distributions, Moments, Moments generating functions and their properties, Functions of Random variables. Estimation Theory, Correlation, Regression, Partial and Multiple correlations, Partial and Multiple regression, Estimation of parameters using maximum likelihood estimator and method of moments.	10	15
Second Internal Examination			
V	Concepts of optimization: Engineering applications-Statement of optimization problem-Classification - type and size of the problem. Linear programming: Standard form-Geometry of LP problems-Theorem of LP-Relation to convexity - formulation of LP problems - simplex method and algorithm -Matrix form-two-phase method. Duality- dual simplex method- LU Decomposition. Sensitivity analysis. Artificial variables	12	20
VI	Nonlinear programming: Nonlinearity concepts-convex and concave functions- non-linear programming - gradient and Hessian. Unconstrained optimization: First & Second-order necessary conditions-Minimisation & Maximisation Local & Global convergence-Speed of convergence. Basic decent methods: Fibonacci & Golden section search - Gradient methods - Newton Method-Lagrange multiplier method - Kuhn- tucker conditions. Quasi-Newton method- separable convex programming - Frank and Wolfe method.	12	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6503	**THERMODYNAMIC POWER CYCLES**	**3-0-0: 3**	**2020**

Course Prerequisites

Basic Understanding of Thermodynamics.

Course Objectives

To enable the students to

1. Discuss different thermodynamic cycles in energy systems
2. Outline the combustion thermodynamics for thermal energy systems
3. Compute the performance of heat engines, refrigeration and air conditioning systems
4. Estimate the exergy in the field of energy systems such as Engines, Power plants and Refrigerators and compressors.

Syllabus

Fundamentals of thermodynamics, Laws of Thermodynamics, exergy analysis, combustion of fuels, boiler types, Rankine cycle, Binary vapor cycle, Cogeneration Technology, Gas power cycles, gas turbine Power Plant Components, Air Compressor, Refrigeration cycle, Steam jet refrigeration systems, Cooling towers, Comfort factors, principles of air conditioning.

Expected Outcomes

On successful completion of the course, the students will be able to

1. Apply the knowledge of thermodynamics to analyze the performance of various thermodynamic cycles
2. Apply second law analysis on energy systems.
3. Illustrate the working of Refrigeration and air conditioning systems.

References

1. Yunus A. Cengel and Michael A. Boles, Thermodynamics-An Engineering Approach,7th Edition, Tata McGraw Hill Education Private Limited, 2011
2. Sonntag, R. E. and van Wylen, G.J., Fundamentals of Thermodynamics, 6th Edition, Wiley student Edition, 2007.
3. Saad, M. A., Thermodynamics for Engineers, Prentice-Hall of India Pvt. Ltd.2nd Edition, 1989
4. El Wakil M. M., Power Plant Engineering, McGraw Hill, 1st Edition, 2010.
5. Stoecker, W. F., Refrigeration and Air Conditioning, McGraw Hill, 4th Edition, 2018
6. Mukunda H. S., Understanding Combustion, Universities Press, 2009

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Basics of Thermodynamics - Thermodynamic systems and postulates, Zeroth law of thermodynamics, First Law of Thermodynamics, Second Law of Thermodynamics, Thermodynamic equilibrium, Thermodynamic relations, stability and phase transition Exergy analysis: Concept of exergy - exergy analysis of power plant cycles and Refrigeration cycle.	7	15
II	Fossil fuel properties, Fuel combustion equations (stoichiometric and non-stoichiometric), Air fuel ratio, Combustion Thermodynamics- calculation of heat of formation & heat of combustion, Analysis of products of combustion, Conversion of	7	15

	volumetric and gravimetric analysis. Boiler Classifications and types-Accessories		
First Internal Examination			
III	Vapour and combined power cycles: Carnot Cycle, Rankine cycle, Reheat cycle, Regenerative cycle, direct contact and surface contact regenerators, Binary vapour cycle, Topping – Bottoming, Organic Rankine Cycles, Thermodynamics of combined cycles, Advantages of Cogeneration Technology.	7	15
IV	Gas power cycles - Stirling cycle, Ericsson cycle, Air standard cycles - Otto cycle, Diesel Cycle, Dual cycle, Brayton cycle, Air standard cycle for jet propulsion, Brayton cycle with inter cooling, reheating &regeneration. Integrated Gasification Combined Cycle (IGCC).	7	15
Second Internal Examination			
V	Air Compressor- Types, construction and working, Effect of clearance, work of compression without clearance, Perfect intercooling, Compressor efficiencies and mean effective pressure.	7	20
VI	Refrigeration cycle, Refrigerators, Refrigeration by non-cyclic process, Vapor compression refrigeration cycle and its performance analysis. Absorption refrigeration cycle, Absorption refrigeration systems. Steam jet refrigeration systems, cooling towers. Comfort factors, principles of air conditioning – psychrometric processes.	7	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10EE6505	**ELECTRICAL ENERGY SYSTEMS**	**3-0-0: 3**	**2020**

Course Prerequisites

Basic knowledge of electrical engineering at the UG level

Course Objectives

This course provides an intensive introduction to the AC system, AC system losses and power factor correction, operation and control of power system, solar and wind energy systems and energy storage techniques with an emphasis on their technology and applications.

Syllabus

AC system fundamentals, power generation, transmission and distribution, load dispatch, automatic generation control, automatic voltage regulator, power factor and reactive power, power factor improvement, solar and wind power systems, converters for solar and wind power systems, energy storage, electric vehicles, harmonics in the power system.

Expected Outcomes

On successful completion of the course, the student will be able to

1. Apply the concepts of AC system and electric power generation.
2. Explain the concepts of transmission and distribution systems.
3. Explain the economic operation and control of the power system.
4. Analyse power factor correction methods.
5. Explain solar and wind energy systems and associated power electronic converters.
6. Explain various energy storage techniques, harmonics in power systems and EVs.

References

1. Nagrath I. J. and Kothari D. P., Power System Engineering, McGraw-Hill; 3rd Edition, 2019
2. Wadhwa C. L., Electrical Power Systems, New Age International (P) Limited Publishers, 7th Edition, 2017.
3. Gupta B.R., Power System Analysis and Design, S. Chand Publishing, 7th Edition, 1998.
4. D P Kothari, K C Singal, Rakesh Panjan, Renewable Energy Sources and Emerging Technologies, PHI, 2nd Edition, 2011.
5. Robert A. Huggins, Energy Storage, Springer, 2010.

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	Review of AC system fundamentals, Indian power sector, the structure of power system, Sources of energy and various power generation schemes, Power system economics and tariff. Distributed Generation and smart grid- Introduction.	7	15
II	Transmission and Distribution, Comparison of AC and DC transmission, Components of overhead transmission lines, Representation of power system components- Single line diagram, reactance diagram and per-unit system, Characteristics and performance of transmission lines. Corona, skin effect, Ferranti effect, proximity effect, transposition of conductors, bundled conductors, sag.	7	15
First Internal Examination			
III	Economic Dispatch Neglecting Losses, Optimum Load Dispatch Including Transmission Losses, automatic generation control, automatic voltage control.	8	15

IV	Concept of power factor and reactive power, causes and effects of low power factor, advantages of improved power factor, energy saving by power factor improvement through a capacitor, synchronous condenser. Active Shunt Compensators, Static Compensators and Flexible A.C. Transmission System.	6	15
Second Internal Examination			
V	Solar energy systems, wind energy conversion systems. Components of HAWT. Converters for grid-connected PV and wind energy systems- Half-bridge inverter, full-bridge inverter, sine PWM inverter. Maximum power point tracking in PV inverters.	8	20
VI	Energy Storage- Battery storage, Thermal Storage, Compressed air storage, Pumped hydro storage, fuel cells, Flywheel - Supercapacitors, Solar electrolytic hydrogen production. Electric and hybrid electric vehicles. Power quality issues- Problem of harmonics in power system, sources of harmonics, performance measures, harmonic mitigation.	6	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6507	**ENERGY RESOURCES AND UTILISATION**	**3-0-0: 3**	**2020**

Course Prerequisites

Fundamental knowledge in thermodynamics and Fluid mechanics

Course Objectives

To enable the students to

1. Create awareness about various energy sources and the availability of conventional fuel reserves for the future.
2. Introduce fundamental concepts about solar energy systems and devices.
3. Impart an idea about the potential of wind energy and the theoretical concepts to utilize wind power.
4. Impart an understanding about the working of OTEC system, geothermal energy system and different possible ways of extracting energy from ocean and biomass.
5. Introduce the different Hydrogen Energy Conversion Systems and their applications

Syllabus

Global and Indian energy scenario, Sector-wise energy consumption in the past, present and future. Availability of solar energy and different types of solar collectors, Energy from biomass, wind energy, geothermal energy, OTEC, tidal and wave energy, Hydrogen energy conversion systems.

Expected Outcomes

On successful completion of the course, the student will be able to

1. Explain the current world and Indian energy scenario and the various renewable and non-renewable energy sources.
2. Describe the working of different types of stationary and sun-tracking solar energy collectors
3. Explain the potential of wind energy and the working of wind energy conversion systems
4. Design a simple biogas plant.
5. Illustrate the applications of different renewable energy sources like ocean thermal, biomass, geothermal energy etc.
6. Discuss the different Hydrogen Energy Conversion Systems

References

1. World Energy Outlook 2019, International Energy Agency, 2019
2. India 2020 Energy Policy Review, International Energy Agency, 2020
3. Sukhatme, S.P., Nayak, J. K., Solar Energy, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2017.
4. Twidell J. W., Weir A. D., Renewable Energy Resources, Third Edition, CRC Press, 2015
5. Jefferson W., Tester et.al., Sustainable Energy: Choosing Among Options, The MIT Press, 2012.
6. Tiwari G. N., Ghosal M. K., Fundamentals of renewable energy sources, Alpha Science International Ltd.
7. Godfrey Boyle, Renewable Energy: Power for a Sustainable Future, Oxford University Press, 2012
8. Roland Wengenmayr, Thomas Buhrke, Renewable Energy: Sustainable energy concepts for the future, Wiley – VCH, 2012.
9. Canan Acar, Ibrahim Dincer., Comprehensive Energy Systems, Elsevier, 2018

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	Introduction to energy resources and utilization: Forms of Energy, the importance of energy consumption as a measure of prosperity, Per Capita Energy Consumption. Conventional and non-conventional energy resources, Global and Indian energy scenario, Sector-wise energy consumption, Coal, Oil, Natural gas, Nuclear power and Hydro-their utilization pattern in the past, present and future.	7	15
II	Solar energy: Availability and limitations; Sun-Earth angles; Sun path diagram; Solar radiation, Extraterrestrial solar radiation, Terrestrial irradiation; solar radiation on horizontal and inclined planes. Solar energy collectors: stationary collectors-Flat plate collectors, Compound parabolic collectors, Evacuated tube collector; Sun tracking concentrating collectors: Parabolic trough collectors, Fresnel collectors, Parabolic dish collectors, Heliostat field collectors; Thermal analysis of flat plate collectors: Absorbed solar radiation, Collector energy analysis, Temperature distribution, Collector efficiency factor.	7	15
First Internal Examination			
III	Wind energy: availability; Turbine types: Horizontal axis machines, vertical axis machines, Concentrators; Linear momentum and basic theory: Energy extraction, Axial force, Torque, Drag machines; Dynamic matching: optimal rotation rate, tip speed ratio, Extensions for linear momentum theory; Blade elementary theory.	8	15
IV	Energy from biomass: Sources of biomass, Different species, Conversion of biomass into fuels; Energy through fermentation, Pyrolysis, gasification, combustion; Aerobic and anaerobic bio-conversion: Types of biogas plants: Design and operation.	7	15
Second Internal Examination			
V	Geothermal energy: Availability, system development and limitations. Ocean thermal energy conversion, Wave and tidal energy, Scope and economics, Introduction to integrated energy systems.	6	20
VI	Hydrogen Energy Conversion Systems: Combustion-Based Hydrogen Energy Conversion Systems, Chemical, Physical and Electrochemical Hydrogen Energy Conversion Systems, Hydrogen for Transportation Sector, Hydrogen for Portable Applications	7	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10ME6513	**ADVANCED OPTIMISATION TECHNIQUES**	**3 – 0 – 0: 3**	**2020**

Prerequisites

Basics of operations research at UG level

Course objectives

To enable the students to

1. Formulate engineering problems as mathematical programming problems
2. Solve linear and non-linear optimization problems using analytical methods
3. Apply different algorithms for solving optimization problems

Syllabus

Mathematical programming problems, Unrestricted and classical optimization, Constrained non-linear optimization, method of feasible directions, Integer and dynamic programming

Expected Outcomes

On successful completion of the course, the student will be able to

1. Formulate engineering problems as mathematical programming problems
2. Apply different exact methods to solve optimization problems
3. Apply different algorithms to solve constrained and unconstrained optimization problems.

References

1. Taha H. A., Operations research: an introduction, 10th Edition, Pearson, 2017.
2. Rao S. S., Engineering optimization: theory and practice, John Wiley & Sons, 2019
3. Kambo N. S., Mathematical programming techniques. Affiliated East-West Press, 2008.
4. Simmons D. M., Nonlinear programming for operations research. Prentice-Hall, 1975.

Course Plan

Module	Content	Hours	Semester Exam Marks(%)
I	Mathematical formulations of engineering problems - Linear Programming Problem formulations, Simplex method for solving LPP, Exceptional cases in LPP, Duality and post optimal analysis, Dual Simplex method.	8	15
II	Integer Programming problem: Applications of Integer Programming problems; Integer Programming algorithms; Cutting Plane method, Branch and Bound method.	8	15
First Internal Examination			
III	Dynamic Programming - Bellman’s principle of optimality, Forward recursion and backward recursion, Application problems - Shortest route and Knapsack problems.	8	15
IV	Classical optimization techniques: Single variable optimization; Multivariable optimization with no constraints; Optimization with equality constraints; Method of Lagrange Multipliers, Optimization with inequality constraints; Kuhn-Tucker conditions.	8	15
Second Internal Examination			
V	Algorithms for unconstrained optimization - Fibonacci search method, Golden section search method, Hooke and Jeeve’s method, Newton-Raphson method, Cauchy's (Steepest descent) method. Algorithms for constrained optimization - Method of feasible	8	20

	directions, Penalty function methods.		
VI	Introduction to heuristic methods: Meta-heuristics, Needs and applications, Genetic Algorithm- steps of GA- Application problems.	8	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6515	**MATERIALS AND INSTRUMENTATION FOR ENERGY SYSTEMS**	**3-0-0 : 3**	**2020**

Course Prerequisite:
Basic knowledge of instrumentation and system measurement at the UG level

Course Objective:
To enable the students to
1. To learn the fundamentals of nanostructures and nanomaterials.
2. To introduce the application of nanostructures and nanomaterials in solar energy conversion devices and systems.
3. To impart the use of nanomaterials in the fuel cell, hydrogen and biofuel production technologies
4. To understand the basic principles of instrumentation and working of various measuring devices for energy systems.

