M.Tech. Program

M.Tech. (Energy and Environmental Management)

Department of Chemical Engineering

School of Technology,

Pandit Deendayal Energy University, Gandhinagar

(Session:- 2020-2021)

Pandit Deendayal Energy University, Gandhinagar
School of Technology
Department of Chemical Engineering

VISION

To impart quality education in an industry research driven modules to motivate the young chemical engineers for creating knowledge wealth to help generate employability following professional ethics and focus towards a sustainable environment and benefits to the society.

Mission

- To facilitate the chemical engineering students with the state-of-the-art facilities with focus on skill development, creativity, innovation and enhancing leadership qualities.
- To nurture creative minds thru' mentoring, quality teaching & research for building a value based sustainable society.
- To work in unison with the national and international level academic and industrial partners by venturing into collaborations to tackle problems of bigger interest to society.
- To build an encouraging environment for the young faculties and staff by providing safe work culture, transparency, professional ethics and accountability that will empower them to lead the department in right spirit.
- To inculcate the culture of continuous learning among the faculties by encouraging them to participate in a professional development programs and envisage to address the social, economic and environmental problems.

Pandit Deendayal Energy University, Gandhinagar
School of Technology
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Program Education Objectives (PEOs)

- Acquire the fundamental principles of science and chemical engineering with modern experimental and computational skills.
- Ability to handle problems of practical relevance of society while complying with economical, environmental, ethical, and safety factors.
- Demonstrate professional excellence, ethics, soft skills and leadership qualities. Graduates will be active members ready.

SEMESTER I			M.TECH. ENERGY AND ENVIRONMENTAL MANGEMENT										
S No.	Course Code	Course Name	Teaching Scheme					Exam Scheme					
			L	T	P	C	Hrs/ wk	Theory			Practical		Total Marks
								MS	ES	IA	LW	LE	
1	20EEM501T	Energy & Environment – Policy, Planning & Climate Change	3	0	0	3	3	25	50	25	--	--	100
2	20EEM502T	Renewable & Non-Renewable Energy	3	0	0	3	3	25	50	25	--	--	100
3	20EEM503T	Thermodynamics In Energy Systems	3	0	0	3	3	25	50	25	--	--	100
4	20EEM504T	Energy and Environment Ecosystem	2	0	0	2	2	25	50	25	--	--	100
5	20EEM505T	Energy Auditing	2	0	0	2	2	25	50	25	--	--	100
6	20EEM506T	Modelling and Analysis of Energy Systems	3	0	0	3	3	25	50	25	--	--	100
7	20MA501T	Advanced Numerical Techniques And Computer Programming	3	1	0	4	4	25	50	25	--	--	100
8	20MA501P	Advanced Numerical Techniques And Computer Programming Lab	0	0	2	1	2				50	50	100
9	20EEM507P	Energy And Environmental Research Lab-1	0	0	2	1	2				50	50	100
		Total	**19**	**1**	**4**	**22**	**24**	**175**	**350**	**175**	**100**	**100**	**900**

Course Code					Energy & Environment – Policy, Planning & Climate Change					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To impart the knowledge of national and global policies on energy and environment
2. To familiarize with trends on energy use in various sectors and facilitate energy modelling to make policy decisions
3. To impart knowledge on environment impact of energy use for controlling the pollution and formulating mitigation strategies

UNIT 1: ENERGY RESOURCES **10 Hrs**

Current trends in energy production and consumption, world energy flows, national energy plan, energy and economic growth, supply and availability; Electric utilities and regulations, cost structure analysis, economics of energy use in agriculture, transport, building, Industry and energy substitution, cost benefit analysis – carbon credit and footprint.

UNIT 2:ENERGY PLANNING AND POLICIES **10 Hrs**

Energy demand analysis and forecasting, Energy supply assessment and evaluation, Energy demand – supply balancing, Energy models. Energy – economy interaction, Energy investment planning and project formulation. Policy and planning implications of energy – environment interaction, Clean development mechanism. Energy policy related acts and regulations. Software for energy planning.

UNIT 3 ENERGY AUDIT AND ENVIRONMENTAL REGULATIONS **12 Hrs**

Energy Audit concept, Elements of measurements, Mass and energy balances, Scope of energy auditing in Industries, Evaluation of energy conserving opportunities and environmental management, Some case studies and potential energy savings. Standards and setting criterion, Role of national and international agencies in dealing with environmental aspects, Standards developed by ministry of environment and forest, Environment management system.

UNIT 4 ENVIRONMENTAL IMPACTS OF ENERGY USE **10 Hrs**

Climate change, Global warming - sources of emissions, CO2 emissions, impacts, mitigation and sustainability. environmental standards, legislation and audits, air pollution - SOx, NOx, CO, particulates, solid and water pollution, formation of pollutants, measurement and controls; Effect of operating and design parameters on emission, control methods, exhaust emission test and procedures, case studies on analysis of energy projects for environmental impact assessment and mitigation.

Max : 42 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: **Define** and **tell** about energy resources, policies, regulations and scenarios

CO2: **Explain** the need for global environmental policies and regulations and **illustrate** their benefits and impact

CO3: **Develop** procedures for conducting energy audit in different utilities in accordance with national and international energy regulations

CO4: **Survey** and **analyse** energy projects, **list** their impact on environment, and suggest control strategies

CO5: **Assess** and **select** a particular industrial process or **recommend** process enhancement, to reduce environmental impacts and ensure efficient operation

CO6: **Develop** and **choose** different pollution control strategies to **minimize** the environmental impact

TEXT/REFERENCE BOOKS

1. Energy and the Challenge of Sustainability, World energy assessment, UNDP New York, 2004.
2. AKN Reddy, RH Williams, TB Johansson, Energy after Rio, Prospects and challenges, UNDP, United Nations Publications, New York, 1997.
3. Nebojsa Nakicenovic, Arnulf Grubler and Alan McDonald “Global energy perspectives”, Cambridge University Press, 1999.
4. Fowler, J.M, “Energy and the environment”, McGraw Hill, 1984.
5. Robert Ristirer and Jack P. Kraushaar, “Energy and the environment”, Willey, 2005.

Course Code					Renewable and Non-Renewable Energy					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
4	-	-	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

1. To impart knowledge on classification of energy sources and their environmental aspects
2. Learn the present energy scenario and concept of sustainable energy
3. Explain the concept of various forms of renewable energy and discuss the scientific principles underpinning the sustainable conversion of energy
4. To impart problem oriented in depth knowledge of renewable energy sources

UNIT 1:ENERGY CLASSIFICATION AND NON-RENEWABLE ENERGY **10 Hrs**

Global & National energy scenarios, Interrelationship between energy and environment, Energy classification- Primary & Secondary energy, commercial & non-commercial energy, non-renewable & renewable energy, primary energy resources, commercial energy production, energy conservation and its importance Non-Renewable energy and their impact on the ecology, Key factors in the exploitation, production and use. Forms & characteristics of renewable energy sources.

