M.TECH (ENERGY ENGINEERING)

Learning Outcome based Course Curriculum

2024

Department of Energy Engineering

Assam Science and Technology University

Tetelia Road, Jalukbari, Guwahati – 781013, Assam, India

http://astu.ac.in/astu/

M.Tech in Energy Engineering

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

The M.Tech program in Energy Engineering seeks to prepare post graduate (PG) students for productive and rewarding careers in the field of energy. The PEOs are listed below:

1. Acquire knowledge and skills significant for employment in energy sector and to emerge as a consultant and entrepreneur and be a part of a supply-chain or manufacture or marketing of renewable energy products for sustainable development.
2. Imparted with knowledge in various domains to identify research gaps and ideate innovations for developing techno-economically sustainable energy efficient products and processes for societal upliftment.
3. Adhere professional, social and ethical responsibilities in implementing sustainable energy solutions.

PROGRAMME OUTCOMES (POs):

PO1	**Engineering Knowledge**	Acquire and apply mathematics, science, engineering fundamentals and energy engineering principles to solve complex energy engineering problems.
PO2	**Problem Analysis**	Identify, formulate, conduct literature search and analyse complex energy engineering problems.
PO3	**Design/Development of Solutions**	Design innovative solutions for complex energy engineering problems that meet specified needs with consideration for public health and safety, cultural, societal and environmental constraints.
PO4	**Investigation**	Utilize research-based knowledge and research methods to investigate complex energy engineering and technology problems.
PO5	**Modern Tool Usage**	Create, select, and apply appropriate techniques, resources, and modern engineering and computational tools to solve complex energy engineering problems and activities with an understanding of the assumptions and limitations.

PO6	**The Engineer and Society**	Apply engineering reasoning to assess societal, health, safety, legal and cultural issues and other consequent responsibilities relevant to energy engineering and technology practice.
PO7	**Environment and Sustainability**	Understand the impact of energy engineering and technology based solutions in societal and environmental context and demonstrate the needs for sustainable development.
PO8	**Ethics**	Demonstrate professional ethical principles, responsibilities and commit to norms of energy engineering practice.
PO9	**Individual and Team Work**	Work effectively as an individual, a team member or a leader in diverse, interdisciplinary and transdisciplinary settings.
PO10	**Communication**	Communicate effectively on complex energy engineering activities and give clear presentation to all stakeholders.
PO11	**Project Management and Finance**	Demonstrate ability to manage projects in interdisciplinary environments using engineering management principles at one's own work, as a team and leader, to satisfy stakeholders requirements.
PO12	**Life Long Learning**	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAMME SPECIFIC OUTCOMES (PSOs):

PSO 1: Apply fundamental knowledge to identify, formulate, design and investigate various problems in the field of energy.

PSO 2: Apply modern software tools for design, simulation and optimization of various energy conversion technologies.

PSO 3: Solve ethically & professionally various problems in societal and environmental context and communicate effectively.

COURSE CURRICULUM AND SYLLABI FOR

M.Tech (Energy Engineering)

The course curriculum for M.Tech (Energy Engineering), in the Department of Energy Engineering, ASTU is developed based on the guidelines of AICTE Model curriculum for Postgraduate Degree in Engineering and Technology:

Course Type	No. of Courses	Total Credits
1. Core Course (CC)	04	12
2. Program Specific Elective (PE)	05	15
3. Lab Course (LC)	04	08
4. Research Methodology and IPR	01	02
5. Open Elective (OE)	01	03
6. Mini Project	02	02
7. Dissertation	02 (Phase-I & Phase II)	26
8. Audit Course (AC)	02	00

Semester wise courses for M.Tech (Energy Engineering)

Course code	Name	Scheme of Studies Per Week L– T - P	Credits C
Semester-I			
EECC18101	Foundation for Energy Engineering	2-2-0	3
EECC18102	Solar and Bio Energy Technologies	2-2-0	3
EECC18103	Energy System Modeling & Optimization	2-2-0	3
EEPE181xx	Elective I	3-0-0	3
EELC18101	Energy Lab-I	0-0-4	2
EELC18102	Energy Lab-II	0-0-4	2
EERM18101	Research Methodology and IPR	2-0-0	2
MAC20211x	Audit Course 1	2-0-0	0
Total Credits			**18**
Semester-II			
EECC18201	Alternative Energy Technologies	3-0-0	3
EEPE182xx	Elective-II	3-0-0	3
EEPE182xx	Elective-III	3-0-0	3
EEPE182xx	Elective -IV	3-0-0	3
EELC18201	Energy Lab-III	0-0-4	2
EELC18202	Energy Lab-IV	0-0-4	2
EEMP18201	Studies with Community MINI PROJECT	0-0-4	1