Syllabus:
Classification and Properties of Nanomaterials, Solar Cells, Carbon Materials, Micro-fuel cell technologies,
Introduction to measurements, Open and closed-loop control systems, Temperature Measurement, Energy measurement

Expected Outcomes:
On completion of the course, the student will be able to
1. Gain knowledge of the nanostructures and nanomaterials and their properties.
2. Identify and describe the usage of nanomaterials in energy storage and conversion & fuel cell
3. Suggest measurement techniques useful for the evaluation of Energy Conservation Schemes

References

1. Garcia-Martinez J., Nanotechnology for Energy Challenge, Wiley-VCH, Weinheim, 2010.
2. Hari Singh Nalwa, Nanomaterials for Energy Storage Applications, Nanomax Technologies, USA, 2009.
3. Martin A Green, Solar cells: Operating principles, technology and system applications, Prentice Hall Inc, Englewood Cliffs, NJ, USA, 1981.
4. Hoogers, Fuel cell technology handbook, CRC Press, 2003.
5. Alan S Morris and Reza Langari, Measurements and Instrumentation – Theory and Application, Elsevier Inc, 2012.
6. K. Sawhney. Puneet Sawney: A course in Mechanical Measurements and Instrumentation. Dhanpat Rai & Co 2002.
7. Curtis D. Johnson, Process Control Instrumentation Technology, PHI Learning Private Limited, 2011.
8. Doblin E.O, Measurement System Application and Design, Second Edition, McGraw Hill, 1978.
9. Nakra, B.C., Choudhry K.K., Instrumentation, Measurements and Analysis, Tata McGraw Hill, New Delhi, 2nd Edition, 2003.
10. Beckwith, T. G., Marangoni, R. D. and Lienhard, J. H., Mechanical measurements, Pearson Education, 2001

Course Plan

Module	Contents	Contract hours	Semester Exam marks (%)

I	Classification and Properties of Nanomaterials - Nano, micro, and polycrystalline and amorphous Si for solar cells, Nano-micro Si-composite structure, various techniques of Si deposition. Nanostructured Materials for High-Efficiency Perovskite Solar Cells, Dielectric Nanomaterials for Silicon Solar Cells, Nanostructured Cathode Buffer Layers for Inverted Polymer Solar Cells - Discotic Liquid Crystals for Self-organizing Photovoltaics.	7	15
II	Carbon Materials- Carbon Nanotubes, Graphene, CNT/Graphene Hybrid, Carbon Fiber, Carbon Grease- Conjugated Polymer-Metal Oxides- Lithium Metal Oxides- Elemental and Compound Semiconductors- Metals. Piezoelectric Nanomaterials-Properties and Synthesis of Piezoelectric Nanomaterials- Energy Harvesting with Piezoelectric Nanomaterials. Nanomaterials for Rechargeable Lithium Batteries- Positive Electrode Materials-Negative Electrode Materials.	7	15
First Internal Examination			
III	Micro-fuel cell technologies, integration and performance for micro-fuel cell systems -thin film and microfabrication methods - design methodologies - micro-fuel cell power sources. Incorporating Graphene into Fuel Cell Design, Mesoporous Materials for Fuel Cells. Nanomaterials for Hydrogen Generation from Solar Water Splitting. Nanomaterials for the Production of Biofuels-Levulinic Acid-Based Fuels-Fuels from Sugar Alcohols-Lignin-Based Fuels. Carbon Cycle- Emissions are Partitioned between the Atmosphere, Land, and Ocean- Methods of CO_2 Capture-Material Used for CO_2 Capture. Introduction to Nanosafety-Measurement- Toxicology.	8	15
IV	Introduction to measurements, Errors in measurements, Basic electrical measurements, Transducers and its types, Static and dynamic characteristics of transducers, signal conditioning and processing - Measurement of temperature, pressure, velocity, flow rate, thermo-physical and transport properties of solids liquids and gases, Radiation properties of surfaces, Vibration and noise - Computer-assisted data acquisition, Data manipulation and data presentation	6	15
Second Internal Examination			
V	Introduction, Open and closed-loop control systems, Transfer function. Types of feedback and feedback control system characteristics – Effect of disturbances – Dynamic characteristics Process characteristics, Control system parameters – DC and AC servo motors, servo amplifier, potentiometer, synchro transmitters, synchro receivers, synchro control transformer, stepper motors - continuous, discontinuous and composite control modes – Analog and Digital controllers.	6	20
VI	Designing of temperature, pressure, flow and liquid level measurement and control system – Performance – Steady state accuracy – Transient response – Frequency response – Fault finding – Computer-based controls. Temperature Measurement - Biomaterials, Pressure thermometers, Thermocouples, RTD, Thermisters, and	9	20

	Pyrometry, pyrometers- Calibration of Pressure measuring equipment. Flow Measurement- Variable head flow meters- Rotameters, Electromagnetic flow meters, Hotwire anemometers, Hot film transducers, Ultrasonic flow meters. Moving Iron/coil, Energy measurement, power factor meter- Analog signal conditioning, Amplifiers, Instrumentation amplifier, A/D and D/A converters, Digital data processing and display, Computer data processing and control, Feedback control system, Stability and transient analysis of control systems, Application of PID controllers, General purpose control devices and controller design		
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6517	**FLUID DYNAMICS AND HEAT TRANSFER**	**3-0-0: 3**	**2020**

Course Prerequisites

The student must have basic knowledge of the fundamentals of Fluid Mechanics and Heat Transfer at the UG level

Course Objectives

To enable the students to

1. Apply the concept of Fluid Flow fundamentals
2. Execute mathematical modeling of fluid flow problems with special reference to laminar and turbulent boundary layer equations.
3. Examine Flow inside pipes, Pressure losses and pumping power requirements in pipes under laminar and turbulent flow conditions.
4. Solve and model mathematically heat conduction problems.
5. Solve and model mathematically convection heat transfer problems in energy systems.
6. Discuss Radiation Heat Transfer among surfaces.
7. Discuss the basics of mass Diffusion and convective mass transfer
8. Discuss analogy between Momentum, heat and mass transfer.

Syllabus

Fundamentals of Fluid Mechanics, differential and integral forms, Boundary-Layer Equations of External and Internal Flows, Laminar and Turbulent Flows, Conduction Heat Transfer, Convection Heat Transfer, Introduction to Radiation, Diffusion mass Transfer, Convective mass transfer, Analogy between momentum, heat and mass transfer.

Expected Outcomes

On completion of the course, the student will be able to

1. Explain the fundamentals of fluid flow
2. Model the fluid flow in the laminar and turbulent boundary layer over a surface.
3. Estimate pressure and power losses in pipe flow
4. Model conduction heat transfer problems mathematically
5. Model convection heat transfer problems
6. Explain principles of Radiation heat transfer between surfaces
7. Explain the analogy between momentum, heat and mass transfer.

References

1. Streeter, V.L., Wylie E.B. and Bedford, K.W., Fluid Mechanics, 9th Edition, WCB McGraw Hill, 1998.
2. Frank M. White, Fluid Mechanics (S I Units), 8th Edition, McGraw Hill Education, 2016.
3. Pijush K. Kundu, Ira M Cohen, Fluid Mechanics, 4th Edition, Academic Press, 2010
4. Irving H. Shames, Mechanics of Fluids, 3rd Edition, McGraw Hill, 2013.
5. Theodore L. Bergman, Adrienne S. Lavine, Frank P. Incropera, David P. DeWitt, Fundamentals of Heat and Mass Transfer, 8th Edition, Wiley, 2017.
6. Ghoshdastidar, P. S., Heat Transfer, Oxford University Press, 2004.
7. M. Thirumaleshwar , Fundamentals of Heat and Mass Transfer, 8th Edition, Pearson Education India, 2009.
8. Holman. J. P., Heat Transfer, 9th Edition, Tata McGraw Hill, 2002.
9. Ozisik M. N., Heat Transfer – A Basic Approach, McGraw Hill Co., 1985.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Introduction to Fluid Mechanics – continuum concept, Ideal flow vs. viscous flow, Rotational and Irrotational flows – circulation – vorticity – stream and potential functions. Newtonian fluid. Continuity, momentum and Energy Equations in differential form and Integral form.	6	15
II	Velocity Boundary Layer – Prandtl's Boundary Layer approximations, External flow Boundary Layer, Boundary-Layer over flat plate, Laminar and Turbulent Boundary Layers, Reynolds Number, Boundary-Layer equations - Continuity, Momentum and Energy Equations. Integral Forms of B L Equations, Solutions to B L equations. Coefficient of Friction, Drag Force, Calculation of Drag Force. Turbulent Flow Boundary Layer, Three Layer model, Boundary-Layer Equations for Turbulent Flow over Flat Plate.	8	15
First Internal Examination			
III	Internal Flow - Laminar flow between parallel plates and in circular pipes – Entry flow, fully developed laminar flow, Poisseuille flow, Couette flow, flow through circular pipes – friction factor – smooth and rough pipes – Moody diagram – losses during flow through pipes. Pipes in series and parallel – transmission of power through pipes.	6	15
IV	Introduction to heat transfer – Modes of heat transfer, General heat conduction equation, one, two and three-dimensional equations, steady-state problems with and without heat generation, boundary conditions in heat conduction problems, Unsteady conduction - Lumped heat capacity heat transfer analysis, Unsteady problem – semi-infinite body.	7	15
Second Internal Examination			
V	Convection Heat Transfer, Forced and Natural convection, Forced Convection Thermal Boundary Layer over a flat plate, Prandtl Number, Energy Equation for Forced convection, Integral form of Boundary Layer Equation, Nusselt Number, Forced convection in Turbulent Flow, Forced convection in pipes. Governing equations in Natural convection, Natural convection velocity and thermal Boundary layers from a vertical surface, Grashoff Number, Rayleigh number, Modified Grashoff Number.	8	20
VI	Radiation Heat Transfer – Preliminary concepts and laws of Radiation – absorptivity, reflectivity, transmissivity, emissivity, mono-chromatic and total radiative properties, Steffan – Boltzmann law, Radiation Intensity, Emissive Power, Radiation Exchange between surfaces. Introduction to mass diffusion-Fick's law of diffusion, Convective mass transfer, concentration Boundary layer, Boundary-Layer equations of convective mass transfer, Schmidt number, Lewis number, Sherwood number. The analogy between fluid flow and heat transfer and mass transfer - Reynolds analogy. Colburn – Chilton analogy.	8	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6519	**ENERGY FORECASTING AND MODELLING**	**3-0-0:3**	**2020**

Course Prerequisites

Basic mathematical knowledge in UG level

Course Objectives

To enable the students to

1. Identify the role of energy in economic development and social transformation.
2. Use forecasting models and optimization models for energy planning.
3. Report writing project proposals and making project cost estimation.
4. Evaluate the limit cost of energy for various renewable energy systems.
5. Identify various national and state-level energy issues and different energy policies.

Syllabus

Role of energy in economic development and social transformation, forecasting techniques, multi variance optimization, Energy Optimization Model, National & State Level Energy Issues.

Expected Outcomes

On successful completion of the course, the student will be able to

1. Identify the present state and future promise of energy sources, demand and consumption globally
2. Operate on Energy prediction using various forecasting techniques
3. Implement optimization model for energy planning
4. Identify national and state energy policies.
5. Report energy-related detailed project report including cost estimation

References

1. Armstrong J. Scott, Principles of forecasting: A handbook for researchers and practitioners, Norwell, Massachusetts, Kluwer Academic Publishers, 2001
2. Dhandapani Alagiri, Energy Security in India Current Scenario, The ICFAI University Press, 2006.
3. Fred Luthans, Organisational Behaviour, An evidence-based approach McGraw Hill, lnc, USA,12th Edition, 2011
4. S. Makridakis, Forecasting Methods and applications, Wiley, 3rd Edition,1997
5. Sukhvinder Kaur Multani, Energy Security in Asia Current Scenario, The ICFAI University Press
6. Yang X.S., Introduction to mathematical optimization: From linear programming to Metaheuristics, Cambridge, International Science Publishing, 2016
7. Peter D Cameron, Xiaoyi Mu, Volker Roeben., The Global Energy Transition: Law, Policy and Economics for Energy in the 21st Century (Global Energy Law and Policy)
8. Nawneeth Vibhaw, Energy Law and Policy in India, 8th Edition, 2014

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Role of energy in economic development and social transformation: Energy & GDP, GNP and its dynamics - Energy Sources and Overall Energy demand and Availability - Energy Consumption in various sectors and its changing pattern - Status of Nuclear and Renewable Energy: Present Status and future promise.	7	15

II	Forecasting Techniques - Regression Analysis - Double Moving Average - Double Experimental Smoothing - Triple Exponential Smoothing - ARIMA model-Validation techniques-Qualitative forecasting -Delphi technique - Concept of Neural Net Works	7	15
First Internal Examination			
III	Principles of Optimization - Formulation of Objective Function - Constraints - Multi-Objective Optimization – Mathematical Optimization Software.	7	15
IV	Development of Energy Optimization Model - Development of Scenarios – Sensitivity Analysis - Concept of Fuzzy Logic.	7	15
Second Internal Examination			
V	Project Preparation – Feasibility Study – Detailed Project Report - Project Appraisal – Social-cost benefit Analysis - Project Cost Estimation – Project Risk Analysis - Project Financing – Financial Evaluation.	7	20
VI	National & State Level Energy Issues - National & State Energy Policy - Energy Security - National solar mission - state solar energy policy - Framework of Central Electricity Authority (CEA), Central & States Electricity Regulatory Commissions (CERC & ERCs).	7	20
Cluster Level End Semester Examination			

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10GN6001	**RESEARCH METHODOLOGY**	**0-2-0:2**	**2015**

Course Prerequisites

1. The basic skill of analyzing data earned through the project work at UG level;
2. Basic knowledge in technical writing and communication skills earned through a seminar at the UG level.

Course Objectives

1. To understand the methodology of doing research.
2. To develop skills related to professional communication and technical report writing.

As a tutorial type course, this course is expected to be more learner-centric and active involvement from the learners is expected which encourages self-study and group discussions.
The faculty mainly performs a facilitator's role

Syllabus

Overview of research methodology - research process - scientific methods -research problem and design - research design process - formulation of the research task, literature review and web as a source - problem-solving approaches - experimental research - ex post facto research. Thesis writing - reporting and presentation - interpretation and report writing - principles of thesis writing- format of reporting, oral presentation - seminars and conferences, Research proposals - research paper writing - publications and ethics - considerations in publishing, citation, plagiarism and intellectual property rights. Research methods – modeling and simulation - mathematical modeling – graphs - heuristic optimization - simulation modeling - measurement design – validity – reliability – scaling - sample design - data collection methods and data analysis.