UNIT 2:SOLAR ENERGY **10 Hrs**

Principles of solar radiation - Origin, nature and availability of solar radiation, estimation of solar radiation, solar geometry, and heat transfer considerations relevant to solar energy.Solar energy collection - Flat plate and concentrating collectors, classification of concentrating collectors, orientation and thermal analysis. Solar energy storage and applications - Sensible, latent heat and stratified storage, solar ponds. Solar Applications- solar heating/cooling technique, solar distillation and drying, Photovoltaic energy conversion, p-n junction, solar cells, PV systems, Stand-alone, Grid connected solar power

UNIT 3: WIND, HYDRO AND GEOTHERMAL ENERGY **10 Hrs**

Principle of wind energy conversion, basic components of wind energy conversion systems - Lift and Drag– Effect of density, frequency variances, angle of attack, and wind speed - design considerations of horizontal and vertical axis wind machines - analysis of aerodynamic forces acting on wind turbine blades and estimation of power output - wind data and site selection considerations. Principles of working, lay out, Site selection classification and arrangement of hydroelectric plants, run off size of plant and choice of units, operation and maintenance, hydro systems, and interconnected systems. Geothermal Energy - nature of geothermal energy, resources like hydrothermal, geo-pressured hot dry rock, magma. Advantages, disadvantages and application of geothermal energy, prospects of geothermal energy in India.

UNIT 4: OTHER RENEWABLE ENERGY SOURCES **12 Hrs**

Biogas - Principles of Bio-Conversion, types of Bio-gas digesters, gas yield, combustion characteristics of bio-gas, utilization for cooking, Biomass gasification - Biomass conversion technologies, Constructional details of gasifier, Biofuels - Introduction and perspective of biofuels, biofuel production and applications, environmental impact of biofuel, Biofuel operated I.C. Engine operation and economic aspects. Energy from Ocean – Basic cycles of Ocean Thermal Energy Conversion, basic principle of tidal power, wave energy conversion devices. Fuel Cells - Introduction, Design principle and operation of fuel cell and its types, conversion efficiency of fuel cell, application. Hydrogen Energy - Introduction, Hydrogen Production methods, Hydrogen storage, hydrogen transportation, hydrogen as alternative fuel for vehicles.

Max : 42 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: **Define** different forms of energy and **list** advantages and disadvantages of different sources of energy

CO2: **Understand** the principles of solar radiation, its availability at various locations and **extend** the knowledge to different applications

CO3: **Develop** knowledge to harness energy from different sources for various applications like heating, cooling, water distillation, electricity etc. and **model** their performance.

CO4: **Analyse** and **compare** different energy sources and their impacts

CO5: **Interpret** the suitability and **determine** the best possible energy resource for a particular location

CO6: **Design** and **develop** innovative methods to harness energy and **propose** sustainable **solutions**.

TEXT/REFERENCE BOOKS

1. Sukhatme, S.P. and Nayak, J.K., 2017. Solar energy. McGraw-Hill Education
2. Duffie, J.A., Beckman, W.A. and Worek, W.M., 2013. Solar engineering of thermal processes (Vol. 3). New York: Wiley
3. Kothari, D.P., Singal, K.C. and Ranjan, R., 2011. Renewable energy sources and emerging technologies. PHI Learning Pvt. Ltd.

PanditDeendayal Petroleum University **School of <Technology>**

<Course Code>					Thermodynamics in Energy system					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To provide basics of thermodynamic and heat transfer in thermal energy system.
2. To get an understanding of thermal environmental design such as heating and cooling requirements and processes.
3. To get an insight and deep learning of Heat exchanger design for industrial thermal energy exchange application
4. To learn the basic heat exchanger network synthesis (HENS). Develop the pinch design approach to inventing a network.

UNIT 1 Thermodynamics and liquification **10 Hrs**

Introduction: Scope of Thermodynamic and thermal energy transfer: First-second and third laws of Thermodynamics. Thermodynamics cycles, Refrigeration. Vapour compression cycles, Refrigerants, Absorption refrigeration; Adsorption cooling using low heat solar energy, Liquification (qualitative case study of LNG)

UNIT 2 Phase equilibrium thermodynamics **9 Hrs**

Thermodynamics properties of pure fluid and fluid mixtures, Phase diagrams, Vapour liquid equilibrium (VLE) diagrams. Models for VLE, Equation of state and activity coefficient models. Construction and interpretation of phase diagrams.

UNIT 3 Equipment's for thermal energy exchange **11 Hrs**

Classification of heat exchangers; basic design methods, double pipe heat exchangers, design of shell and tube heat exchangers; TEMA codes; flow arrangements for increased heat recovery, Heat exchange equipments: with and without phase change. Solar Applications- Solar heating and cooling technique, case studies of Solar distillation and drying.

UNIT 4 Pinch Technology-an overview **10 Hrs**

Introduction, Basic concepts and Basic Elements of Pinch Technology, how it is different from energy auditing, Roles of thermodynamic laws, problems addressed by Pinch Technology, Heat Exchanger Network and its design, stream splitting, design of maximum energy recovery (MER)

Max. 40 Hrs.

COURSE OUTCOMES: On completion of the course, student will be able to

CO1 - **apply** principles of thermodynamics for energy and work transfer
CO2 - **estimate** the efficiency of heating /cooling cycles at different conditions
CO3 - **analyze** phase equilibrium data and **construct** P-x-y, T-x-y diagram for binary vapour-liquid systems
CO4 - **evaluate** heat transfer rate and **design** heat exchanger for thermal energy transfer application
CO5 - **apply** concept of energy integration and solve heat exchanger networks along with utilities
CO6 - **construct** cold and hot composite curves and to do pinch point **analysis** in heat exchanger network

TEXT/REFERENCE BOOKS

1. INTRODUCTION TO CHEMICAL ENGINEERING THERMODYNAMICS, 8th Edition by J. M. Smith, H. C. Van Ness, M. M. Abbott, M. T. Swihart: Published by McGraw-Hill Education, 2 Perm Plaza, New York, NY 10121.
2. Chemical Process Design and Integration, by **Robin Smith** John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex PO19 8SQ, England
3. Process Heat Transfer by D. Q. Kern, McGraw-Hill College publication

<>					Energy and Environment Ecosystem					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
2	0	0	2	2	25	50	25	--	--	100

COURSE OBJECTIVES

1. To develop an insight and understanding on co-relation between energy and environment
2. Impart knowledge on energy and environment management
3. To impart knowledge on concept of sustainability and energy conservation
4. To inculcate concern on Environment degradation and remedial solutions

UNIT 1:ECOSYSTEM AND GENERAL AWARENESS **12 Hrs**

Concepts of ecosystems and environment, Characteristics and types of ecosystems, Autecology and synecology, Energy flow in ecosystems, Eco-technology and Eco-development, Interrelationship between energy and environment, Energy Scenario and Classification: Primary & Secondary energy, Non-renewable & renewable energy, Globally energy reserves and production, Energy and environment conservation and importance.

UNIT 2: ENERGY-ENVIRONMENT INTERACTION **10 Hrs**

Natural Resources- Water Resources, Availability and Quality aspects. Water borne diseases, Water Induced diseases, Fluoride problem in drinking water. Mineral Resources, Forest Wealth, Material cycles- Carbon, Nitrogen and Sulphur Cycles. Electro-magnetic radiation. Conventional and Non-Conventional sources - Hydro Electric, Fossil Fuel based Nuclear, Solar, Biomass and Biogas. Hydrogen as an alternative future source of Energy.

UNIT 3: GLOBAL ISSUES AND NEED FOR ENERGY CONSERVATION **9 Hrs**

Air Pollution, Acid rain, Ozone layer, depletion, global warming and climate change, loss of biodiversity. Need for conservation, Strategies for Energy Conservation, Clean Development Mechanism (CDM), and Sustainable development.