EEMP18202	Factory/Industry/Site Visit [MINI PROJECT]	0-0-4	1
MAC20211x	Audit Course 2	2-0-0	0
Total Credits			**18**
Semester-III			
EEPE1830x	Elective -V	3-0-0	3
EEOE18-0x	Open Elective	3-0-0	3
EED18P-I	Dissertation Phase – I	0-0-20	10
Total Credits			**16**
Semester-IV			
EED18P-II	Dissertation Phase – II	0-0-32	16
Total Credits			**16**

Open Elective (EEOE18-0x)

1. EEOE18-01 Business Analytics
2. EEOE18-02 Industrial Safety
3. EEOE18-03 Operations Research
4. EEOE18-04 Cost Management of Engineering Projects
5. EEOE18-05 Composite Materials
6. EEOE18-06 Waste to Energy

Audit course 1 & 2 (MAC20211x)

1. MAC202111 English for Research Paper Writing
2. MAC202112 Disaster Management
3. MAC202113 Sanskrit for Technical Knowledge
4. MAC202114 Value Education
5. MAC202115 Constitution of India
6. MAC202116 Pedagogy Studies
7. MAC202117 Stress Management by Yoga
8. MAC202118 Personality Development through Life Enlightenment Skills

Program Specific Electives (PE)

Elective-I

EEPE18101 Energy Scenario and Energy Policy
EEPE18102 Energy and Society
EEPE18103 Energy Economics and Planning
EEPE18104 Electricity Regulations and Reforms in India

Elective-II

EEPE18201 Environmental Science and Engineering
EEPE18202 Energy, Ecology and Environment/
EEPE18203 Energy, Environment and Climate Change

Elective-III

EEPE18204 Electrical and Mechanical Energy Utility Systems

EEPE18205	Power Plant Engineering
EEPE18206	Decentralized Energy Systems
EEPE18207	Instrumentation and Control for Energy Systems
EEPE18208	Power Generation and System Planning
EEPE18209	Energy Conservation and Waste Heat Recovery
EEPE18210	Project Management

Elective-IV

EEPE18211	Fuel & Combustion Technology
EEPE18212	Energy Generation from Waste
EEPE18213	Alternative Fuels for IC Engine
EEPE18214	Energy Storage System
EEPE18215	Energy Efficient Building
EEPE18216	Renewable Energy Grid Integration
EEPE18217	Energy Audit and Management
EEPE18218	Vacuum Technology

Elective-V

EEPE18301	Fuel Cells and Hydrogen Energy
EEPE18302	Hydro Power Management
EEPE18303	Advanced Solar Thermal and PV
EEPE18304	Wind Power Technology
EEPE18305	Solar Thermal Technology
EEPE18306	Bioenergy Technology
EEPE18307	Solar Photovoltaic Technology
EEPE18308	Petroleum Production & Refining
EEPE18309	Industrial Plasma Technology
EEPE18310	Nuclear Energy Engineering
EEPE18311	Hybrid Renewable Energy Systems Design

Mapping of Courses with Programme Outcomes (POs) and Course Outcomes (COs)

Mapping of Programme Outcomes (POs) with Course Outcomes (COs)												
Course Code	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
Core Courses												
EECC18101	CO1, CO3, CO4	CO2, CO3, CO4, CO5	CO3, CO4	CO3, CO4, CO5	CO3, CO5							
EECC18102	CO1, CO3	CO2		CO4								
EECC18103	CO1	CO2, CO3	CO4				CO4					
EECC18201	CO1	CO2	CO3,			CO3,	CO4					