Expected Outcomes

The students are expected to :

1. Be motivated for research through the attainment of a perspective of research methodology.
2. Analyze and evaluate research works and formulate a research problem to pursue research.
3. Develop skills related to professional communication, technical report writing and publishing papers.

References

1. C.R Kothari, Research Methodology: Methods & Techniques, New Age International Publishers
2. R. Panneerselvam, Research Methodology, Prentice Hall of India, New Delhi, 2012.
3. K. N. Krishnaswamy, Appa Iyer Sivakumar, and M. Mathirajan, Management Research Methodology, Integration of Principles, Pearson Education.
4. Deepak Chawla, and Meena Sondhi, Research Methodology – Concepts & Cases, Vikas Publishing House.
5. J.W. Bames, Statistical Analysis for Engineers and Scientists, McGraw Hill, New York.
6. Schank Fr., Theories of Engineering Experiments, Tata McGraw Hill Publication.
7. Willktnsion K. L, Bhandarkar P. L, Formulation of Hypothesis, Himalaya Publication.
8. Douglas C Montgomery, Design and analysis of experiments, Wiley International
9. Ranjit Kumar, Research Methodology: A step by step guide for beginners, Pearson Education.
10. Donald Cooper, Business Research Methods, Tata McGraw Hill, New Delhi.
11. Leedy P D, Practical Research: Planning and Design, 4th Edition, N W MacMillan Publishing Co
12. Day R A, How to Write and Publish a Scientific Paper, Cambridge University Press, 1989
13. Coley S M and Scheinberg C A, Proposal Writing, 1990, Newbury Sage Publications.
14. Sople, Managing Intellectual Property: The Strategic Imperative, Prentice Hall of India, New Delhi, 2012

15. Manna, Chakraborti, Values and Ethics in Business Profession, Prentice Hall of India, New Delhi, 2012.
16. Vesilind, Engineering, Ethics and the Environment, Cambridge University Press.
17. Wadehra, B.L. Law relating to patents, trademarks, copyright designs and geographical indications, Universal Law Publishing.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Overview of Research Methodology: Research concepts, meaning, objectives, motivation, types of research, research process, criteria for good research, problems encountered by Indian researchers, scientific method, research design process.	5	15
II	Research Problem and Design: Formulation of the research task, literature review, methods, primary and secondary sources, web as a source, browsing tools, formulation of research problems, exploration, hypothesis generation, problem-solving approaches, introduction to TRIZ (TIPS), experimental research, principles, laboratory experiment, experimental designs, ex post facto research, qualitative research.	5	15
First Internal Examination			
III	Thesis Writing, Reporting and Presentation: Interpretation and report writing, techniques of interpretation, precautions in interpretation, the significance of report writing, principles of thesis writing, the format of reporting, different steps in report writing, layout and mechanics of research report, references, tables, figures, conclusions, oral presentation, preparation, making a presentation, use of visual aids, effective communication, preparation for presentation in seminars and conferences.	4	15
IV	Research proposals, Publications, Ethics and IPR: Research proposals, development and evaluation, research paper writing, the layout of a research paper, journals in engineering, considerations in publishing, scientometry, impact factor, other indexing like h-index, citations, open access publication, ethical issues, plagiarism, software for plagiarism checking, intellectual property right (IPR), patenting, case studies.	5	15
Second Internal Examination			
V	Research Methods - Modeling and Simulation: Modeling and simulation, concepts of modeling, mathematical modeling, composite modeling, modeling with ordinary differential equations, partial differential equations (PDE), graphs, heuristics and heuristic optimization, simulation modeling.	5	20
VI	Research Methods - Measurement, Sampling and Data Acquisition: Measurement design, errors, validity and reliability in measurement, scaling and scale construction, sample design, sample size determination, sampling errors, data collection procedures, sources of data, data collection methods, data preparation and data analysis.	4	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6509	**SEMINAR I**	**0- 0-2: 2**	**2020**

Course Prerequisites

1. The habit of reading technical magazines, conference proceedings and journals.
2. Basic knowledge in technical writing and communication skills earned through a seminar at the UG level.

Course Objectives

To enable the students to

1. Enhance the ability to conduct a literature review for the project work.
2. Find a proper area of research for the M. Tech thesis.
3. Develop the skills of professional communication and technical report writing.

Guidelines

The student shall prepare a paper and present a seminar on any current topic related to the branch of specialization under the guidance of a staff member. The student will undertake a detailed study based on currently published papers, journals, books on the chosen subject and submit a seminar report at the end of the semester. The student shall submit a printed copy of the paper to the Department. Grades will be awarded based on the contents of the paper and the quality of the presentation. A common format, preferably the IEEE format, (in PDF/MS Word/LaTeX) shall be given for students for preparing the report. All such reports submitted by the students shall be in this given format, for uniformity.

Expected Outcomes

On successful completion of the course, the student will be able to

1. Prepare the literature review required for doing project work.
2. Identify a suitable area of research for the M. Tech thesis.
3. Demonstrate the skills of professional communication and technical report writing.

References

1. M. Ashraf Rizvi, Effective Technical Communication, Tata Mc Graw Hill Education, New Delhi, Second Edition, 2017.
2. Day R.A., How to Write and Publish a Scientific Paper, Greenwood Press, Seventh Edition, 2011.
3. Coley S M and Scheinberg C. A., Proposal Writing, Sage Publications, Second edition, 2000.

Course plan

Item	Description	Time
1	Abstract Submission	3 Weeks
2	Allotment of Topic and Scheduling Seminars	2 Weeks
3	Presentation Sessions	4 Weeks
4	Report Submission	4 Weeks
5	Publishing Grades	2 Weeks

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6511	**ENERGY SYSTEMS LAB**	**0-0-2: 1**	**2020**

Course Prerequisites

Basic knowledge of Mechanical/Electrical/Chemical Engineering at UG level

Course Objectives

To enable the students to

1. Understand various energy systems by physically operating them.
2. Be able to set the operating parameters with physical sense to conduct experiments on various energy systems within the safe limit.
3. Be capable of generating experimental data with repeatability.
4. Be able to analyse the performance of various energy systems/devices by applying the thermodynamic, fluid flow and heat transfer principles they gained in the theory courses.

Expected Outcomes

On successful completion of the course, the student will be able to

1. Discuss the functions and operations of various components in energy systems.
2. Illustrate parametric setting for the experimentation in various types of Energy systems.
3. Use the knowledge gained in outcome 2 to conduct experiments to generate data with a satisfactory level of confidence, within the constraints of precision and accuracy of the measurement devices.
4. Rate the performance of different energy systems by analysing the data based on theoretical knowledge.

List of Experiments

1. Experimental study of the performance of solar water heaters.
2. Characteristics study of solar photovoltaic devices.
3. Performance study of the biogas plant.
4. Fuel characterization study in different fuels (proximate analysis, calorific value, viscosity, specific gravity etc.,)
5. Measurements of direct and diffused solar radiation.
6. Performance study on the boiler.
7. Performance characteristics of the motor test rig.
8. Computation of pump & pumping system characteristics (pump curve, system curve and BEP)
9. Experimental analysis on the performance of vapour compression air conditioning system.
10. Experimental analysis of the performance of downdraft biomass gasifier.
11. Experimental Investigation of the performance of Variable compression IC Engine

SEMESTER 2

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6502	**SOLAR ENERGY SYSTEMS**	**3-1-0: 4**	**2020**

Course Prerequisites

Basic knowledge in thermodynamics, fluid mechanics and heat transfer

Course Objectives

To enable the students to

1. Acquire analytical skills about various solar thermal collectors.
2. Understand the concepts of various solar thermal energy conversion systems.
3. Understand the principle and working of Photo Voltaic energy conversion systems.
4. Understand the utilization of solar energy for thermal comfort.

Syllabus

Solar radiation, different types of solar collectors, heat transfer fluids for solar collectors, thermal analysis of solar power plants, Solar photovoltaics, PV system design, power electric circuits for output of solar panels, Thermal comfort.

Expected Outcomes

On successful completion of the course, the student will be able to

1. Analyse the performance of various solar thermal collectors.
2. Comprehend the concepts of various solar thermal energy conversion systems
3. Design solar photovoltaic energy conversion and transmission systems.
4. Discuss the utilization of solar energy for thermal comfort.

References

1. Goswami D.Y., Kreider, J. F., Francis., Principles of Solar Engineering, 3rd Edition, CRC Press, 2015.
2. Chetan Singh Solanki, Solar Photovoltaics – Fundamentals, Technologies and Applications, PHI Learning Private Limited.
3. Sukhatme S.P., Nayak. J.P., Solar Energy – Principle of Thermal Collection and Storage, Tata McGraw Hill,2008.
4. Roger A. Messenger, Amir Abtahi, Photovoltaic Systems Engineering,4th Edition, CRC Press,2017
5. Garg H. P. and Prakash J., Solar Energy – Fundamentals and Applications, Tata McGraw-Hill, 2016

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	Solar radiation, components and spectral distribution; Radiation instruments and radiation measurements. Flat plate collector thermal analysis - testing methods- evacuated tubular collectors –Sun tracking concentrating collectors: classification, design and performance parameters, tracking systems, compound parabolic concentrators, parabolic trough concentrators, concentrators with point focus, Fresnel collectors, Heliostats.	8	15

II	Heat transfer fluids for solar collectors, Emerging technologies in solar concentrators Solar thermal power generation schemes: Central receiver power plants (solar power towers) - solar chimney power plants - Dish sterling systems - solar ponds - thermal analysis of solar power plants.	8	15
First Internal Examination			
III	Semiconductor – properties - energy levels - basic equations of semiconductor devices physics. Solar cells - p-n junction: homo and heterojunctions - metal-semiconductor interface - characteristics - the figure of merits of solar cell - efficiency limits - a variation of efficiency with band-gap and temperature - efficiency measurements - high-efficiency cells – Solar thermo-photovoltaics.	8	15
IV	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 - maximum tracking - centralized and decentralized SPV systems - standalone - hybrid and grid-connected system.	8	15
Second Internal Examination			
V	Power electric circuits for output of solar panels: Choppers, inverters, batteries, charge regulators. System installation - operation and maintenances - field experience - PV market analysis and economics of solar power systems.	8	20
VI	Thermal comfort - bioclimatic classification – passive heating concepts: direct heat gain - indirect heat gain - isolated gain and sunspaces - passive cooling concepts: evaporative cooling - Radiative cooling - application of wind, water and earth for cooling; shading - paints and cavity walls for cooling - roof radiation traps - earth air-tunnel. – energy-efficient landscape design - thermal comfort.	8	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6504	**THERMAL ENERGY CONSERVATION TECHNIQUES**	**3-0-0 : 3**	**2020**

Course Prerequisites

Basic knowledge of thermodynamics and heat transfer

Course Objectives

To enable the students to

1. Learn the present energy scenario and the need for energy conservation
2. Study the different measures for energy conservation and financial implications of various thermal utilities
3. Understand the energy crisis and environmental concerns associated with energy management, and the importance of energy conservation,
4. Apply energy conservation techniques in thermal systems

Syllabus

Basics of Energy and its various forms- Salient Features - Schemes of Bureau of Energy Efficiency (BEE)- Energy audit, definition, need, types of the energy audit. Energy management (audit) approach- Energy conservation in boilers- Cogeneration – Principles & Operation- Energy conservation in refrigeration and air conditioning systems- Energy conservation in Compressors, furnaces and heat exchangers-Case study of energy conservation.

References

1. Diamant R.M.E., Total Energy, Pergamon, Oxford, 1970.
2. Hamies, Energy Auditing and Conservation; Methods, Measurements, Management and Case study, Hemisphere, Washington, 1980.
3. Handbook on Energy Efficiency, TERI, New Delhi, 2001.
4. Trivedi P.R., Julka K.R., Energy Management, Commonwealth Publication, New Delhi, 1997
5. Practical guide to energy conservation – a ready reckoner on energy conservation measures; Petroleum Conservation Research Association, 2009.
6. Reay D. Industrial energy conservation, Pergamon Press, 1979.
7. White L. C., Industrial Energy Management and Utilization; Hemisphere Publishers, 1988.
8. Eastop T. D. and Croft D. R., Energy Efficiency for Engineers and Technologists, Longman-Scientific and Technical Series, 1988.

Expected Outcomes

On successful completion of the course, the student will be able to

1. Execute thermal energy auditing.
2. Discuss financial aspects as far as Energy Conservation Schemes are concerned.
3. Apply the scientific knowledge for energy conservation and management in the thermal energy systems
4. Discuss the most used energy planning and management systems

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	Basics of Energy and its various forms, Primary/Secondary Energy Sources, Energy crisis and environmental concerns. Principles of energy conservation and management, Energy Conservation, Energy Intensive Industries, Barriers, Energy Conservation Acts - Salient Features, Schemes of Bureau of Energy Efficiency (BEE) including Designated consumers, State Designated Agencies, Integrated energy policy, National action plan on climate change.	7	15

II	Energy audit, definition, need, types of the energy audit. Energy management (audit) approach - understanding energy costs, benchmarking, energy performance, optimizing the input energy requirements, energy audit instruments and metering, smart metering. Roles and responsibilities of an energy manager, Financial Analysis Techniques, CUSUM Technique, Energy Management Information Systems (EMIS), ESCO Concept, ESCO Contracts.	7	15
First Internal Examination			
III	Energy conservation in boilers-Types of fuel used - properties of fuel- oil, coal and gas. Stoichiometry, Boiler efficiency-performance of a boiler, Heat Loss Estimation, Steam Traps, Steam Piping & Distribution. Thermic Fluid Heaters – Insulation & Refractories.	7	15
IV	Cogeneration – Principles & Operation, Power Ratio, Economics of Cogeneration Scheme, Case Study on Cogeneration, WHR – Sources & Grades, Types (Heat Wheel, Recuperators, Regenerators, Heat Pipe etc), Scheme Evaluation, Economics of WHR Systems. Thermal Energy Storage – Basics & Concepts as an ENCON scheme.	7	15
Second Internal Examination			
V	Energy conservation in refrigeration and air conditioning systems- EER / SEC Evaluation –. Types & Applications of Cooling Towers, Basics, Performance Analysis. DG Set – Performance Prediction, Cost of Power Generation. Energy conservation in Cooling Towers and DG set.	7	20
VI	Energy conservation in Compressors, furnaces and heat exchangers-Case study of energy conservation in energy-intensive industries-Steel, cement, paper.	7	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10EE6126	**ENERGY MANAGEMENT**	**3-0-0 : 3**	**2015**

Course Prerequisites

Basic knowledge of Electrical & Mechanical Engineering at UG Level.

Course Objectives

The course is designed to provide students the knowledge and ability to understand the principles of Energy management and apply this to practical systems.

Syllabus

Importance of energy management. Energy auditing-Electric motors- Variable speed drives; Pumps and Fans-Reactive Power management-Lighting- Compressed Air Systems, Refrigeration & air conditioning systems-Boiler -Cogeneration- Electric water heating-Solar Water Heaters- solar PV systems.