UNIT 4: ECOLOGY **9 Hrs**

Ecology – definitions, Biodiversity, Examples of Historical Impact of economy and pollution on Ecology, Restoration / Ecological Engineering. Pollution and Waste Management, environmental ethics, United Nations Framework Convention on climate change (UNFCCC), National action plan on climate changes, Kyoto Protocol, Environmental Protection- Role of Government/Public

Max : 40 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: To **define** ecosystem and **relate** to the synergy between energy and environment
CO2: To **demonstrate** knowledge of different resources and **outline** their relationship with ecology & environment
CO3: To **identify** the effect of harnessing energy on global climatic change and ecology
CO4: To **analyze** and **discover** the need for energy conservation and control measures for enabling rational use of energy
CO5: To **mark** the **influence** of global issues and **determine** remedial solutions for sustainable development
CO6: To **predict** the impact on ecology and environment and **develop solutions** for mitigating climate change and ensure environment protection

TEXT/REFERENCE BOOKS

1. Gilbert M. Masters and Wendell P. ELA – Introduction to Environmental Engineering And Science
2. W. Cunningham – Principles of Environmental Science, TMH
3. P. Venugoplan Rao – Principles of Environmental Science and Engineering, PHI.
4. Kreith F., Goswami D.Y. (2007). Energy Management and Conservation Handbook. CRC Press. ISBN: 9781420044294.
5. Energy Management Supply and Conservation, Dr. Clive Beggs, Butterworth Heinemann, 2002.

<course Code>					Energy Auditing					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
2	0	0	2	2	25	50	25	--	--	100

COURSE OBJECTIVES

1. To understand energy scenario and general aspects of energy audit
2. Learn about methods and concept of energy audit and necessity of conservation of energy
3. To familiarize to the methods of energy management and practices
4. Understand the energy utilization pattern and perform economic analysis

UNIT 1 BASIC OF ENERGY AUDIT **10 Hrs.**

Definitions, concept, types of audit, energy index, cost index, energy management approach, understanding energy costs, bench marking, matching energy use to requirement, maximizing system efficiencies, optimizing energy requirements, duties and responsibilities of energy auditors, energy audit instruments, procedures and techniques

UNIT 2 ENERGY MANAGEMENT **10 Hrs.**

Principles of energy management, design and development of energy management program, initiating, planning, controlling, promoting, monitoring, reporting, energy manger, qualities, duties and functions, preparation and presentation of energy audit reports, case studies of energy management

UNIT 3 ECONOMIC ANALYSIS **10 Hrs.**

Economics analysis, depreciation methods, time value of money, rate of return, present worth method , replacement analysis, life cycle analysis, energy efficient electrical instruments, calculation of payback period, net present worth method, power factor correction, lighting – applications of life cycle analysis, return on investment

Max 30 hrs

COURSE OUTCOMES

CO1 – **Relate** to the basics of Energy Audit and need to the Industry
CO2 – **Demonstrate** the principles and details of energy management system
CO3 – **Identify** the duties and functions of energy manager and his role in EMS
CO4 – **Analyze** the EMS framework, and its methodologies for energy auditing
CO5 – **Appraise** to the energy audit practice and perform the economic analysis
CO6 – **Elaborate** the understanding of Energy Auditing and identify energy saving potential

TEXT/REFERENCE BOOKS

1. Murphy, W. R., Energy Management, Elsevier, 2007.
2. Smith, C. B., Parmenter K., Energy Management Principles, Pergamon, 1981
3. Turner, W. C., Doty, S. and Truner, W. C., Energy Management Hand book, 7th edition, Fairmont Press, 2009.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: Theoretical knowledge and understanding 50 Marks
Part B/Question: Critical Analysis and Problem Solving 50 Marks

					Modelling and Analysis of Energy Systems					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. The student will develop the ability to model a given set of data by various methods
2. The student will develop the ability to carry out simulation of simple energy systems.
3. The student will develop the ability to formulate a problem and carry out optimization of simple thermal system by various methods.

UNIT 1 Introduction and overview of system modelling concepts **10 Hrs.**

State variables, energy and mass balances, simulation parameters and equations, degree of freedom analysis, different types of specifications, inequalities, objective functions, Interpolation, Regression, ANOVA. Equation Fitting: Mathematical modeling, Polynomial representation, Functions of two variables, Exponential forms, Best fit Method of least squares

UNIT 2 Energy systems models& system simulation **10 Hrs.**

Steps in model development, steady state and dynamic, lumped and distributed parameter models, flowsheets, degrees of freedom, sequential or simultaneous solving approach, Qualitative techniques - curve-fitting, regression analysis, numerical methods and their implications; Simulation of Large Systems, Numerical Simulation Versus Real System, Sequential and simultaneous calculations, Successive substitution, Newton-Raphson method, sizing of systems like fan-duct, etc

UNIT 3 Stating and solving optimization problems **10 Hrs.**

Decision variables, objective functions and constraints, solving strategies, Unconstrained problems- necessary and sufficiency conditions, Constrained optimisation- Lagrange multipliers, constrained variations, Kuhn-Tucker conditions Linear Programming – simplex method, pivoting, sensitivity analysis Search Techniques- Univariate/Multivariate. Case studies of optimisation in Energy systems problems.

UNIT 4 Dynamic Programming **10 Hrs.**

Characteristic of the Dynamic programming solution, apparently constrained problem, Application of Dynamic programming to energy system problems; Recent Research work on application of dynamic programming, Lagrange multiplier method, LPP, geometric programming and Fibonacci search method.

Max:- 40 hours

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – answer **what** are the basic concepts of modelling an energy system.
CO2 – **compare** between different energy system models and **interpret** algorithms
CO3 – **model** simple problem.
CO4 – **discover and analyze** how the energy systems affected by changes in key parameters.
CO5 – **select** appropriate energy system model.
CO6 – **formulate and solve** optimization problems.

TEXT/REFERENCE BOOKS

1. K. M. Hangos and I. T. Cameron,, *Process Modeling and Model Analysis*, Academic Press , 2001
2. T. F. Edgar, D. M. Himmelblau and L. S. Lasdon, *Optimization of Chemical Processes*, McGraw Hill, New York, , 2001.
3.F.Carl Knopf, Modelling, Analysis and Optimisation of Process and Energy systems, Wiley, 2012
4. B. K. Hodge: "Analysis and Design of Thermal Systems", Prentice Hall Inc., 1990.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 12 short answer questions of 2 marks each 24 Marks
Part B/Question: 6 long answer questions 76 Marks

20MA 501T					ADVANCED NUMERICAL TECHNIQUES					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

1. To understand and acquaint the concept of various numerical methods.
2. To develop numerical skills in solving problem of engineering interest.
3. To enrich the concept of finite element techniques.
4. To extract the roots of a polynomial equation.

UNIT 1 EIGEN VALUES EIGEN VECTORS AND INTERPOLATION 10 Hrs

Eigen values and eigen vectors: Numerical evaluation of largest as well as smallest (numerically) Eigen values and corresponding Eigen vectors. **Interpolation:** Introduction, Newton Gregory Forward Interpolation Formula, Newton Gregory Backward Interpolation Formula, Central difference interpolation formula, Lagrange's Interpolation Formula for unevenly spaced Formula, Error in interpolation, Newton's Divided Difference Formula, cubic spline interpolation, surface interpolation.