Expected Outcomes

On successful completion of the course, the student will be able to

1. Acquire the need of energy conservation
2. Analyse types and objectives of energy auditing
3. Analyze the methods for reactive power compensation
4. Analyze tools for economics of energy conservation
5. Analyze the ECO (Energy Conservation opportunity) in electric systems such as motors, lighting etc.
6. Analyze the ECO (Energy Conservation opportunity) in mechanical systems such as boilers, pumps, compressors, water heaters etc.

References

1. Guide Book for National Certification Examination for Energy Managers & Energy Auditors – Bureau of Energy Efficiency, Ministry of Power, Govt of India.
2. Handbook on Energy Audit and Environment Management, Y P Abbi and Shashank Jain, TERI, 2006
3. Utilization, Generation & Conservation of Electrical Energy, Sunil S.Rao, Khanna publishers, 2007.
4. Anthony J. Pansini, Kenneth D. Smalling, Guide to Electric Load Management., Pennwell Pub; (1998)
5. Partab H., 'Art and Science of Utilisation of Electrical Energy', Dhanpat Rai and Sons, New Delhi. 1975
6. Tripathy S.C., 'Electric Energy Utilization And Conservation', Tata McGraw Hill, 1991
7. L.C.Witte, P.S.Schmidt, D.R.Brown, Industrial Energy Management and Utilisation, Hemisphere Publ, Washington, 1988.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Importance of energy management, electric energy conservation, Energy auditing – methodology, System approach and End-use approach to efficient use of Electricity, Electricity tariff types, Types and objectives, audit instruments, specific energy analysis, Minimum energy paths, consumption models, Case study. Demand-side management.	8	15
II	Electric motors- Energy efficient controls and starting -Motor Efficiency and Load Analysis- Energy-efficient motors-Case study; Load Matching and selection of motors-Variable speed drives.	7	15

First Internal Examination			
III	Reactive Power management-Capacitor Sizing-Degree of Compensation-Capacitor losses- Location-Placement Maintenance, case study. Peak Demand controls Methodologies- Types of Industrial loads-Optimal Load scheduling-case study.	8	15
IV	ECO assessment and Economic methods- Simple payback period- time value of money-Net Present value- Internal rate of return Lighting- Energy efficient light sources-Energy conservation in Lighting Schemes- Electronic ballast-Power quality issues Luminaries, case study.	7	15
Second Internal Examination			
V	Energy conservation in Pumps- Optimal selection and sizing -Case study- Fans (flow control), Refrigeration & air conditioning systems. Boiler -efficiency testing, excess air control, Steam distribution & use- steam traps, condensate recovery, flash steam utilization Cogeneration-Types and Schemes-Optimal operation of cogeneration plants-case study	6	20
VI	Power Consumption in Compressors, Energy conservation measures. Water heating-Gysers-Solar Water Heaters- solar PV Systems.	6	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6122	**QUALITY AND RELIABILITY ENGINEERING**	**3-0-0: 3**	**2015**

Course Prerequisites

Fundamental knowledge in probability theory and statistics is desirable.

Course Objectives

To learn in-depth the quality and reliability aspects with emphasis on an industrial-organizational environment.

Syllabus

Traditional Quality Control-Total Quality management-QMS-ISO9000 standards- Taguchi methods-Six sigma concepts- Design of experiments- Reliability- Total Productive Maintenance-Reliability management.

Expected Outcomes

After completing the course, the students will be able to

1. Identify and describe various areas in the quality control and reliability engineering fields.
2. Plan and design a quality control program in an industry/organization.
3. Estimate the reliability of complex engineering systems
4. Gain good understanding of the principles of total productive maintenance

References

1. Dale H; Besterfield, Total Quality Management, Pearson Education Inc, 3rd Edition, 2003.
2. Caplen, Practical Approach to Quality Control, Random House, 1994.
3. O'Connor, Practical Reliability Engineering, John Wiley and Sons, 5th Edition, 2012
4. Ryan, Statistical Methods for Quality Improvement, John Wiley and Sons,3rd Edition, 2011.
5. Ross, Taguchi Techniques for Quality Engineering, McGraw Hill Publishers, 2nd Edition, 1995.
6. Douglas C. Montgomery. Design and Analysis of Experiments, John Wiley and Sons, 6th Edition, 2004.
7. Balaguruswami E., Reliability Engineering, Tata Mc Graw Hill Publishing Co. Pvt Ltd, 2015

Course plan

Module	Content	Contact Hours	Semester Exam Marks (%)
I	Basic concepts and definition, Traditional Quality Control, Total Quality Management, Deming's principles, Customer focus, Employee involvement, Continuous process improvement, PDCA cycle	8	15
II	Seven step process, Kaizen, Quality measurements, Quality costs, QFD, QMS-ISO9000 standards-requirements and documentation, Taguchi methods, quality loss function, Parameter design and Tolerance design concepts	8	15
First Internal Examination			
III	Six sigma concepts –define and measure phase, flowcharting, basic tools, probability and hazard plotting, Six sigma measurements, basic control charts and process performance matrices, Measurement systems analysis.	8	15

IV	Design of experiments-basics, single factor, two-factor experiments. ANOVA, Taguchi approach to the design of experiments, orthogonal arrays, Signal to noise ratio, RSM-concepts and methods.	8	15
Second Internal Examination			
V	Fundamental aspects of reliability, Reliability mathematics, Reliability testing and evaluation methods. FMEA, Failure data analysis.	8	20
VI	Total Productive Maintenance, maintainability and Availability Concepts, Reliability management.	8	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6516	**BIOENERGY TECHNOLOGIES**	**3-0-0 : 3**	**2020**

Prerequisites

Basic knowledge in Thermodynamics.

Objectives

1. Dissemination of important information on bioenergy to enable students to acquire knowledge on cutting-edge technologies for conversion of various biomass feedstocks to bioenergy/biofuel and their utilization in combustion engines/devices and fuel cells.
2. Enable the students to contribute towards providing biomass-based sustainable energy solutions.

Syllabus

Introduction to bioenergy, biomass harvesting, characterization of biomass feedstock, classification of biomass feedstock- first, second and third-generation biofuels, Different pre-treatment processes of biomass; different production routes for biomass conversion to biofuels, Utilization of biomass in external combustion engines.

Expected Outcomes

On successful completion of the course, the student will be able to

1. Explain the classification and characterization of biomass feedstock.
2. Compare the different production routes for biomass conversion to biofuels
3. Explain the working of biomass-based incineration plants, co-firing of biomass for heat generation for industrial processes and biomass-fuelled combustion devices.
4. Discuss the utilization of biomass in external combustion engines including the steam turbine power plant and Stirling engine.

References

1. Jay J. C., Biomass to Renewable Energy Processes, Taylor and Francis, CRC Press, 2018
2. Konur O., Bioenergy and Biofuels, Taylor and Francis, CRC Press, 2018
3. Love J. and Bryant J. A., Biofuels and Bioenergy, John Wiley & Sons, 2017
4. Henderson O. P., Biomass for Energy, Nova Science Publishers, 2011
5. Mukunda, H. S., Understanding Clean Energy and Fuels from Biomass, Wiley India, 2011.

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	Introduction to bioenergy; biomass harvesting; availability and assessment of biomass for bioenergy applications; characterization of biomass feedstock (Physico-chemical properties, ultimate, proximate, compositional, calorific value, thermogravimetric, differential thermal and ash fusion temperature analyses).	7	15
II	Classification of biomass feedstock: first, second and third-generation biofuels; hybrid biofuels, basic principles of chemical thermodynamics; carbon-neutral fuels.	7	15
First Internal Examination			
III	Different pre-treatment processes of biomass; different production routes for biomass conversion to biofuels: biochemical methods (anaerobic, enzymatic- saccharification and fermentation process, and dark fermentation, ABE fermentation).	7	15

IV	Chemical processes (transesterification, hydro-processing, micro-emulsification); thermochemical methods (combustion, gasification, pyrolysis, partial oxidation, auto-thermal reforming) for biofuels production including synthesis gas, bio-hydrogen, ethanol, butanol, biogas, methanol, dimethyl ether and paraffinic fuels.	7	15
Second Internal Examination			
V	Biomass compaction (briquetting and palletisation); biofuel quality up-gradation; and biomass and biofuel quality norms. Biomass-based incineration plant for heat generation; co-firing of biomass for heat generation for industrial processes; Biomass fuelled combustion devices for cooking and heating applications.	7	20
VI	Utilization of biomass in external combustion engines including steam turbine power plant and Stirling engines; utilization of biofuels in a gas turbine, internal combustion engines and fuel cells; analysis of carbon neutral and carbon credit.	7	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6518	**COMPUTATIONAL METHODS IN FLUID FLOW**	**3-0-0: 3**	**2020**

Course Prerequisites

A course on Mechanics of Fluids and heat transfer at the UG or PG level

Course Objectives

To enable the students to

1. Use governing equations of viscous fluid flows for Numerical analysis of flow problems.
2. Understand numerical modelling and its role in the field of fluid flow and heat transfer
3. Understand the various discretization methods, solution procedures and turbulence modelling.
4. Solve numerically complex problems in the field of fluid flow and heat transfer using high-speed computers.

Syllabus

Introduction to CFD, Governing equations, Steady and unsteady flows, Analytical solution of a one-dimensional convection-diffusion equation, Statistical representation of turbulent flows, Different types of turbulence models, Grid generation, Pressure-velocity coupling for incompressible flows.

Expected Outcomes

On successful completion of the course, the students will be able to

1. Formulate the fluid flow and or heat transfer problems mathematically.
2. Use various discretization schemes for forming difference equations from the governing equations.
3. Apply the various discretization methods and solution procedures for heat transfer and fluid flow problems.
4. Apply the Numerical Techniques to carry out M Tech project work which involves a numerical investigation of heat transfer problems.

References

1. Versteeg H. K., Malalasekera W., An introduction to Computational Fluid Dynamics, 2nd Edition, Longman, 2008
2. Patankar Suhas V., Numerical Heat Transfer and Fluid Flow, Taylor & Francis, 1980
3. Dale Anderson, John C. Tannehill, Richard H. Pletcher, Ramakanth Munipalli, Vijaya Shankar, Computational Fluid Mechanics and Heat Transfer, 4th Edition, CRC Press, 2020.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Introduction to CFD, Historical background, applications, advantages. Basic steps of CFD –Meshes - Structured and unstructured mesh, Classification of structured grids. Governing equations: continuity and momentum equations.v Euler and Navier-Stokes equations.	7	15
II	Steady and unsteady flows. Boundary conditions such as Dirichlet boundary condition, Neumann boundary condition and convective boundary condition. TDMA method- Numerical problem up to four unknowns using TDMA. Cell centered finite volume discretisation of terms of governing equations such as unsteady, convective and diffusion terms.	7	15
First Internal Examination			

III	The solution of the one-dimensional convection-diffusion equation. Upwind, central and blended difference approximations for convection term, QUICK scheme. Implicit, explicit and Crank-Nicolson schemes	7	15
IV	A statistical representation of turbulent flows: Homogeneous turbulence and isotropic turbulence, General Properties of turbulent quantities, Reynolds averaged Navier Stokes (RANS) equation, Closure problem in turbulence	7	15
Second Internal Examination			
V	Turbulence modeling, Different types of turbulence models: advantages and disadvantages. Structured Grid generation – Unstructured Grid generation– Mesh refinement – Adaptive mesh	7	20
VI	Pressure-velocity coupling for incompressible flows – SIMPLE, SIMPLER, SIMPLEC and PISO algorithms.	7	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EE6116	**POWER CONVERSION IN RENEWABLE ENERGY SYSTEMS**	**3–0–0 : 3**	**2015**

Course Prerequisites

Basic knowledge in Electrical power systems and Power Electronics at the UG level.

Course Objectives

To give an idea about the renewable energy sources and the application of power electronic devices and converters in renewable energy systems.

Syllabus

Solar photovoltaic systems, bioenergy, wind energy, fuel cells, ocean energy, MHD, Geothermal and Small hydro systems.

Expected Outcomes

Students who complete this course will have the ability to understand the fundamental concepts of generating electrical energy from renewable energy systems.

References:

1. D P Kothari and Nagrath, “Modern Power System Analysis”, Mcgraw Hill, Chapter 1, 2011.
2. Thomas Ackerman, “Wind power in power systems”, John Wiley& Sons, Chapter 4, London, 2005.
3. M G Simoes and F A Farret, "Alternate energy systems, "CRCPress, Chapter7, London, 2008.
4. Domkundvar, "Solar Energy Resources", Dhanpatrai& Sons, New Delhi.
5. J P Lyons and V Vlatkovic, “power electronics and alternative energy generation”, in proc IEEE power electronics specialist conference, vol.1, no 1, pp.16-21, Aachen 2004.
6. P F Rebeiro, B K Jhonson, M L Crow, A Arsoy and Y Liu, “Energy Storage systems for advanced power application”, in proc IEEE conf. vol.89, no 12, Dec. 2001.

Course plan

Module	Content	Hours	Semester Exam Marks
I	Introduction to renewable energy sources and potential- Solar energy needs and its utilization-Solar thermomechanical systems-direct conversion to electricity- grid-interactive PV systems-Isolated PV systems- the requirement for maximum power tracking (MPPT) - dc to dc converter topologies for MPPT- control algorithms for MPPT	8	15
II	Introduction to biomass -Resource potential –technology and applications - Biomass gasifiers.–Electrical energy conversion methods–biomass conversion process. Biogas plants- Technology and status- Biogas generation-types of biogas plant-community biogas plants.	6	15
First Internal Examination			
III	Wind energy – Resonance potential –Vertical axis and horizontal axis wind turbines –Gilbert's limit- Power coefficient – wind farms –Power plants –Generators for WECS- Induction Generators- Solid-state converters and control	8	15
IV	Fuel cells**:** Introduction – working –efficiency –classification –performance characteristics – dc-dc converters and control	6	15
Second Internal Examination			
V	Geothermal Energy**-** Resources of Geothermal –vapour dominant system-liquid dominant binary cycle. The total flow	8	20

	of geothermal power unit- energy conversion systems. MHD: Principle –simplified analysis of MHD- factors affecting the efficiency of MHD-types-present status of MHD generation.		
VI	Ocean energy conversion: OTEC –Principle –cycle, operation of OTEC systems.Location of plants –types –technology and applications- Tidal and wave energy. Small hydropower generation-turbines and generators- grid-tied systems- stand-alone systems- induction generators-Electronic load controllers.	6	20
	TOTAL	42	100
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6326	**DESIGN OF HEAT TRANSFER EQUIPMENTS**	**3-0-0 : 3**	**2015**

Course Prerequisites

Basic knowledge of Heat transfer, Thermodynamics, Psychrometry, Material science and Manufacturing process at UG/PG Level

Course Objectives

The course is designed to provide a complete design knowledge of various heat transfer equipments which are invariably used in most of the chemical process industries.