UNIT 2 NUMERICAL SOLUTION NON LINEAR EQUATIONS AND POLYNOMIAL 8 Hrs

Introduction, Solution of non linear simultaneous equations, Descarte's Sign rule, Horner's method, Lin-Bairstow's method, Graeffe's root squaring method, Muller's method, Comparison of various methods.

UNIT 3 NUMERICAL SOLUTION OF ODEs AND PDEs 14 Hrs

Taylor's method, Euler's method, Runge-Kutta methods of various order, Modified Euler's method, Predictor corrector method: Adam's method, Milne's method. Solution of Boundary value problems using finite differences. Finite difference approximation of partial derivatives, Classification of 2nd order PDEs, different type of boundary conditions, solutions of Elliptic, parabolic and hyperbolic equations of one and two dimensions, Crank- Nicholson method, ADI method.

UNIT 4 FINITE ELEMENT METHOD 8 Hrs.

Introduction, Method of Approximation, The Rayleigh-Ritz Method, The Galerkin Method, Application to One dimensional and two dimensional problems.

Max:- 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – To **apply** a suitable numerical technique to extract approximate solution to the problem whose solution cannot be obtained by routine methods.

CO2 - To **estimate** the errors in various numerical methods.

CO3 - To **analyse/ interpret** the achieved numerical solution of problems by reproducing it in graphical or tabular form.

CO4 - To **approximate** the data generated by performing an experiment or by an empirical formula with a polynomial on which operations like division, differentiation and integration can be done smoothly.

CO5 - To **evaluate** a sufficiently accurate solution of various physical models of science as well as engineering interest whose governing equations can be approximated by nonlinear ODEs or PDEs or system of ODEs or PDEs.

CO6 - To **design/ create** an appropriate numerical algorithm for various problems of science and engineering.

TEXT/REFERENCE BOOKS

1. B.S. Grewal, Numerical Methods in Engineering and Science with Programs in C & C++,Khanna Publishers (2010).
2. S.S. Sastry, Introductory Methods for Numerical Analysis,4th Ed., Prentice Hall of India (2009).
3. M.K. Jain, S.R.K. Iyenger and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, 5th Ed., New Age International (2007).
4. C F Gerald and P O Wheatley, Applied Numerical analysis, Pearson education, 7th edition, 2003.
5. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley publication, 9th edition. 2005
6. R.K. Jain & S.R.K. Iyenger, Advanced Engineering Mathematics, 3rd Ed., Narosa (2002).
7. S C Chapra, Raymond P. Canale, Numerical Methods for Engineers, Tata McGraw Hill Pub. Co. Ltd.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A : 4 questions of 6 marks each 24 Marks (40 min)

Part B: 4 questions of 10 marks each 40 Marks (80 min)

Part C: 3 questions of 12 marks each 36 Marks (60 min)

Teaching Scheme					Energy And Environmental Research Lab-1					
					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
-	-	2	1	4	--	--	--	50	50	100

COURSE OBJECTIVES:-

In order to supplement various topics related to energy and environment aspects in class-room lectures, some laboratory experiments are needed as a part of curriculum development of energy and environment management programme for better understanding of the subjects. The experiments based on basic science/engineering principles are so designed so as to provide students enough stimulation for further.

List of Experiments:

1. Determination of Energy requirement in an Absorption/desorption process for an industrial gas-liquid reacting/non-reacting system.
2. Energy/enthalpy measurement for a gas-liquid/liquid-liquid flow system using a heat flow reaction calorimeter.
3. Measurement of Energy/heat of reaction and to characterize a gas-liquid reacting/non-reacting system, endothermic or exothermic thermodynamically.
4. Quantitative comparison of Production of biodiesel using conventional and PI techniques
5. Estimation of physico-chemical properties of Biodiesel.
6. Determination of calorific value of solid fuel.
7. Characterization of solid fuel (Proximate Analysis).
8. Handling and Operation of high pressure reactions in an autoclave.
9. Fabrication of polymeric membranes.
10. Study of ultra filtration and nano filtration membrane processes in batch as well as in cross flow.
11. Adsorption study in batch process.
12. Heat Pipe Heat Exchanger and its efficiency

COURSE OUTCOMES

On completion of the course, student will be able to

CO1:- **Select** the process to perform the energy and environmental based experiments.

CO2: **Demonstrate** the importance of the energy requirement in Absorption/desorption process.

CO3: **Utilize** the concept to solve and perform the experiments related with Energy systems.

CO4: **Examine and assess** a complete development of energy and environment management systems.

CO5: To **develop understanding** and **skills** for innovative energy efficiency solutions, and demand management strategies

CO6: Suggest best methods to **improve** the overall efficiency for different energy intensive industries.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: Practical Work 50 Marks

Part B/Question: Practical and Viva Exam 50 Marks

SEMESTER II			M.TECH. ENERGY AND ENVIRONMENTAL MANGEMENT										
S No.	Course Code	Course Name	Teaching Scheme					Exam Scheme					
			L	T	P	C	Hrs/ wk	Theory			Practical		Total Marks
								MS	ES	IA	LW	LE	
1	20EEM508T	Environmental Science and Engineering	3	0	0	3	3	25	50	25	--	--	100
2	20EEM509T	Integrated Waste Management And Environmental Economics	3	0	0	3	3	25	50	25	--	--	100
3		Elective A	3	0	0	3	3	25	50	25	--	--	100
4		Elective B	3	0	0	3	3	25	50	25	--	--	100
5	17CE527T	Successful Research Program Development	2	0	0	2	2	25	50	25	--	--	100
6	20EEM510T	Intellectual Property Rights (IPR)	2	0	0	2	2	--	--	--	50	50	100
7	20EEM511P	Energy and Environmental research Lab-2	0	0	4	2	4	--	--	--	50	50	100
		Total	**16**	**0**	**4**	**18**	**20**	**125**	**250**	**125**	**100**	**100**	**700**

Course Code	Basket for Electives A	Theory	Tutorial	Practical	Hrs	Credits
20EEM512T	Advanced Energy Storage Systems	3	0	0	3	3
20EEM513T	Pollution Control in Power Plants	3	0	0	3	3
20EEM514T	Instrumentation and Control in Energy Systems	3	0	0	3	3

Course Code	Basket for Electives B	Theory	Tutorial	Practical	Hrs	Credits
20EEM515T	Environmental Audit and Impact Assessment	3	0	0	3	3
20EEM516T	Environment and Energy Conservation	3	0	0	3	3
20EEM517T	Life Cycle Assessment	3	0	0	3	3

					Environmental Science and Engineering					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To understand the basics approaches of environmental science and engineering.
2. To understand and identify air pollutants and control techniques.
3. To identify and understand treatment approach for water pollution.
4. To identify and understand solid, hazardous and plastic waste management.

UNIT 1 – OVERVIEW OF ENVIRONMENTAL SCIENCE AND ENVIRONMENTAL LAWS 8 Hrs.

Basics of environment Science-definition, scope and importance, environmental impact assessment, environmental risk assessment, Emerging environmental issues with air, water, wastewater and solid wastes. Environmental protection Act, Air (Prevention and Control of Pollution) act – Water (Prevention and control of Pollution) act.

UNIT 2 – AIR POLLUTION CONTROL 10 Hrs.