Syllabus:

Thermal performance analysis of heat exchangers - Design calculation of double pipe heat exchanger, LMTD, NTU and P-NTU Methods; Shell and tube heat exchangers- classification of shell and tube exchangers-The Circulating Water System-Introduction-System Classification-Wet Cooling Towers-Dry cooling towers- Heat Pipes Types and Applications-Capillary Limitation and Temperature Characteristics - Sonic, Entrainment, and Boiling Limitations- Heat pipe design – Fluid, Wick and Material Selection- Heat Pipe Design Procedure-Design Problems.

Expected Outcomes

This subject exposes students to the practical applications of the fundamental laws using thermodynamics, Heat transfer, Material sciences and Manufacturing processes. This course will provide a gist of the theory behind the heat transfer equipment and will emphasize direct applications of theory to design.

References

1. R K Shah, Fundamentals of Heat Exchanger Design, John Wiley & Sons.
2. Chi, S. W., Heat Pipe Theory and Practice - A Source Book, McGraw-Hill, 1976
3. Reay, D. A., Kew, P.A., Heat pipes, fifth edition, Butterworth-Heinemann publications, 2006.
4. Fraas, A. P., Heat Exchanger Design, Second Edition, John Wiley & Sons, 1989.
5. Dunn, P. D. and Reay, D. A., Heat Pipes, Fourth Edition, Pergamon Press, 1994.
6. El Wakil., Power Plant Technology, McGraw Hill.
7. Das, S.K., Process heat transfer, Narosa publishing house, 2005

Course Plan

Module	Content	Contract hours	Semester Exam Marks (%)
I	Heat Exchangers: Meaning, Classification, Significance, Applications and Selection. Thermal Performance Analysis of Heat Exchangers: compact, cross flow, liquid to gas, and double pipe heat exchangers, film coefficients for tubes and annuli, the equivalent diameter of annuli, fouling factors, caloric or average fluid temperature, true temperature difference.	8	15
II	Design calculation of double pipe heat exchanger: LMTD, NTU and P-NTU Methods.	8	15
First Internal Examination			
III	Shell and tube heat exchangers: classification of shell and tube exchangers.	8	15
IV	The Circulating Water System: Introduction-System Classification-The Circulation System-Wet Cooling Towers-Wet Cooling Tower Calculations-Dry cooling towers.	8	15
Second Internal Examination			

V	Heat Pipe Types and Applications: Heat pipe invention and Operating principles-Working fluids-Wick structures-Control Techniques-Applications Capillary Limitation and Temperature Characteristics: Pressure balance- Maximum capillary pressure-Liquid and Vapor pressure drops- Effective thermal conductivity of wick structures- Capillary limitation on heat transport capability-Heat Pipe Temperature Characteristics	9	20
VI	Sonic, Entrainment and Boiling Limitations: Introduction Sonic Limitation-Entrainment Limitation-Boiling Limitation Heat Pipe Design – Fluid selection- Wick selection- Material selection- Preliminary Design Considerations. Heat Pipe Design Procedure: Introduction- Heat Pipe Diameter-Design of Heat Pipe Containers- Wick design. Entertainment and Boiling limitations-Design Problems.	9	20
End Semester Cluster Level Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6514	**ENERGY EFFICIENT BUILDINGS**	**3-0-0 : 3**	**2020**

Course Prerequisites

Basic knowledge of heat transfer.

Course Objectives

1. To learn the concepts of the green building applicable to modern buildings.
2. Acquaint students with the principle theories, materials, construction techniques and create energy-efficient buildings
3. Earn the knowledge of human comfort factors
4. To learn the concepts of building energy management

Syllabus

Building architecture, Energy efficient building concepts, Natural ventilation, passive cooling and heating, Heat transfer in buildings, Estimation of building loads, Introduction of renewable energy systems in buildings.

Expected Outcomes

On successful completion of the course, the students are expected to

1. Conceptualize the methods for establishing energy-efficient buildings.
2. Design green buildings for maximum human comfort
3. Employ the knowledge on different climatic zones in establishing energy-efficient buildings
4. Describe the concept of energy management in buildings.

References

1. Krieder J. and Rabi A., Heating and Cooling of Buildings: Design for Efficiency, Mc Graw Hill, 1994.
2. Ursala Eicker, Solar Technologies for buildings, Wiley publications, 2003.
3. Sodha M.S, Bansal, P. K., Kumar, A. and Malik, M. A. S., Solar Passive Buildings, Pergamon Press, New York, 1986.
4. J. Duffie, W. Beckman, Solar Engineering of Thermal Processes, 4^{th} Edition, Wiley.
5. Energy Conservation Building Codes; Bureau of Energy Efficiency.
6. Handbook on Energy Conscious Buildings (http://mnre.gov.in)

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Introduction - Building Science and its significance, Building Materials, Indoor Environment, and Components of Indoor Environment. Quality of Indoor Environment. Conventional versus Energy Efficient buildings – Water, Energy, and IAQ requirement analysis. Future building design aspects– Criticality of resources and needs of modern living.	7	15
II	Human Comfort-Thermal, Visual, Acoustical and Olfactory comfort. Ventilation and its significance. Micro-climates –Shading, water bodies. Building materials, Envelope heat loss and heat gain and its evaluation, paints, Insulation, Design Methods and tools.	7	15
First Internal Examination			
III	Heating concept -Passive Heating - Direct Gain, Indirect Gain, Isolated Gain, and Solarium. Cooling concept- Passive Cooling-Ventilation Cooling, Evaporative Cooling, Nocturnal Radiation Cooling, Desiccant Cooling, Earth Coupling. Design of	7	15

	daylighting.		
IV	Climate zones – Introduction, Climatic zones and their characteristics, Factors affecting climate, Implications of climate on building design- Urban climate. Surface co-efficient- air cavity, internal and external surfaces, overall thermal transmittance, wall and windows.	7	15
Second Internal Examination			
V	Heat transfer due to ventilation/infiltration, internal heat transfer; Decrement factor; Phase lag. Estimation of building loads: Steady-state method, network method, numerical method, correlations; Computer packages for carrying out the thermal design of buildings and predicting performance.	7	20
VI	Roof radiation traps, Earth air tunnel, Solar water heating, Small wind turbines, Stand-alone PV systems, Hybrid system – Economics. Energy Management of Buildings - Energy Audit of Buildings, Energy Management matrix monitoring and targeting.	7	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6522	**STATISTICAL METHODS FOR EXPERIMENTAL DESIGN**	**3-0-0: 3**	**2020**

Course Prerequisites

Basic knowledge of probability and statistics

Course Objectives

1. To make the student able to design experiments and analyze the results statistically.
2. To build statistical models for real-world problems

Syllabus

Designed experiments – Overview of statistics and probability distributions – Sampling distributions – Confidence intervals – Hypothesis testing – ANOVA – Design of single-factor experiments – Factorial experiments -Two-level factorial experiments – Model adequacy checking - Fractional factorial designs – Blocking and confounding - Response surface methods.

Expected Outcomes

On completion of this course, the students will be able to

1. Conduct statistical hypothesis tests on mean and variance
2. Conduct factorial experiments
3. Design experiments
4. Estimate model parameters for experimental design
5. Interpret experimental results

References

1. Montgomery, D. C. Design and analysis of experiments, John Wiley, New York, 2001.
2. Montgomery, D. C. & Runger, G. C. Applied Statistics and Probability for Engineers, John Wiley, New York, 2007.
3. Krishnaiah, K. & Shahabudeen, P. Applied Design of Experiments and Taguchi Methods, PHI, New Delhi 2012.
4. George, E. P., J. S. Hunter and W. G. Hunter. Statistics for experimenters: design, innovation, and discovery, John Wiley, New York 2005.

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	Introduction to Design of Experiments: One factor at a time experiments and designed experiments; Role of DoE in experimentation; Application of software packages for designing experiments. Basic statistical concepts: Probability distributions, pdf and cdf, mean and variance; Normal and t distributions, Normal probability plot; tables and chart to represent data, Stem and leaf, Box plot, Pareto chart.	7	15
II	Sampling distribution: Central limit theorem, Construction of confidence intervals. Hypothesis testing: Hypothesis testing of single means, testing of two means, with known and unknown population variance; Paired t-test; Testing of variances.	7	15
First Internal Examination			
III	Single-factor experiments: Analysis of Variance; Completely randomized design; Replication, Randomization, Blocking; Randomized complete block design; Latin square design; Model adequacy checking, residual plots.	7	15

IV	Factorial experiments: Two and three-factor full factorial experiments; Model adequacy checking; Blocking in a factorial experiment	7	15
Second Internal Examination			
V	Two-level factorial design: 2^kfull factorial experiments, Effects and contrasts; Yate's algorithm; Single replicate case; Addition of central points to the 2^k design; Blocking and confounding in the 2^k factorial design.	7	20
VI	Fractional factorial designs: 2-level fractional factorial experiments; Alias structures in fractional factorial designs; Design resolutions; Response Surface Methods and Designs; Taguchi designs	7	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6524	**ENERGY STORAGE TECHNOLOGIES**	**3-0-0: 3**	**2020**

Course Prerequisites

Basic knowledge in thermodynamics, fluid mechanics and heat transfer

Course Objectives

1. Enable students to appreciate the need for energy storage.
2. Impart concepts of various energy storage methods like chemical, thermal, batteries and other innovative methods of energy storage.
3. Enable the students to choose the most appropriate energy storage method based on technology, economic and environmental aspects.

Syllabus

The necessity of energy storage, Chemical Energy storage, Thermal storage, Fundamental concept of batteries, Fuel Cell, PCM, Pumped storage, Concept of Hybrid Storage

Expected Outcomes

After the completion of the course the student should be able to:

1. Describe the various Chemical and Thermal Energy storage systems.
2. Apply the principles of Electro-Chemical Batteries to design effective storage systems.
3. Use fuel cells for various industrial applications
4. Introduce the use of special materials for effective energy storage systems.
5. Select appropriate energy storage systems based on technical and economic considerations.

References

1. Ibrahim Dincer and Mark A. Rosen, Thermal Energy Storage Systems and Applications, John Wiley & Sons 2002.
2. S. P. Sukhatme, Solar Energy - Principles of thermal collection and storage, second edition, Tata McGraw-Hil, New Delhi, 1996.
3. Schmidt F.W and Willmott. A. J., Thermal Storage and Regeneration, Hemisphere Publishing Corporation, 1981
4. Alfred Rufer, Energy Storage Systems and components, CRC Press, 2017
5. James Larminie and Andrew Dicks, Fuel cell systems Explained, Wiley publications, 2003.
6. Ru-shiliu, Leizhang and Xueliang sun, Electrochemical technologies for energy storage and conversion, Wiley publications, 2012.
7. Power Sources for Electric Vehicles, Edited by B.D. Mc Nicol and D.A.J. Rand, Elsevier Publications,1998
8. Lithium Batteries for Hybrid Cars By John Voelcker, IEEE Spectrum, 1990.
9. Hand Book of Batteries and Fuel cells, 3rd Edition, Edited by David Linden and Thomas.B. Reddy, McGraw Hill Book Company, N.Y. 2002.
10. Viswanathan, B. and Scibioh, Aulice M, Fuel Cells, Principles and Applications, Universities Press, 2006.

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	The necessity of energy storage – types of energy storage – comparison of energy storage technologies – Applications. General consideration, petroleum product storages, LPG storages, LNG storages, hydrogen storages, toxic storages, chlorine storages, ammonia storages, other chemical storages – underground storages– loading and unloading facilities–drum and cylinder storage – warehouse, storage hazard assessment of LPG and LNG	6	15

II	Thermal storage – Types – Modelling of thermal storage units – Simple water and rock bed storage system – pressurized water storage system – Modelling of phase change storage system – Simple units, packed bed storage units -Modelling using the porous medium approach.	8	15
First Internal Examination			
III	The fundamental concept of batteries – measuring of battery performance, charging and discharging of a battery, storage density, energy density, Free energy, theoretical cell voltage, specific capacity, specific energy, energy density, memory effect, cycle life, shelf life, state of charge (SOC) and depth of discharge (DOD), internal resistance and Coloumbic efficiency and safety issues. Types of batteries – Primary and secondary batteries -Lead Acid, Nickel – Cadmium, Zinc Manganese dioxide and modern batteries for example (i) zinc-Air (ii) Nickel Hydride, (iii) Lithium Battery	8	15
IV	Fuel Cell – History of the Fuel cell, Principles of Electrochemical storage – Types – Hydrogen oxygen cells, Hydrogen air cell, Hydrocarbon air cell, alkaline fuel cell, detailed analysis – advantage and drawback of each type. Fuel cell outlook, Applications of fuel cells – Industrial and commercial.	6	15
Second Internal Examination			
V	Phase Change Materials, Pumped storage Energy Storage - Sensible, latent heat and thermo-chemical storage-pebble bed etc. materials for phase change-Glauber's salt-organic compounds. Solar ponds	7	20
VI	Flywheel, Supercapacitors, Principles & Methods – Applications, Compressed air Energy storage, Concept of Hybrid Storage – Applications- Combustion Engine Hybrid Electric Vehicles, Laboratory Test of Electric Vehicle Batteries, Vehicle tests with Electric Vehicle Batteries, Future of Electric Vehicles.	7	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6508	**MINI PROJECT**	**0-0-4: 2**	**2020**

Course Prerequisites

1. The habit of reading technical magazines, conference proceedings and journals.
2. Skills in hardware/software implementation techniques earned through UG studies.
3. Seminar I

Objectives

1. To support the problem-based learning approach and to enhance the reading habit among students
2. To enhance the skills regarding the implementation aspects of small hardware/software projects.

Guidelines

Each student has to do a mini project related to the branch of specialization under the guidance of a faculty member. It has to be approved by a committee constituted by the institute concerned. It is recommended that the same faculty member may serve as his/her Project Supervisor during the 3rd& 4th semesters. The mini-project is conceptualized in such a way that, some the outcomes of the work can be utilized in the selection of the thesis. Hence on completion of the mini project, the student can suggest a possible list of their thesis topic in the second semester itself. The implementation of the mini project can be a software and/or hardware-based one. Mini project is envisaged as a way for implementing problem-based learning. Problems of social relevance and/or problems identified by the institute/ research organizations/ industry/ state should be given high priority. In such interdisciplinary and inter-institutional projects, a student can have co-guide (s) from another department/ institute/ research organizations/ industry. The university encourages interdisciplinary projects and problem based learning strategies. References cited shall be authentic.

Expected Outcomes

On successful completion of the course, the student will be able to

1. Compare the different strategies to be adopted for carrying out project work.
2. Apply the knowledge and skills gained into carrying out the main project work.
3. Analyse problems chosen for the main Project.