Concept of air pollutants, air pollution sources and its dependence on the atmospheric factors, atmospheric stability and dispersion of pollutants. Control of emission of pollutants using settling chamber, multi-cyclone systems, electrostatic precipitators, bag filters, wet scrubbers for gas cleaning, absorption, adsorption by activated carbon etc.

UNIT 3 –TREATMENT OF WATER POLLUTION 12 Hrs.

Physical, chemical characteristics and microbiology of wastewater, BOD kinetics, Concept of inorganic and organic wastes and definition of BOD and COD. Control of water pollution: primary treatment-(Equalization tank, sedimentation, coagulation-flocculation, sand filters), biological treatment-(activated sludge process, trickling filters, aerated lagoons) systems, sludge treatment and tertiary treatment-(disinfection, membrane separation, ion-exchange).

UNIT 4 – WASTE MANAGEMENT 10 Hrs.

Municipal solid waste management systems: Composition and characteristics of solid waste, treatment, 3Rs, disposal methods (recycling, landfills, composting, incineration). Hazardous waste treatment: identification, minimization and treatment. Plastic waste and e-waste management: recovery and reuse.

Max. 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 –**Define** the basic knowledge of environmental science and environmental Laws.
CO2 –**Classify** air and water pollutants and their effects on living and non-living things.
CO3 –**Apply** knowledge in municipal solid waste, hazardous waste, plastic waste and e-wastemanagement.
CO4 –**Analyze** the physical, chemical and biological properties of water.
CO5 –**Estimate** the efficiency and performance of particulate emission control devices.
CO6 – **Design** different treatment units involved in minimization and treatment of polluted water.

TEXT/REFERENCE BOOKS

1. M.L. Mckinney, “Environmental Science” Printed in the United States of America.
2. H. S. Peavy, "Environmental Engineering", McGraw-Hill, International Ed., New York -1985.
3. Metcalf & Eddy, "Waste Water Engineering: Treatment, Disposal, Reuse", 2nd Ed., McGraw-Hill, New York - 1979.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: <Details> <> Marks
Part B/Question: <Details> <> Marks

					Integrated Waste Management and Environmental Economics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. Understand basics of waste management
2. Acquire knowledge about waste treatment technologies
3. Know the need of integrated waste management
4. Get acquaintance with waste management systems
5. Study the linkage between economic growth and pollution
6. Role of economics in waste handling

Unit-I-Introduction to Waste Management **12 hrs**

waste- Definition, characteristics, sources, classification, physico-chemical properties, segregation, characterization, generation, quantification, transportation, collection systems, transfer stations, collection route optimization, regulations, Treatment methods, processing of waste, waste minimization, waste exchange, recovery, recycling. Treatment methods-Physical, chemical, thermo chemical, biological, land filling, stabilization, solidification, open dumping, site selection, sanitary land fill, design criteria an design examples, leachate and gas collection system, incineration, pyrolysis, gasification

Unit-II-Integrated Waste Management **8 hrs**

Integrated waste management, waste management hierarchy, methods and importance of waste management, policies of waste management, Municipal Solid Wastes (Management and Handling) Rules 2000; Hazardous Wastes Management and Handling Rules 1989; Bio-Medical Waste (Management and Handling) Rules 1998; Plastic Waste (Management and Handling) Rules, 2011; E-Waste (Management) Rules, 2016

Unit-III-Environmental Programs **8 hrs**

Social costs and benefits of environmental programmes: marginal social benefit of abatement, marginal social cost of abatement; pollution control: policies for controlling air and water pollution, disposal of toxic and hazardous waste-standards vs. emissions charges, environmental subsidies, modelling and emission charges; polluter pay principles; pollution permit trading system.

Unit-IV-Environmental Economics **12 hrs**

Growth and environment; environmental audit and accounting, Kuznets curve, environmental risk analysis, assessing benefits and cost for environmental decision making; cost benefit analysis and valuation: discounting, principles of Cost-Benefit Analysis, estimation of costs and benefits, techniques of valuation, adjusting and comparing environmental benefits and costs.

Max: 40 hrs

COURSE OUTCOMES

On completion of this course, the students will able to

CO1-**Choose** the technologies available for the processing of different solid wastes.
CO2-**Explain** the need of integrated waste management.
CO3-**Develop** solutions to mitigate the growing solid wastes.
CO4-**Analyze** the various air and water pollution abatement technologies.
CO5-**Evaluate** the economic potential of waste feed stocks.
CO6-**Maximize** the income obtained from the processing of wastes.

TEXT/REFERENCE BOOKS

1. Bagchi, A. 2004. Design of Landfills and Integrated Solid Waste Management. John Wiley & Sons.
2. McDougall, F.R., White, P. R., Franke, M., &Hindle, P. 2008. Integrated Solid Waste Management: A Life Cycle Inventory. John Wiley & Sons
3. Tietenberg, T. H. & Lewis, L. 2010. Environmental Economics and Policy. Addison-Wesley
4. Singh, K. &Shishodia, A. 2007. Environmental Economics: Theory and Applications. Sage Publications

Course Code					Advanced Energy Storage System					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To provide an insight into the various modes of energy storage
2. Discuss the scientific principles underpinning the operation of energy storage systems
3. To impart knowledge on construction, working principle and performance analysis of electrochemical, electric and thermal storage systems
4. To provide problem solving skills in energy storage engineering and apply them to achieve energy conservation

UNIT 1: MODES OF ENERGY STORAGE **10 Hrs**

Energy storage methods and their technological maturity; Potential energy and Pumped hydro storage; KE and Compressed gas system: Flywheel storage, compressed air energy storage; Electrical and magnetic energy storage: Capacitors, electromagnets; Chemical Energy storage: Thermo-chemical, photochemical, bio-chemical, Superconducting Magnet Energy Storage (SMES) systems.

UNIT 2: THERMAL ENERGY STORAGE **12 Hrs**

Classification; SHS mediums; Stratified storage systems; Rock-bed storage systems; Thermal storage in buildings; Earth storage; Energy storage in aquifers, Phase Change Materials (PCMs); Selection criteria of PCMs; solar thermal LHTE systems.

UNIT 3: ELECTRIC ELECTROCHEMICAL ENERGY STORAGE SYSTEMS **10 Hrs**

Capacitor and Batteries: Comparison and application; Super capacitor: Electrochemical Double Layer Capacitor (EDLC), principle of working, structure, performance and application, role of activated carbon and carbon nano-tube. Batteries-primary, secondary, Lithium; Solid-state and molten solvent batteries; Lead acid batteries; Nickel Cadmium batteries; Advanced batteries, Role of carbon nano-tubes in electrodes.

UNIT 4: ENERGY STORAGE SYSTEM INTEGRATION **10 Hrs**

Basics of optimization; Energy storage system optimization; Integration of Energy Storage Systems within buildings; Energy storage examples to resolve intermittency in solar applications and calculations; Case studies

Max : 42 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: **List** and **define** various energy storage options/methods
CO2: **Outline** different thermal energy storage systems and **compare** sensible and latent heat storage systems for a given application
CO3: **Apply** knowledge of storage systems for enhanced performance of electrical and electro chemical systems
CO4: **Analyse** the impact of having storage for various applications
CO5: **Compare** and **select** the energy storage strategy for resolving the intermittency of renewable energy sources such as solar.
CO6: **Design** and **develop** innovative energy efficient solutions using energy storage

TEXT/REFERENCE BOOKS

1. Ibrahim Dincer and Mark A Rosen, “Thermal Energy Storage Systems and Applications”, John Wiley and Sons 2011.
2. Luisa F. Cabeza. “Advances in thermal energy storage systems”, Woodhead publications 2014.
3. James Larminie and Andrew Dicks, “Fuel cell systems Explained”, Wiley Publications, 2003.
4. Ru-shiliu, Leizhang, Xueliang sun, “Electrochemical technologies for energy storage and conversion”, Wiley Publications, 2012.
5. Yves Brunet., “Energy storage”, Wiley publications, 2013.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part B/Question: Questions from each unit with internal choice, each carrying 20 marks 100 Marks

<Course Code>					Pollution Control in Power plants					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To provide learning of basics of super thermal power plant technologies for increasing efficiency and reducing emission/pollutants
2. To get an understanding of greenhouse gas emission control and technology options for fuel combustion in thermal power plants with CO_2 capture
3. To get an insight and deep learning of greenhouse gas separation form exhaust flue gas
4. To learn about mitigation of CO_2 with safe sequestration/utilization.

UNIT 1 Emissions from Thermal Power plants and clean coal technology 10 Hrs.

Thermal Power plants principles and operations, Coal and gas-based plants, super thermal, critical, super critical and ultra-supercritical power plants. Solid, liquid and gaseous effluent from power plants. Flyash and its disposal, emission of SOx and NOx. SOx removal process by dry and wet scrubbing. NOx removal process by selective catalytic reduction. Industrial scenario.

UNIT 2 Technology challenges for Green-house gas control in power plants > 10 Hrs.

Greenhouse gas emission, Carbon footprints, CO_2 capture concept. Power plant technologies for CO_2 Capture, Pulverised Coal plants, Integrated Gasification Combined Cycle power plants, Oxyfuel combustion power plant, Chemical Looping Combustion plant, Calcium looping plants. Technology maturity, advantage and disadvantage, Research need.

UNIT 3 Technology for CO_2 capture from flue gas> 10 Hrs.

CO2 separation process: Recent advances in chemical Absorption, solvent characteristics Physical Absorption, physical solvents, membrane separation, membrane materials, Adsorption, new materials for Adsorption, Cryogenic distillation, Advantage and disadvantage, Research needs.

UNIT 4 CO_2 sequestration and utilization > 10 Hrs.

CO_2 sequestration: Geological CO_2 sequestration, Enhanced Oil-recovery, Enhanced coal- bed methane recovery. Carbon mineralization, Trapping mechanism, CO_2 integrity, biological sequestration, CO_2 utilization for the production of chemicals, fuels and other green materials. Case studies.

Max. 40 Hrs.

OURSE OUTCOMES

On completion of the course, student will be able to

CO1 - **Understand** different thermal power plant terminologies; **showcase** various emissions from power plants, consequence and their treatment.

CO2 - **Estimate** carbon footprint for large point sources of CO_2 emission and **analyze** power plant technologies for CO_2 capture with a understanding of Environmental impact.

CO3 - **Demonstrate** processes for CO_2 separation from flue gas streams of thermal power plants.

CO4 - **Analyse** technology challenges for CO_2 capture in thermal power plants and **perceiving** technology, advantage/disadvantage/ economic and research needs.

CO5 - **Demonstrate** and **analyze** options for CO_2 sequestration, industrial operation and environmental safety.

CO6 - **List** and **demonstrate** CO_2 sequestration and utilization projects with case studies.

TEXT/REFERENCE BOOKS

1. Coal-Fired electricity and emission Control, by David A Tillman, ISBN: 978-0-12-809245-3, @ 2018 Elsevier>
2. Clean -Coal engineering Technology by Bruce G.Miller, ISBN 978-0-12-811365-3, @2017 Elsevier
3. Carbon Capture and Storage, second edition by Stephen A. Rackley, ISBN: 978-0-12-812041-5 @2018 Elsevier

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: <Details> <> Marks

Part B/Question: <Details> <> Marks

<Course Code>					Instrumentation and Control in Energy Studies					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. Introduce the student to terminology and mathematics of process control.
2. To provide understanding of instruments related to energy audit.

UNIT 1 Introduction **10 Hrs.**

Basic measurement concepts, Measurement errors, Transducer classification, Static and dynamic characteristics of transducers, Instruments for measuring Temperature, pressure, velocity and flow, heat flux, liquid level and concentration in energy systems.

UNIT 2 Instrumentation in Energy field **10 Hrs.**

Energy auditing instruments, Energy audit kit, humidity measurement, characterization of electrical power systems, Instruments for monitoring electrical parameters, Analysis of power system measurements.

UNIT 3 Control theory **10 Hrs.**

Revisiting basic control theory, transfer functions, feedback control mechanism, Servo and regulatory control, sensitivity and robustness, Noise reduction, Stability analysis and controller tuning.

UNIT 4 Introductory Advanced Control **10 Hrs.**

Development of control relevant discrete time models, Grey and black box modelling, Difference between continuous time and discrete time systems, General purpose control devices and controller design.

Max. 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Highlighting the terminology used in instrumentation and control.
CO2 - Comparing and **contrasting** continuous time and discrete time processes.
CO3 - Choosing instruments for energy audit purposes.
CO4 - Breaking-down overall controller actions in its components..
CO5 - Predicting stability conditions for a given model.
CO6 - Building grey and black box models from data.

TEXT/REFERENCE BOOKS

1. K.J. Åström and B. Wittenmark, Computer-Controlled System – Theory and Design.
2. D.V.S Murty, Transducers and Instrumentation, Prentice-Hall of India Pvt. Ltd. 1995.
3. N.H. Afgan, Measurement Techniques in Power Engineering, Hemisphere Publishing Corporation, 1985

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: Problems with multiple questions each carrying 2-3 marks	40-50 Marks
Part B/Question: Problems with multiple questions each carrying 5-10 marks	50-60 Marks

<course Code>					Environmental Audit and Impact Assessment					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To provide learning of basics of EIA, its terminology, strategies, shortcoming and affecting factors.
- To understand rules, regulations, notifications, guidelines and compliance requirements for EIA study
- To get an insight and deep learning of EIA framework and its methodologies
- To learn about environment audit, structure, protocol of audit and its evaluation

UNIT 1 BASICS OF ENVIRONMENT IMPACT ASSESSMENT **08 Hrs.**

Scope and terminologies, EIA and sustainable development, benefits, drawbacks, strategic environmental assessment and social impact assessment, initial environmental examination, elements of EIA, factors affecting, impact evaluation and analysis, preparation of environmental base map, classification of environmental parameters.

UNIT 2 POLICIES, LEGISLATION AND PROCEDURES **10 Hrs.**

Environmental Clearance; Forest clearance; Consent to Establish & Consent to Operate; Environmental conservation plan for endangered flora and fauna, National Policies, EIA notifications, EIA Guidelines and compliance requirements, administrative procedures in India and states, Accreditation, Requirements and guidelines, EIA in foreign countries.

UNIT 3 EIA METHODOLOGIES **12 Hrs.**

Framework for EIA, Screening, Baseline studies, EIA planning, Activities, Methodology for EIA, Role of Environmental Engineering, Criteria for the selection of EIA Methodology, EIA methods, Ad-hoc methods, matrix methods, Network method Environmental Media Quality Index method, overlay methods, cost/Benefit Analysis

UNIT 4 ENVIRONMENT AUDIT **10 Hrs.**

Environmental Audit, objectives, types, elements of an audit process and its importance, environment audit in India, audit protocol, stages of environmental audit, audit tools and technology/general audit methodology and basic structure of audit, evaluation of audit data and preparation of audit report, post audit activities, case studies.