References

1. J.W. Barnes, Statistical Analysis for Engineers and Scientists, 2nd Edition, Mc Graw Hill, New York, 1994
2. Schank Fr., Theories of Engineering Experiments, Tata McGraw Hill Publication.
3. Douglas C Montgomery, Design and analysis of experiments, Wiley International, 2013
4. Leedy P D, Jeanne Ellis Ormrod, Practical Research: Planning and Design, 12th Illustrated Edition, Pearson, 2019

Course plan

Item	Course Plan	Time	
I	Abstract Submission	2 weeks	
II	Allotment of Topic	1 week	
III	Preliminary Presentation Session	1 week	
IV	Implementation Phase	9 weeks	
V	Final Presentation-cum Demonstration	1 week	

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6512	**ENERGY SIMULATION LAB**	**0-0-2: 1**	**2020**

Course Prerequisites

Nil

Course Objectives

This laboratory shall primarily address the practical aspects of the key areas of modeling and simulation analysis of various energy systems using appropriate software

Expected Outcomes

To enable the students to

1. Model different energy-related problems with appropriate initial and boundary conditions.
2. Apply the Numerical tools for solving the problems using high-speed computers.
3. Analyse the results using high-speed computers and commercial software or by computer coding.
4. Evaluate an energy system by the parametric study.

List of Experiments

1. Modeling of a gas turbine powerplant and performance evaluation using Cycle Tempo software
2. Modeling of a steam turbine powerplant and performance evaluation using Cycle Tempo software
3. Modeling of a Combined Cycle powerplant and performance evaluation using Cycle Tempo software
4. Modeling of Nonconventional energy systems like geothermal powerplant, Gasifier, Fuel Cell etc. and performance evaluation using Cycle Tempo software
5. Flow and heat transfer analysis of fluid flow over a plate using ANSYS Fluent
6. Flow and heat transfer analysis of pipe flow using ANSYS Fluent
7. Simulation and parametric variation of thermal systems using Aspen Plus
8. Data prediction of energy systems by ANN using MATLAB
9. Optimization of energy systems by Genetic Algorithm using MATLAB

SEMESTER 3

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME7505	**WIND ENERGY TECHNOLOGIES**	**3-0-0: 3**	**2020**

Course Prerequisites

Basic knowledge of engineering mechanics and electrical engineering

Course Objectives

To enable the students to

1. Have an understanding of the wind energy potential and its conversion systems.
2. Disseminate the design principles of wind turbine blades.
3. Have an understanding of the generators for wind energy conversion.
4. Learn modern wind turbine control.

Syllabus

Wind Energy Basics, Betz limit, Airfoil terminology, Blade element theory, Grid Synchronization System, Generators for wind energy systems, Details of Pitch System & Control Algorithms.

Expected Outcomes

On successful completion of the course, the student will be able to

1. Explain the potential of wind energy and its conversion systems
2. Design the wind turbine blades
3. Explain the electrical systems and generators for wind energy conversion.
4. Explain the control of modern wind turbines.

REFERENCES

1. J. F. Manwell, J. G. McGowan and A. L. Rogers, Wind Energy Explained- Theory, Design and Application, 2nd Edition, John Wiley & Sons Ltd, 2009
2. M. O. L. Hansen, Aerodynamics of Wind Turbines, 3rd Edition, Earth scan, 2015
3. F. D. Bianchi, H. D. Battista and R. J. Mantz, Wind Turbine Control Systems- Principles, Modeling and Gain Scheduling Design, Springer, 2007.
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, 2009.
6. John D Sorensen and Jens N Sorensen, Wind Energy Systems, Wood head Publishing Ltd, 2011.
7. Kaldellis J. K., Stand – alone and Hybrid Wind Energy Systems, CRC Press, 2010.
8. Mario Garcia –Sanz, Constantine H. Houpis, Wind Energy Systems, CRC Press 2012
9. Povl Brøndsted , Rogier P. L. Nijssen, Advances in Wind Turbine Blade Design and Materials ,Wood head Publishing Ltd, 2013

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	Wind Energy Basics, Wind Speeds and scales, Terrain, Roughness, Wind Mechanics, Power Content, Class of wind turbines, Atmospheric Boundary Layers, Turbulence. Instrumentation for wind measurements, Wind data analysis, tabulation, the wind rose diagrams, Wind resource estimation, Betz's Limit, Turbulence Analysis. Beaufort number -Gust parameters, wind type, power-law index -Betz constant, Terrain	7	15

	value.		
II	Airfoil terminology, Blade element theory, Blade design, Rotor performance and dynamics, Balancing technique (Rotor & Blade), Types of loads; Sources of loads Vertical Axis Type, Horizontal Axis, Constant Speed Constant Frequency, Variable speed Variable Frequency, UpWind, Down Wind, Stall Control, Pitch Control, Gear Coupled Generator type, Direct Generator Drive /PMG/Rotor Excited Sync Generator.	7	15
First Internal Examination			
III	Electronics Sensors/Encoder/Resolvers, Wind Measurement - Anemometer & Wind Vane, Grid Synchronization System, Soft Starter, Switchgear, Transformer, Cables and assembly, Compensation Panel, Programmable Logic Control, UPS, Yaw & Pitch System - AC Drives, Safety Chain Circuits, Generator Rotor Resistor controller, Differential Protection Relay for Generator, Battery/Super Capacitor Charger & Batteries/ Super Capacitor for Pitch System, Transient Suppressor/Lightning Arrestors, Oscillation & Vibration Sensing.	7	15
IV	Generators for wind energy conversion systems - Squirrel Induction generators, Wound rotor Induction generators. Rotor resistance control.	7	15
Second Internal Examination			
V	Doubly fed Induction generators - Principle and control, Permanent magnet Synchronous generators - Controlled Rectifiers, Capacitor Banks, Transformers and Inverters.	7	20
VI	Details of Pitch System & Control Algorithms, Protections used & Safety Consideration in Wind turbines, Wind Turbine Monitoring with Error codes, SCADA & Databases - Remote Monitoring and Generation Reports, Operation & Maintenance for Product Life Cycle, Balancing technique (Rotor & Blade), FACTS control & LVRT & New trends for new Grid Codes.	7	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME7507	**WASTE MANAGEMENT AND ENERGY RECOVERY**	**3-0-0: 3**	**2020**

Course Prerequisites

Basic engineering knowledge

Course Objectives

To enable the students to

1. Learn the sources and types of waste generation.
2. Acquaint the methods of collection, transport and processing technologies.
3. Earn the knowledge of waste size reduction, hazardous waste management
4. Learn the technologies of waste processing and energy generation.

Syllabus

Waste sources, composition, properties, handling, size reduction, hazardous wastes, waste management, and environmental impact assessment.

Expected Outcomes

On successful completion of the course, the student will be able to

1. Explain the various sources of waste and waste management methods
2. Discuss technologies of waste handling and disposal
3. Explain technologies of energy generation from wastes
4. Prepare Environmental Impact Assessment of various types of pollution

References

1. Shah, Kanti L., Basics of Solid & Hazardous Waste Management Technology, Prentice Hall 1999.
2. Barthwal, R. R., Environmental Impact Assessment, New Age International Publishers (P) Ltd 2012
3. Parker, Colin, & Roberts, Energy from Waste - An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985
4. Adaptive environmental assessment and Management Ed. C. S. Holling, John Wiley and Sons 2005
5. S.A. Abbasi and N. Abbasi, Renewable Energy Sources and Their Environmental Impact, Prentice Hall of India 2010
6. Environmental Impact Assessment L.W.Canter, McGraw Hill Book Company 1995
7. Barthwal, R. R., Environmental Impact Assessment, New Age International Publishers (P) Ltd 2012

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	Sources, generation and estimation, types, compositions, Properties - physical, chemical and biological. Collection, Transfer stations, waste minimization, Recycling of municipal wastes, regulations.	7	15
II	Collection, Transportation And Processing Techniques - onsite handling, storage, processing, types of waste collection mechanisms, Transfer stations - types and location, Manual component separation and other separation techniques.	7	15
First Internal Examination			
III	Size Reduction - Aerobic Composting, Incineration for Medical /Pharmaceutical Waste. Land Fill Method- Types, Methods & siting consideration. Composition, characteristics, generation.	7	15

	Control of landfill leachate & gases, an environmental monitoring system for landfill gases.		
IV	Hazardous Waste – definition, potential sources, impact on the environment, transportation regulations, risk assessment, remediation technologies. Private-public partnership, Government initiatives. Disposal of Hazardous Waste - Underground Storage Tanks Construction, Installation and Closure.	7	15
Second Internal Examination			
V	Managing wastes - Basics, types, working and typical conversion efficiencies of composting, anaerobic digestion, combustion, incineration, gasification, pyrolysis.	7	20
VI	Environmental Impact Assessment - Production and assessment of impacts due to air and water pollution on the environment. Environment Impact Assessment in the land and biological environment. Environmental Effects due to Incineration	7	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME7511	**INDUSTRIAL NOISE CONTROL**	**3-0-0: 3**	**2020**

Course Prerequisites

Basic knowledge in physics and mathematics.

Course Objectives

To enable the students to

1. Acquire basic knowledge in acoustics and industrial noise control.
2. Be familiar with the noise control measures used in industries.

Syllabus

Fundamentals of acoustics, wave equation, solutions, sound measurement and instrumentation, transmission loss, absorption coefficient, room acoustics, acoustic enclosures, mufflers, noise from various sources and regulations.

Expected Outcomes

On successful completion of the course, the student will be able to

1. Describe the principles of acoustics
2. Estimate the noise levels in various locations
3. Analyse the acoustic modes in rooms
4. Apply noise control measures in various engineering fields
5. Analyse the performance of different types of mufflers
6. Discuss the latest norms on noise control.

References

1. Barron, Randall F. Industrial noise control and acoustics. CRC Press, 2002.
2. Crocker, Malcolm J., ed. Handbook of noise and vibration control. John Wiley & Sons, 2007.
3. Williams, Earl G. Fourier acoustics: sound radiation and nearfield acoustical holography. Academic Press, 1999.

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	Fundamentals: acoustic pressure, acoustic intensity, acoustic energy density, impedance, levels and decibels, a combination of decibels, octave bands, weighted sound levels.	5	15
II	Wave equation, plane waves, spherical waves, solution, near field, far field, direct field, reverberant field, standing waves, directivity factor and directivity index.	7	15
First Internal Examination			
III	Measurement: microphones, sound level meter, intensity level meter, octave band filters, acoustic analysers, dosimeter, measurement of sound power, measurement in a reverberant room, measurement in anechoic & semi-anechoic rooms, sound transmission and absorption, measurement using impedance tube.	8	15
IV	Room acoustics: acoustic modes, mechanism of surface absorption, surface absorption coefficients, steady-state sound level, reverberation time, sound transmission from an adjacent room, acoustic enclosures, acoustic barriers.	6	15
Second Internal Examination			
V	Mufflers - design requirements, lumped parameter analysis, Helmholtz resonator, side branch mufflers, expansion chamber mufflers, dissipative mufflers, estimation of attenuation	10	20

	coefficient.		
VI	Noise sources & regulations - Fan noise, electric motor noise, noise from gears, pump noise, gas compressor noise, transformer noise, cooling tower noise, valve noise, air distribution system noise, traffic noise, train noise-Noise criteria for interior spaces, day-night level, EPA criteria, HUD criteria, aircraft noise criteria, OSHA regulations.	8	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EE7107	**ELECTRIC VEHICLE SYSTEMS**	**3 - 0 – 0: 3**	**2015**

Course Prerequisites

Basic knowledge of four-stroke and two-stroke engines, Various type of motors used for traction purposes; DC series, Slip ring IM, Basics of Electrical Drives, Fuel Cell - UG Level.

Course Objectives

This course is designed to understand electric vehicles and to develop design skills for electric vehicles. This course will introduce general aspects of Electric Vehicles (HEV), including architectures, modeling, sizing, vehicle control. It will cover vehicle dynamics, energy storage sources, electric propulsion systems, power electronics design, and EV drives.

Syllabus

Fundamentals of Vehicle Propulsion and Brake: - Vehicle Resistance - Dynamic Equation - Tire–Ground Adhesion and Maximum Tractive Effort - Power Train Tractive Effort and Vehicle Speed - Vehicle Power Plant and Transmission Characteristics - Vehicle Performance

Internal Combustion Engines – 4 stroke spark ignited and compression ignited engines – 2 stroke engines – Wankel rotary engines – Stirling engines – gas turbine engines – quasi isothermal Brayton cycle engines

Electric vehicles: configuration – performance – tractive effort in normal driving – energy consumption

Hybrid electric vehicles: series and parallel electric drive trains

Electric propulsion systems: DC motor drives – Induction motor drives – permanent magnet BLDC motor drives – SRM drives – SRM design

Parallel (Mechanically Coupled) Hybrid Electric Drive Train Design - Design and Control Methodology of Series–Parallel (Torque and Speed Coupling) Hybrid Drive Train - Statistics of Daily Driving Distance - Energy Management Strategy - Energy Consumed in Braking and Transmission - Regenerative Braking - Control Strategy for Optimal Energy Recovery

Fuel Cells - Fuel Cell Hybrid Electric Drive Train Design - Power and Energy Design of Energy Storage

Expected Outcomes

On successful completion of the course, the student will be able to

1. Identify the various fundamentals in the traction design problems
2. Understand the various factors that influence the vehicle tractive power and performance.
3. Able to design hybrid electric vehicle system depending on the power requirement, input available, energy management requirement, alternate fuel system etc.
4. Propose various electric driving motors and Power electronics drives systems for the electrical vehicle.