COURSE OUTCOMES

CO1 – **Relate** to the basics of EIA, different terminologies, strategies, and showcase its utility to Industrial projects

CO2 –**Demonstrate** the compliance requirements in an EIA study of any project

CO3 – **Identify** different rules, regulations, and guidelines to **plan** for an approval of a project

CO4 – **Analyze** the EIA framework, and evaluate its methodologies for study

CO5 – **Appraise** to the environment audit practices and protocol

CO6 – **Elaborate** the understanding of EIA and **formulate** an EIA study report for a proposed project

TEXT/REFERENCE BOOKS

1. Larry Canter, Environmental impact Assessment, McGraw Hill International Edition, 1997
2. J. Glynn Henry, Gary W. Heinke, Environmental Science and Engineering, Pearson Publisher, 1988
3. J Glasson, R Therivel, A Chadwick, Intro. to Environmental Impact Assessment, Routledge Taylor and Francis, 1994

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: Theoretical knowledge and understanding	70-80 Marks
Part B/Question: Critical Analysis and Demonstration	20-30 Marks

Course Code					Environment and Energy Conservation					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To develop an insight and understanding on co-relation between energy and environment
2. Impart knowledge on energy conservation techniques for energy and environment management
3. To assess the impact of implementing energy environment conservation techniques in process industries
4. To inculcate knowledge and skills to identify, formulate and solve fields problem in a multi-disciplinary frame individually or as a member of a group

UNIT 1:GENERAL ASPECTS AND KNOWLEDGE BASE (10L)

Interrelationship between energy and environment, Basics of electrical & thermal energy, energy units and conversion. Energy Scenario: Primary & Secondary energy, Non-renewable & renewable energy, Globally energy reserves and production, Energy and environment conservation and its importance. Energy Conservation Acts: 2001, 2010, Electricity act 2003, Integrated energy policy, Schemes under EC act 2001

UNIT 2:GLOBAL ISSUES AND NEED FOR ENERGY AND ENVIRONMENT CONSERVATION (10L)

Air Pollution, Acid rain, Ozone layer, depletion, global warming and climate change, loss of biodiversity. Need for conservation, United Nations Framework Convention on climate change (UNFCCC), National action plan on climate changes, Kyoto Protocol, Clean Development Mechanism (CDM), Sustainable development.

UNIT 3: ENERGY EFFICIENCY AND PERFORMANCE OF THERMAL AND ELECTRICAL UTILITIES (14L)

Energy Conservation in thermal utilities such as Boiler, furnace, Insulation & Refractories, Heat exchangers. Energy Conservation in electrical utilities such as Electric motor, Air compressed system, HVAC and refrigeration system, Fans & Blowers, Pumps & Pumping System, Cooling towers, Occupancy sensors, Energy efficient lighting controls, ECBC codes. Case studies

UNIT 4: APPLICATION OF ENERGY CONSERVATION AND ITS IMPACT IN REAL CASE SCENARIOS (12L)

Energy Conservation in buildings and its environmental impact assessment, Thermal Insulation, Concept of smart grid, Tariff, Energy Data Analysis using Smart Energy Systems, Market Opportunities, Innovations and Best Practices, Industrial case studies – assessment of energy generation/consumption in thermal station, steel industry, cement industry, textile industry, etc.

[Total : 46 L]

COURSE OUTCOMES

CO1: To **develop knowledge** base and **understanding** of energy and environment conservation policy, regulations and scenarios

CO2: To **develop understanding**, **appreciate** the need for energy conservation and control measures

CO3: Recognize opportunities for **enabling** rational use of energy and **analyse** energy systems from a **supply** and **demand** perspective

CO4: **Apply knowledge** to **evaluate** the performance of thermal and electrical utilities

CO5: To **develop understanding** and **skills** for innovative energy efficiency solutions, and demand management strategies

CO6: **Carryout performance assessment** and **suggest** methods to improve the overall efficiency for different energy intensive industries

TEXT/REFERENCE BOOKS

1. Sumper Andreas and Baggini Angelo: Electrical Energy Efficiency: Technologies and Applications (John Wiley 2012)
2. LC Witte, PS Schmidt and DR Brown: Industrial Energy Management and Utilization (Hemisphere Publishing Corporation, Washington, 1998)
3. Kreith F., Goswami D.Y. (2007). Energy Management and Conservation Handbook. CRC Press. ISBN: 9781420044294.
4. Patrick D.R., Fardo S.W., Richardson R.E., Fardo B.W. (2014). Energy Conservation Guidebook (3rd Edition). Fairmont Press.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part B/Question: Questions from each unit with internal choice, each carrying 20 marks 100 Marks

<Course Code>					Life Cycle Assessment					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To introduce the students to the concept of life cycle thinking.
2. To deal with environmental pollution problems and make use of Life Cycle Assessment (LCA) as an assessment tool
3. To expose the application of LCA to waste management and energy conversion systems

UNIT 1 Introduction and need of LCA **7 Hrs.**

An Introduction to Sustainability, Energy and Environment aspects: (Environment: The magnitude of sustainability challenge, Material use, Environmental emissions, Environmental interactions – biogeochemical cycles; Energy: Energy Demand and Supply, Scenario Techniques) Economic and Social dimensions, need for LCA>

UNIT 2 Overview of the Life Cycle Assessment Method **14 Hrs.**

Life Cycle Analysis: Goal Definition, Life Cycle Inventory, Life Cycle Impact Assessment, Life Cycle Interpretation, LCA Software tools; limitations with LCA; history of LCA

UNIT 3 LCA in Environment Management > **11 Hrs.**

LCA of Greenhouse Gases; Application of LCA in Strategic Environmental Assessment; Application of LCA in waste management, Application of LCA in environmental certification (ISO 14001 compliance with EMS)

UNIT 4 LCA in Energy **10 Hrs.**

Life-Cycle Analysis of Primary and Intermediate Energy Conversion; Application of LCA in assessing energy systems (refining, power plant, biofuels (fuel vs electric vehicle, gas vs fuel oil, etc.); Life-Cycle Analysis of End-Use Energy Conversion (transportation, building and space conditioning etc.)

Max. <42> Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Learn **basic concepts** of life cycle assessment (LCA)
CO2 - **Explain** the overall purpose and principles of LCA.
CO3 - **Discuss** possible **applications** and limitations of LCA
CO4 - **Examine and assess** a complete LCA of a product or service system
CO5 - Write a report of the performed LCA and appraise its compliance with ISO standards for LCA
CO6 - Make a **critical review** of alternative LCA

TEXT/REFERENCE BOOKS

1. US EPA manual on 'Life Cycle Assessment: Principles and Practice; EPA/600/R-06/060 May 2006
2. W. Klöpffer, 'Background and Future Prospects in Life Cycle Assessment', Springer Netherlands, 2014
3. M A Curran, 'Life Cycle Assessment Handbook: A Guide for Environmentally Sustainable Products', Scrivener-Wiley, 2012

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: <Questions with no choice> <25> Marks
Part B/Question: <Questions with choice> <75> Marks

<CE527T>					<Successful Research program development>					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
2	0	0	2	2	25	50	25	--	--	100

COURSE OBJECTIVES

- To develop understanding of the basic framework of research process
- To develop an understanding of various research designs and techniques.
- To identify various sources of information for literature review and data collection.
- To develop an understanding of the ethical dimensions of conducting applied research
- Appreciate the components of scholarly writing and evaluate its quality

UNIT 1 <Research Organization> **9 Hrs.**

<Objectives & Goals of a Research Organization, Components of a research organization, Sponsors & Funding Agencies: Funding Agencies − Types**,** Types of Interface with Funding & Sponsor Agencies**,** Call for Proposals & Opportunity Tracking**,** Types of Proposals & Grants**,** Contracting Vehicles & Arrangements**,** Deliverables, Interim & Final Reviews**,** Cost & Performance Audits**,** Contract Laws &

UNIT 2 <Development of Proposal Writing> **9 Hrs.**

<Proposals for Research Program Funding: Center & Consortia Proposals, Individual Principal Investigator Proposals, Continuation & Renewal Proposals, Prime*/*Subcontractor Relationships & Contracting, Cost Accounting, Laws and Regulations. intellectual Property & Patent Laws**,** Writing a Successful Research Proposal: Technical Proposal, Management Proposal, Cost Proposal, Technology Proposal, Statement of Work & Deliverables, Case Studies>

UNIT 3 <Development of Research Methodology> **9 Hrs.**

<**The Research Process – I**: Steps in development of successful research program, Quality and Cost consideration, Laboratories and infrastructure setup, Staffing & Support Models, Peer−Review, Independent Verification & Validation, Internal & External Review processes, Ethics & Regulatory Laws & Guidelines, Case Studies.>

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - < Students should be able to **identify** the overall process of designing a research study from its inception >

CO2 - <Students should **understand** the characteristics of various kinds of research (quantitative and qualitative).>

CO3 - <Students should **apply** the knowledge of a forward chronological, backward chronological and manual search methods in framing the literature review for a scholarly educational study>

CO4 - <students should be **analyze** with conducting scholarly educational study: a. The steps in the overall process. b. The types of databases often searched. c. The criteria for evaluating the quality of a study. d. The ways of organizing the material found. e. The different types of literature reviews>

CO5 - <student can able to **exercise** on various Ethical issues in conducting research>

CO6 - <**Develop** research designs and project proposals in achieving project deliverables in stipulated period of time and cost>

TEXT/REFERENCE BOOKS

1. <Research Methodology (Methods and Techniques) book by CR Kothari New age Publications 3rd edition>
2. <Research Methodology book by Ranjith Kumar, Sage Publications 3rd edition (Softcopy Available)>
3. Nptel Lectures: Introduction to Research,Prof. Prathap Haridoss, Department of Metallurgical and Materials Engineering, Indian Institute of Technology, Madras

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question1: <identifying overall research process>	<> Marks
Part A/Question2: <relation between quantitative and qualitative>	<> Marks
Part A/Question3: <literature review process>	<> Marks
Part A/Question4: <hypothesizing and concept building>	<> Marks
Part A/Question5: <Ethical issues in conducting research>	<> Marks

					Intellectual Property Rights					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
2	0	0	2	2	25	50	25	--	--	100

COURSE OBJECTIVES

- To understand the basics importance of sustainability and green chemistry
- To understand principal, application and synthesis methods.
- To learn Conventional Process and Operations-Current status.
- Learn to understand new process developments.

UNIT – 1: Intellectual Property Rights (IPR) – An Introduction [7 hrs]
Basic concept of Intellectual Property, Characteristics and Nature of Intellectual Property right, Justifications for protection of IP, IPR and economic development.

UNIT – 2: Publications & Patents [8 hrs]
Effective technical writing: how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

UNIT – 3: Understanding Intellectual Property Rights (IPR) [8 hrs]
Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT – 4: Patents & Copyrights [7 hrs]
Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System, Traditional knowledge Case Studies, IPR and IITs.

COURSE OUTCOMES

On completion of the course, student will be able to
CO1: **Find** the importance of Intellectual property.
CO2: **Show** the ability to write paper developing a Research Proposal and patent.
CO3: **Apply** the knowledge for Process of Patenting and Development
CO4: **Distinguish** between the Scope of Patent Rights, Licensing and transfer of technology.
CO5: **Access** and understand of New Developments in IPR.
CO6:- **Develop** the technique for IPR protection provides and follow the research ethics.

TEXT/REFERENCE BOOKS

1. Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.
2. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological Age”, 2016.
3. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

Teaching Scheme					Energy And Environmental Research Lab-2					
					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
-	-	4	2	4	--	--	--	50	50	100

COURSE OBJECTIVES:-

In order to supplement various topics related to energy and environment aspects in class-room lectures, some laboratory experiments are needed as a part of curriculum development of energy and environment management programme for better understanding of the subjects. The experiments based on basic science/engineering principles are so designed so as to provide students enough stimulation for further.

List of Experiments:

1. Use of microprocessor kit, microcontroller, data acquisition and display experiments.
2. Performance evaluation of energy systems using microprocessor/microcontroller based data acquisition systems.
3. Determination of Density, Viscosity, Flash-point, Fire-point, Pour-point of fuel.
4. Performance study of heat pump system & Thermoelectric Generator and Refrigerator
5. Heat Pipe Heat Exchanger and its efficiency
6. Production of Carbon nanotubes using plastic waste.
7. Microwave assisted carbonaceous susceptor heating.
8. Adsorption study in batch process.
9. Performance of Solar Still.
10. I-V Characteristics a Solar Cell
11. Power generation using fuel cell technology
12. Fractional distillation of Petroleum

COURSE OUTCOMES

On completion of the course, student will be able to

CO1:- **Select** the process to perform the energy and environmental based experiments.

CO2: **Demonstrate** the importance of the energy systems, data acquisition and display experiments.

CO3: **Utilize** the concept to solve and perform the experiments related with environmental Managements.

CO4: **Examine and assess** a complete development of energy and environment management systems.

CO5: To **develop understanding** and **skills** for innovative energy efficiency solutions, and demand management strategies

CO6: Suggest best methods to **improve** the overall efficiency for different energy intensive industries.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: Practical Work 50 Marks

Part B/Question: Practical and Viva Exam 50 Marks

SEMESTER III			M.TECH. ENERGY AND ENVIRONMENTAL MANGEMENT										
Sr. No	Course Code	Course Name	Teaching Scheme					Exam Scheme					
								Theory			Practical		Total
			L	T	P	C	Hrs/wk	MS	ES	IA	LW	LE/Viva	Marks
1	20MT611	Seminar-I	--	--	--	5	--	40	60	--	--	--	100
2	20MT621	Dissertation	--	--	--	14	--	40	60	--	--	--	100
		Total	--	--	--	**19**	**10**	--	--	--	--	--	**200**

SEMESTER IV			M.TECH. ENERGY AND ENVIRONMENTAL MANGEMENT										
Sr. No	Course Code	Course Name	Teaching Scheme					Exam Scheme					
								Theory			Practical		Total
			L	T	P	C	Hrs/wk	MS	ES	IA	LW	LE/Viva	Marks
1	20MT621	Seminar-II	--	--	--	5	--	40	60	--	--	--	100
2	20MT622	Dissertation	--	--	--	23	--	40	60	--	--	--	100
		Total	--	--	--	28	--	--	--	--	--	--	200