Textbooks

1. Modern Electric Vehicles, Hybrid Electric and Fuel Cell Vehicles – 2nd Edition – Meherdad Ehsani, Yimin Gao, Ali Emadi – CRC Press
2. Electric Vehicle Technology Explained – James Larminie, John Lowry – John Wiley & Sons
3. Batteries for Electric Vehicles (Electronic & Electrical Engineering Research Studies Power Sources Technology) - D Rand - Wiley-Blackwell (21 January 1998)
4. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design, Second Edition (Power Electronics and Applications Series) - Mehrdad Ehsani, Yimin Gao, Ali Emadi, Standardsmedia (2009)

References

1. Propulsion System for Hybrid Vehicle" 2nd Edition" by John M. Miller
2. History of Electric Vehicles Bellis.

Course plan			
Module	**Content**	**Hours**	**Semester Exam Marks(%)**
I	Fundamentals of Vehicle Propulsion and Brake: - Vehicle Resistance - Dynamic Equation - Tire–Ground Adhesion and Maximum Tractive Effort - Power Train Tractive Effort and Vehicle Speed - Vehicle Power Plant and Transmission Characteristics - Vehicle Performance.	6	15
II	Internal Combustion Engines – 4 stroke spark ignited and compression ignited engines – 2 stroke engines – Wankel rotary engines – Stirling engines – gas turbine engines – quasi isothermal Brayton cycle engines Electric vehicles: configuration – performance – tractive effort in normal driving – energy consumption Hybrid electric vehicles: series and parallel electric drive trains.	8	15
First Internal Examination			
III	Electric propulsion systems: DC motor drives – Induction motor drives – permanent magnet BLDC motor drives – SRM drives – SRM design	6	15
IV	Parallel (Mechanically Coupled) Hybrid Electric Drive Train Design - Design and Control Methodology of Series-Parallel (Torque and Speed Coupling) Hybrid Drive Train - Statistics of Daily Driving Distance	8	15
Second Internal Examination			
V	Energy Management Strategy - Energy Consumed in Braking and Transmission - Regenerative Braking - Control Strategy for Optimal Energy Recovery Fuel Cells -	8	20
VI	Fuel Cell Hybrid Electric Drive Train Design - Power and Energy Design of Energy Storage.	6	20
Total		42	100
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10ME7513	**ENERGY, ENVIRONMENT AND CLIMATE CHANGE**	**3-0-0: 3**	**2020**

Course Prerequisites

Nil

Course Objectives

1. To introduce the interrelationship between energy, ecology and environment
2. To detail on the sources of air, water and soil pollution and possible solutions for mitigating their degradation
3. To impart knowledge on the atmosphere and its present condition, global warming and eco-legislations
4. To elaborate on the technologies available for generating energy from waste

Syllabus

Basic definitions, link with ecology, resource classifications, Energy Transfer and Nutrient cycling, Environmental Impact of conventional resources, Alternate mitigation aspects using non-conventional resources, air pollution, water pollution, soil pollution, thermal pollution, e-waste pollution, radioactive waste pollution, global effects and climate change

Expected Outcomes

On successful completion of the course, the student will be able to

1. Discuss the interrelationship between energy, ecology and environment
2. Understand sources of air, water and soil pollution and possible remedies
3. Interpret the environmental impacts of energy technologies.
4. Illustrate the issues related to climate change and related protocols

References

1. Rao C.S., Environmental Pollution Control Engineering, 2nd Edition, New Age International Publishers, 2006.
2. Gilbert M. M., Wendell P. E., Introduction Environmental Engineering and Science, Prentice Hall of India, 2008.
3. Behri J., Sustainability, Green Energy and Climate Change: Revisited, Capital Publishing Company, 2016.
4. D. Nevers, Air Pollution Control Engineering, McGraw Hill, 2001.
5. Y. Anjaneyulu, Air pollution: Prevention and Control Technologies, BS Publications, 2020.
6. G. M. Masters, W P Ela, Introduction to Environmental Engineering and Science, Prentice Hall, 3rd Edition, 2007.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Energy Overview: Basics of energy, Types of energy and its utilization, Overview of global energy scenario, Fossil Fuel Reserves –Estimates, Overview of India's energy scenario, Examples for trends in energy use patterns, energy and development linkage	7	15
II	Fundamentals of environment; Water cycle, Oxygen cycle, Carbon cycle, Nitrogen cycle, Phosphorous cycle, Rock cycle; Bio-diversity; Environmental aspects of energy utilization, Public health issues related to environmental Pollution, Carbon footprint and its measurement	7	15
First Internal Examination			

III	Air Pollution: Classification of air pollutants, sources of emission and air quality standards, Physical and chemical characteristics, Meteorological aspects of air pollutant dispersion, Factors influencing dispersal of air pollutant, Air pollution dispersion models, Air pollution sampling and measurement, types, Ambient air sampling, Gaseous air pollutants, Particulate air pollutants, control methods of air pollution, Exhaust emission test, procedures, standards and legislation	7	15
IV	Water resources, water pollutants – characteristics, BOD, COD, TOC – quality, water treatment systems, waste water treatment, utilization and disposal of sludge, monitoring compliance with standards, measurement and control of water pollution.	7	15
Second Internal Examination			
V	Sources and Classification of Solid waste, Hazardous waste, Characteristics, Collection and Transportation, Disposal, Processing and Energy Recovery, Environment impact assessment for various projects – case studies, Radioactive waste: types, sources, effects, control of radiation pollution, Pollution due to e-waste, Soil pollution- causes and effects, remedial solutions.	7	20
VI	Elements of climate - Climatic classifications, Possible causes of climate change, Causes and consequences of global warming, ozone hole and consequence of ozone depletion, Effects on oceans, Montreal protocol, Kyoto protocol and recent conventions, Strategies for conservation of environmental changes induced by CO_2 rise, Concept of carbon sequestration; Future energy systems	7	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME7515	**ENERGY SYSTEMS MODELLING AND ANALYSIS**	**3-0-0: 3**	**2020**

Course Prerequisites

Basic knowledge in thermodynamics, fluid mechanics, heat transfer and numerical analysis at the UG level

Course Objectives

To enable the students to

1. Apply mass and energy balances for the systems and to perform the design of Energy systems.
2. To utilize accurate and efficient computational methods for the solution and optimization of energy system models.

Syllabus

The course covers the design process, mathematical modelling and numerical simulations, economic consideration and optimization of energy systems.

Expected Outcomes

On successful completion of the course, the student will be able to

1. Apply the scientific knowledge to Model and Simulation a typical energy system.
2. Analyze the effect of constraints on the performance of energy systems.
3. Design of HEN and perform Energy-Economic Analysis for typical applications.

References

1. B. K.Hodge, Analysis and Design of Thermal Systems, Prentice Hall Inc., 1990.
2. Bejan A., Tsatsaronis G. and Moran M., Thermal Design and Optimization, John Wiley &Sons 1996.
3. C. Balaji, Essentials of Thermal System Design and Optimization, Aue Books, 2011.
4. Kapur J. N., Mathematical Modeling, Wiley Eastern Ltd, New York, 1989.
5. Stoecker W.F., Design of Thermal Systems, McGraw Hill, 2011.
6. Yogesh Jaluria, Design and Optimization of Thermal Systems, CRC Press INC, 2008
7. W. F. Stoecker: Design of Thermal Systems, 3rd Ed., McGraw Hill, 1989.
8. B. K. Hodge: Analysis and Design of Thermal Systems, Prentice Hall Inc., 1990.
9. J. Nagrath & M .Gopal: Systems Modelling and Analysis, Tata McGraw Hill.
10. D.J. Wide: Globally Optimal Design, Wiley- Inter-Science, 1978

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	Primary energy analysis - energy balance for closed and control volume systems - applications of energy analysis for selected energy system design - modeling overview - levels and steps in model development - Examples of models – curve fitting and regression analysis.	6	15
II	Modeling of energy systems – Mathematical modeling, Exponential forms- Method of least squares, heat exchanger - solar collectors – distillation -rectification turbomachinery components - refrigeration systems - information flow diagram - solution of set of non-linear algebraic equations - successive substitution – Newton -Raphson method- examples of energy systems simulation	8	15
First Internal Examination			

III	Objectives - constraints, problem formulation - unconstrained problems - necessary and sufficiency conditions. Constrained optimization - Lagrange multipliers, constrained variations, Linear Programming - Simplex tableau, pivoting, sensitivity analysis.	8	15
IV	Multiplier Analysis - Energy and Environmental Input / Output Analysis - Energy Aggregation – Econometric Energy Demand Modeling	6	15
Second Internal Examination			
V	New generation optimization techniques – Genetic algorithm and simulated annealing – examples, Overview of Econometric Methods - Dynamic programming - Search Techniques - Univariate / Multivariate	8	20
VI	Case studies of optimization in Energy systems problems- Dealing with uncertainty- probabilistic techniques – Trade-offs between capital and energy using Pinch analysis	8	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME7517	**PROJECT MANAGEMENT**	**3-0-0: 3**	**2020**

Course Prerequisites
Basic knowledge of Industrial Engineering or Management at the UG Level

Course Objectives:
1. This course examines project management in theory and practice and the roles and responsibilities of the project manager.
2. The course offers a practical approach to managing projects, focusing on organizing, planning, and controlling the efforts of the project.

Syllabus

Overview of Project Management - Project Management Concepts and Techniques - Project Cost Estimation - Project Planning and Scheduling- Resource-Constrained Scheduling - Project Monitoring and Control - Management of Special Projects.

Expected Outcomes
On successful completion of the course, the student will be able to
1. Discuss the principles of project management.
2. Organise project plan to lead a team
3. Execute project plans without cost and time overruns.
4. Recognize the procedure for implementing big and special projects.

References

1. Shtub, Bard and Globerson, Project Management: Processes, Methodologies, and Economics, 2/E, Prentice Hall Inc, 2005.
2. Lock, Project Management Handbook, Gover Publishing Ltd, 1981.
3. Cleland and King, Project Management Handbook 2nd Edition, Wiley, 1988.
4. Wiest and Levy, A Management Guide to PERT/CPM, Prentice Hall of India, New Delhi.
5. Horald Kerzner, Project Management: A Systemic Approach to Planning, Scheduling and Controlling, CBS Publishers, 2002.
6. S. Choudhury, Project Scheduling and Monitoring in Practice, South Asian Publishers, Delhi, 1983.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Introduction to Project management, Characteristics of projects, Definition and objectives of Project Management, Stages of Project Management, Project Planning Process, Establishing Project organization, the role of Project Manager-.	6	15
II	Project screening and Selection Techniques - Structuring concepts and Tools - Work Breakdown Structure, Organisation Breakdown Structure, and Linear Responsibility Chart - Project Planning Tools- Bar charts, Line of Balance – Critical Path Method, and Project Evaluation and Review Technique- Risk Analysis and Management	8	15
First Internal Examination			
III	Types of Estimates and Estimating Methods- Capital Cost Estimation - Project Budgeting - Project cash flow analysis.	6	15

IV	Project Scheduling with Resource Constraints- Resource Leveling- Resource-constrained scheduling with multiple resources- linear programming formulation – Introduction to staff scheduling and rostering.	8	15
Second Internal Examination			
V	Monitoring Techniques and time control System- Project Cost Control -Time cost Tradeoff procedure, lowest cost schedule Computer applications in project management	7	20
VI	Management of Software Engineering Projects, New Product Development Projects, R&D Projects and Large Scale Construction Projects - Case Studies	7	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10EE7505	**ELECTRICAL DRIVES AND CONTROL**	**3-0-0: 3**	**2020**

Course Prerequisites

Basic knowledge in Electrical Engineering at the UG level

Course Objectives

To enable the students to

1. Understand the principle of motor drives.
2. Understand the concept of Solid State motor controllers and their applications

Syllabus

Introduction to Electrical Drives, Power Electronic Converters for Motor Drives, D.C. Motor Drives, Induction Motor Drives, Synchronous motor drives, BLDC drives, reluctance motors, hysteresis motor, Stepping and switched reluctance motor drives, Drive selection and closed-loop control.

Expected Outcomes

On successful completion of the course, the student will be able to

1. Explain the principle of electrical motors.
2. Explain the concept of Solid-State controllers and their applications
3. Analyze DC motor drives
4. Analyze induction motor drives
5. Analyze Synchronous motor, BLDC motor, stepper motor, reluctance motor and hysteresis motor drives
6. Choose appropriate drives and controllers for various applications

References

1. Austin Hughes, "Electric Motor & Drives", Newnes, 4/e, 2013.
2. M. D. Singh and K.B. Khanchandani, "Power Electronics", Tata McGraw-Hill Education Ltd, 2006.
3. Pillai. S. K., "A First Course on Electric Drives", Wiley Eastern Limited, 3/e, 2012.
4. Vedam Subrahmanyam, "Electric Drives: Concepts & Applications" 2/e, Tata McGraw-Hill Education, 2011.
5. Gopal K. Dubey, "Fundamentals of Electric Drives", Narosa, 2/e, 2010.
6. R. Krishnan, "Electric Motor Drives – Modeling, Analysis and Control," Prentice-Hall of India, 1/e, 2015.

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	Basics of electric motors, Magnetic flux density, Force on a conductor, Magnetic Circuits- Electric circuit analogy, Reluctance, Magnetic circuits in motors, torque production, Equivalent Circuit, General Properties of Electric Motors	6	15
II	Power Electronic Converters for Motor Drives- Voltage Control-D.C. Output from D.C., D.C. from A.C., A.C. from D.C. Switching Devices, Cooling of Power Switching Devices.	8	15
First Internal Examination			
III	D.C. Motor Drives- D.C. Motor Fundamentals, Four-Quadrant Operation and Regenerative Braking, Thyristor D.C. Drives, Control Arrangements for D.C. Drives, Chopper-Fed D.C. Motor Drives, D.C. Servo Drives, Digitally Controlled Drives.	6	15

IV	Induction motors fundamentals, methods of starting induction motors, stable operating regions, influence of supply voltage on torque–speed curve, generating, doubly-fed induction machine for wind-power generation, braking, speed control, variable frequency operation of induction motors. Inverter-fed induction motor drives	8	15
Second Internal Examination			
V	Synchronous motors- excited rotor and pm rotor, equivalent circuits of synchronous motors, constant-voltage, constant-frequency operation, variable-frequency operation, synchronous motor drives. BLDC drives, reluctance motors, hysteresis motors. Stepping and switched reluctance motors	8	20
VI	Drive selection- power ratings and capabilities, drive characteristics, constant-torque load, fan and pump loads. closed-loop control- driving a car at a target speed. Steady-state analysis of closed-loop systems	6	20
Cluster Level End Semester Examination			

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10ME7501	**SEMINAR II**	**0 - 0 – 2: 2**	**2020**

Course Prerequisites

1. The habit of reading technical magazines, conference proceedings, journals etc.
2. Knowledge in technical writing and communication skills earned through a seminar at the UG level and in the first semester
3. The course Seminar I in the first semester

Course Objectives

To enable the students to

1. Enhance the reading ability required to conduct a literature review.
2. Identify the Project Phase II topic.
3. Establish the fact that the student is not a mere recipient of ideas, but a participant in discovery and inquiry.
4. Develop the skills of professional communication and technical report writing.
5. Train to prepare and publish technical papers.

Guidelines

Students have to present the second seminar in 3rd semester. It is highly recommended that Seminar II may report the literature survey being conducted as a requirement for doing the main project. Since the topic for the main project topic is to be finalized at the end of the second semester/at the beginning of the 3rd semester, one can perform the literature search and present it as a seminar towards the middle of the semester. The Progress Evaluation Committee (PEC) formed in the second semester itself, may be the panel of evaluators for Seminar II also. The presentation of Seminar II shall be of 20 minutes duration with another 5 minutes allocated for a discussion session. The committee shall evaluate the seminar based on the style of presentation, technical context, and coverage of the topic, adequacy of references, depth of knowledge and the overall quality. Moreover, each student has to submit a seminar report in the prescribed format given by the Institution. It is recommended that the report for Seminar II may be in the form of a technical paper which is suitable for publishing in Conferences/Journals as a review paper. This makes a student learn how to publish a paper and consequently develops a publishing culture among the PG student community. The references cited in the report shall be authentic.

Expected Outcomes

On successful completion of the course, the student will be able to

1. Prepare a Review Paper out of the literature review.
2. Identify the Project Phase II topic for M Tech thesis through literature review.
3. Demonstrate the capacity to observe intelligently and propose and defend opinions and ideas with tact and conviction.
4. Demonstrate the skills of professional communication and technical report writing.
5. Apply the methodology of publishing technical papers.

References

1. M. Ashraf Rizvi, Effective Technical Communication, Tata Mc Graw Hill Education, New Delhi, Second Edition, 2017
2. Day R.A., How to Write and Publish a Scientific Paper, Greenwood Press, Seventh Edition, 2011
3. Coley S M and Scheinberg C. A., Proposal Writing, Sage Publications, Second edition, 2000

Course plan

Item	Description	Time	
1	Abstract Submission 3 Weeks	3 Weeks	
2	Allotment of Topic and Scheduling Seminars	1 Week	

3	Literature Review and Presentation Sessions	6 Weeks	
4	Report Submission	3 Weeks	
5	Publishing Grades	1 Week	

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10ME7503	**PROJECT (PHASE I)**	**0- 0–12: 6**	**2020**

Course Prerequisites

1. The habit of reading technical magazines, conference proceedings and journals;
2. Interest in solving socially relevant or research problems
3. Skills in hardware/software implementation techniques earned from UG and mini project in semester1
4. Course Mini project, Seminar II & Research Methodology

Course Objectives

1. The student is expected to finalise the thesis topic from the areas identified during seminar II. Background studies towards the project have to be done through a literature survey in relevant fields.
2. He/she will work on the topic, familiarize himself with the design and analysis tools required for the project work and plan the experimental platform, if any, required for project work.
3. To develop the skill of identifying research problems/socially relevant projects
4. To enhance the skills regarding the implementation aspects of small hardware/software projects.

Guidelines

Each student has to identify the topic project (phase I) related to the branch of specialization under the guidance of a faculty member. It has to be approved by a committee constituted by the institute concerned. It is recommended that the same faculty member may serve as his/her Project Supervisor during the semester also. This project phase is conceptualized in such a way that, some of the outcomes of the work may be continued for thesis work. Hence on completion of this project phase, (S)he will make a presentation based on the work and suggest a plan for his thesis work. The implementation of this phase of the project can be software and/or hardware-based. This project phase is also envisaged as a way for implementing problem-based learning. Problems of social relevance and/or problems identified by the institute/ research organizations/ industry/ state should be given high priority. In such interdisciplinary and inter-institutional projects, a student can have co-guide(s) from other department/ institute/ research organizations/ industry. The university encourages interdisciplinary projects and problem-based learning strategies. References cited shall be authentic. The following guidelines also have to be followed.

1. The student will submit a detailed project (phase I) report
2. The student will present at least two seminars
3. The first seminar will highlight the topic, objectives and methodology
4. A progress seminar can be conducted in the middle of the semester
5. The third seminar will be a presentation of the work they have completed till the end of the third semester and the scope of the work which is to be accomplished in the fourth semester, mentioning the expected results.

Expected Outcomes

On successful completion of the course, the student will be able to

1. Develop the skill of identifying industrial/ research problems/socially relevant projects
2. Develop skills regarding enumerating and selecting problems, subsequent analysis, and effective implementation of the solution.
3. Design the tools required for the project work
4. Plan the experimental platform, if any, required for project work, which will be helpful in actual real-life project planning
5. Acquire documentation and problem-solving skills.
6. Develop professionalism.
7. Communicate technical information through written and oral reports.

References

1. J. W. Bames, Statistical Analysis for Engineers and Scientists, Mc Graw Hill, New York.
2. Schank Fr., Theories of Engineering Experiments, Tata McGraw Hill Publication.
3. Douglas C. Montgomery, Design and analysis of experiments, Wiley International
4. Leedy P. D., Practical Research: Planning and Design, 4th Edition, N W MacMillan Publishing Co.

Course plan

Item	Description	Time	
1	Abstract Submission	2 Week	
2	Allotment of Topic	1 Week	
3	Preliminary Presentation Sessions	1 Week	
4	Implementation Phase	9 Weeks	
5	Final Presentation-cum Demonstration	1 Week	

SEMESTER 4

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10ME7504	**PROJECT (PHASE II)**	**0-0–23: 12**	**2020**

Course Prerequisites

1. The habit of reading technical magazines, conference proceedings and journals;
2. Interest solving in socially relevant or research problems
3. Skills in hardware/software implementation techniques earned from UG and mini project in semester1
4. Course Seminar II & Research Methodology
5. Course PROJECT (Phase I)

Course Objectives

To enable the students to

1. It is expected to complete the thesis work, which is normally based on Project (phase I)
2. To work on the topic, and get the result.
3. To develop the skill of achieving specific research target in a limited time
4. To implement/complete the thesis work

Guidelines

Each student has to complete the project (phase II) under the guidance of a faculty member, as specified in Phase I. It has to be approved by a committee constituted by the institute concerned. Hence on completion of this project phase, (S)he will make a presentation based on the work and suggest future possibilities. This project phase is also envisaged as a way for implementing problem-based learning. Problems of social relevance and/or problems identified by the institute/ research organizations/ industry/ state should be given high priority. In such interdisciplinary and inter-institutional projects, a student can have co-guide(s) from other department/ institute/ research organizations/ industry. The university encourages interdisciplinary projects and problem-based learning strategies. References cited shall be authentic.

The following guidelines also have to be followed.

1. The student will submit a detailed project (phase II) report
2. The student will present at least three seminars
3. The first seminar will highlight the topic, objectives and methodology
4. A progress seminar can be conducted in the middle of the semester
5. The third seminar (pre-submission seminar) will be a presentation of the work they have completed till the end of the fourth semester and the scope for future work also has to be mentioned. The pre-Submission seminar has to be presented before the Evaluation Committee for assessing the quality and quantum of work. This would be the qualifying exercise for the students for getting approval from the Department Committee for the submission of the Thesis.

Expected Outcomes

On successful completion of the course, the student will be able to

1. Identify industrial/research problems/socially relevant projects
2. Formulate the problem using the knowledge acquired during the earlier semesters of the program.
3. Apply various tools required for the project work
4. Implement the scientific skills so developed for real-life hardware/software projects
5. Analyse the real problems in the Energy scenario.
6. Evaluate the problem in the Energy-related area in a scientific manner, by upholding Energy

conservation and environmental policies.

References

1. J. Wesley Barnes, Statistical Analysis for Engineers and Scientists, Mc Graw Hill, New York, 1994.
2. Schank Fr., Theories of Engineering Experiments, Tata McGraw Hill Publication.
3. Douglas C Montgomery, Design and analysis of experiments, Wiley International, 2013
4. Leedy P D, ,Jeanne Ellis Ormrod Practical Research: Planning and Design, 12^{th} Illustrated Edition, Pearson, 2019

Course plan			
Item	**Description**	**Time**	
(1)	Implementation Phase	10 Weeks	
(2)	Thesis Preparation	3 Weeks	
(3)	Final Internal Presentation-cum Demonstration	1 Week	
(4)	Evaluation by the External expert	4 Weeks	

ASSESSMENT CRITERIA

A. Evaluation of Theory Courses

KTU follows a continuous academic evaluation procedure. This includes two internal examinations and one end semester cluster level University examination. Besides, students should be given proper assignments/course seminars which are essential aspects of a student-centric teaching approach. The continuous assessment procedure and corresponding weights for awarding 100 marks for a theory subject are as follows.

1. Two internal tests, each having 15 marks summing to a total of 30 marks
2. Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and
3. Cluster level end-semester examination having 60 marks

B. Evaluation of Research Methodology

The course Research Methodology should be a common one for all specializations, which is envisaged to provide a research orientation for PG students. The teaching-learning process for this course should be a student-centric one in which the faculty-in-charge would take the role of a facilitator in the system. Students should be given proper guidelines for practicing the various methodologies which aim at the overall improvement of their skills required for pursuing research. The continuous assessment procedure and corresponding weights for awarding 100 marks (fully internal) for Research Methodology are as follows.

1. Three internal tests, each having 20 marks summing to a total of 60 marks
2. Tutorials / Assignments / Course Seminars summing to a total of 40 marks

C. Evaluation of Practical Courses

The continuous assessment procedure and corresponding weights for awarding 100 marks for a practical subject are as follows.

1. Practical Records / Results summing to a total of 40 marks
2. Regular Class Viva-Voce summing to a total of 20 marks
3. Final Test (Internal & Objective Type) having 40 marks

D. Guidelines for Seminar-1

Students have to select a topic and present a seminar in the first semester on any current topic related to the branch of specialization under the guidance of a faculty member. It is recommended that the same faculty member may serve as his/her supervisor for the mini-project in the 2nd semester and also for the main project during the 3rd& 4th semesters. Hence it is also recommended that a topic, possibly relevant to his mini-cum-main project may be selected as the topic for seminar-1, after the consultation with the guide. The student will undertake a detailed study of the subject based on currently published papers, journals, and books and present it before a committee with the Head of the Department as the chairman and two faculty members (Faculty advisor + Guide) from the department as members. The presentation shall be of 20 minutes duration with another 5 minutes allocated for a discussion session. The committee shall evaluate the seminar based on the style of presentation, technical context, and coverage of the topic, adequacy of references, depth of knowledge and the overall quality. Moreover, each student has to submit a seminar report in the prescribed format given by the Institution.

The weights for awarding 100 marks (totally internal) for the seminar-1 is as follows.

1. Presentation (Verbal & Nonverbal Communication skills) : 20 marks
2. The breadth of the topic (Coverage: Content of the slides and speech): 20 marks
3. Depth of knowledge (Ability to answer questions): 30 marks
4. Seminar Report in the prescribed format given by the Institution: 30 marks

E. Guidelines for the Mini Project

Each student has to do a mini project related to the branch of specialization under the guidance of a faculty member. It has to be approved by a committee constituted by the institute concerned. It is recommended that the same faculty member may serve as his/her Project Supervisor during the 3rd& 4th semesters. The mini-project is conceptualized in such a way that, some of the outcomes of the work can be utilized in the selection of the thesis. Hence on completion of the mini project, the student can suggest a possible list of their thesis topic in the second semester itself. The implementation of the mini project can be software and/or hardware-based. Mini project is envisaged as a way for implementing problem-based learning. Problems of social relevance and/or problems identified by the institute/ research organizations/ industry/ state should be given high priority. In such interdisciplinary and inter-institutional projects, a student can have co-guide(s) from other department/ institute/ research organizations/ industry. The university encourages interdisciplinary projects and problem-based learning strategies.

There should be a Progress Evaluation Committee (PEC) for each student which is constituted by three faculty members: (1) HoD as chairman, (2) Faculty advisor, and (3) Guide. This committee should evaluate the mini project through 2 presentations - (i) a preliminary presentation which is to be held soon after finalizing the topic, and (ii) a final presentation towards the end of the semester. In between, the Guide and /or the Co-guide is entrusted for the continuous evaluation of the work progress.
The weights for awarding 100 marks (totally by internal assessment) are as follows.

(1) Preliminary Presentation (PEC) : 20 marks
(2) Progress Evaluation (Guide and/or Co-guide) : 30 marks
(3) Final Presentation-cum-demonstration (PEC): 30 marks
(4) Report (Mandatory) : 20 marks

F. Guidelines for Seminar-II

Students have to present the second seminar in 3rd semester. It is highly recommended that seminar-2 may report the literature survey being conducted as a requirement for doing the main project. Since the topic for the main project topic is to be finalized at the beginning of the 3rdsemester, one can perform the literature search and present it as a seminar towards the middle of the semester. The Progress Evaluation Committee (PEC) formed in the second semester itself, will be the panel of evaluators for Seminar-2 also. The presentation of seminar-2 shall be of 20 minutes duration with another 5 minutes allocated for a discussion session. The committee shall evaluate the seminar based on the style of presentation, technical context, and coverage of the topic, adequacy of references, depth of knowledge and the overall quality. Moreover, each student has to submit a seminar report in the prescribed format given by the Institution. It is recommended that the report for seminar-2 may be in the form of a technical paper which is suitable for publishing in Conferences / Journals as a review paper. This makes a student learn how to publish a paper and consequently develops a publishing culture among the PG student community.
The weights for awarding 100 marks (totally by internal assessment) for the seminar-2 is as follows.

1. Presentation (Verbal & Nonverbal Communication skills) : 20 marks
2. The breadth of the literature review (Coverage: Content of the slides and speech): 20 marks
3. Depth of knowledge (Ability to answer questions): 30 marks
4. Seminar Report / Paper in the prescribed format given by the Institution: 30 marks

G. Guidelines for the Project Work

Project work is to be carried out in the 3rd and 4th semesters and also to be evaluated in both semesters. It is recommended that students should execute the project work using the facilities of the institute itself. However, external projects can be taken up in the 4th semester, if that work solves a technical problem of the external firm. The prior sanction should be obtained from the Head of Institution before taking up external project work. The project evaluation committee should study the feasibility of each project work before giving consent. The project work is also to be evaluated continuously, during the 3rd& 4th semesters through presentation sessions. Based on these evaluations the grade is finalized in the fourth semester. The internal committee (PEC) and an External Expert shall evaluate the project based on four presentations by the student during these semesters. The first presentation in the 3rd semester should be held at the beginning of the semester which would highlight the topic, objectives, and methodology. The second presentation in the same semester should bring out the work progress through the preliminary results and is to be conducted towards the end of the semester. These are evaluated internally by the PEC. Project Phase - II will be an extension of the Project Phase - I. A student has to prepare a project report, namely the thesis, towards the end of the 4th semester. Both the presentation and the thesis will be evaluated by the Committee and the External expert. The third presentation on the project is to be made towards the end of the 4th semester as a final internal presentation. At least one technical paper is to be published in Journals / Conferences to meet the requirements for final external submission. The fourth presentation is a repetition of the third one, but before an External Expert, appointed through the process of submitting the M. Tech. Thesis to the University (Cluster). The external expert will assess the quality and quantity of the work done by the student in the final (fourth) presentation. The comments of the examiners during this presentation should be incorporated in the work and report and is to be submitted as hardbound copies before the program exit by the student.

The weights for awarding 150 marks for Project shall be as follows.

A. 3rd Semester - Marks: 50 for Project Progress Evaluation
    1. Preliminary Presentation, evaluated by PEC: 15 marks
    2. Progress evaluation by the Project Supervisor/s: 20 marks
    3. End-semester presentation, evaluated by PEC: 15 marks
B. 4th Semester - Marks: 100 for Final Evaluation
    1. Project evaluation by the supervisor/s: 30 marks
    2. Final internal evaluation by PEC: 40 marks
    3. Evaluation of the thesis presentation by an External Expert: 30 marks