			CO4			CO4						
Program Specific Elective (PE)												
EEPE18101		CO1, CO2	CO3	CO3		CO4	CO4					
EEPE18102	CO1		CO2	CO2		CO3, CO4	CO3, CO4					
EEPE18103	CO1	CO2	CO3		CO3	CO3	CO3				CO4	
EEPE18104	CO1	CO2, CO4	CO5	CO3								
EEPE18201	CO2, CO3, CO4	CO1, CO3		CO4		CO4						
EEPE18202	CO1	CO2		CO4	CO3		CO4					
EEPE18203	CO1		CO2	CO4		CO3, CO4						
EEPE18204	CO1, CO2	CO4	CO3	CO3	CO4							
EEPE18205	CO3	CO4, CO5	CO1, CO2	CO4	CO5							
EEPE18206	CO1	CO2	CO3	CO3, CO4, CO5	CO5							
EEPE18207	CO1	CO2, CO3	CO5	CO4								
EEPE18208	CO1	CO2	CO3		CO3	CO3					CO2, CO3	CO2, CO3
EEPE18209	CO1	CO3	CO2		CO3							
EEPE18210		CO1			CO2, CO3					CO4	CO4	CO4
EEPE18211		CO1, CO2	CO4	CO3, CO5	CO3, CO4	CO5	CO4, CO5					
EEPE18212	CO1	CO2	CO3	CO4	CO3	CO4	CO3, CO4					
EEPE18213	CO1	CO3	CO4	CO3	CO2		CO2					
EEPE18214	CO1	CO2	CO3	CO4		CO4	CO4					
EEPE18215	CO1	CO2	CO3	CO4	CO4		CO4					
EEPE18216	CO1	CO2		CO3		CO3						
EEPE18217	CO1	CO1, CO2, CO3		CO3	CO4	CO4	CO4				CO2	
EEPE18218	CO1, CO2	CO3		CO3								
EEPE18301	CO1, CO2	CO3	CO5	CO4			CO4, CO5					
EEPE18302	CO1, CO2		CO3			CO3, CO4	CO3, CO4				CO4	CO4
EEPE18303	CO1, CO2		CO3, CO4			CO5	CO5				CO5	CO5
EEPE18304	CO1, CO2		CO3			CO4	CO4					
EEPE18305	CO1	CO1, CO2	CO3			CO3, CO4	CO4					
EEPE18306	CO1	CO1, CO2	CO3	CO2		CO3, CO4	CO3, CO4					
EEPE18307	CO1	CO2	CO3,		CO3,	CO5	CO5				CO5	CO5

			CO5		CO4							
EEPE18308	CO1, CO2	CO3, CO5	CO5		CO5	CO4	CO4					
EEPE18309	CO1, CO2	CO4		CO3		CO4	CO4					
EEPE18310	CO1, CO3	CO2		CO4		CO5	CO5					
EEPE18311		CO1	CO2, CO3		CO3	CO4	CO2, CO4					
Lab Course (LC)												
EELC18101	CO2, CO3	CO1		CO4								
EELC18102	CO1	CO2, CO3		CO2, CO3								
EELC18201	CO1		CO2, CO3		CO2, CO3							
EELC18202		CO1, CO2, CO3		CO1, CO2								
Research Methodology and IPR												
EERM18101		CO1, CO2						CO3				C4, C5, C6
Open Elective (OE)												
EEOE18-01	CO1	CO2, CO3	CO4									
EEOE18-02	CO1, CO2	CO1, CO3, CO5				CO4						
EEOE18-03		CO1, CO3, CO5			CO2, CO3, CO4							
EEOE18-04	CO1	CO1, CO2, CO4		CO5	CO5				CO3	CO3	CO3, CO4	CO3
EEOE18-05	CO1	CO2, CO5	CO3, CO4									
EEOE18-06	CO1, CO2			CO3								
Mini Project												
EEMP18201	CO1	CO2			CO3	CO2	CO2	CO4	CO4	CO4	CO3	CO4
EEMP18202		CO1			CO2	CO1, CO2	CO3		CO4	CO4	CO3	CO4
Dissertation												
EED18P-I	CO2	CO1, CO2, CO3		CO4	CO4							CO5
EED18P-II		CO2, CO4	CO1	CO1		CO3, CO4		CO3				CO3

Semester wise detailed course curriculum

1ST SEMESTER

Course code	Course Name	L– T - P	C
EECC18101	Foundation for Energy Engineering	2-2-0	3

Course Outcomes

CO1: Understand the principles of engineering thermodynamics and different process utilities
CO2: Identify important features of solid, liquid and gaseous fuels
CO3: Recognize the principles of heat transfer in industrial applications
CO4: Interpret fluid flow operations involved in energy conversion processes
CO5: Analyze performance of electrical machines, devices, power transmission and distribution

Course Content:

Engineering Thermodynamics& Process Utilities: Laws of thermodynamics and applications,

Refrigeration systems, humidification and dehumidification, Internal combustion engine cycles, Rankine cycles and their characteristics and performances, Thermodynamic analysis of conventional power plants

Introduction to Fuel Technology

Heat Transfer Operations: Heat Transfer by Conduction, Convection (natural & force convection), Radiation, Boiling, Condensation, Evaporation, Basics of Heat transfer equipment

Heat Exchangers: Classification, temperature distribution in heat exchangers, Overall heat transfer co-efficient, the LMTD method for heat exchanger analysis, Preliminary design aspect of Heat Exchangers

Fluid Mechanics: Introduction, Fluid flow phenomena, Basic equation of fluid flow, Flow of incompressible fluid in conduits, Flow past immersed bodies, Fluidization, Transportation and metering of fluids, Compressible fluids

Electrical Machines & power systems: Principles and applications of DC Machines, Transformer, Induction Motor, A.C. Synchronous machines, Measuring Instruments, Introduction to power generation, transmission and distribution, power systems losses and compensation, High voltage AC (HVAC) and High voltage DC (HVDC) transmission; Interconnected grid system

Course code	Course Name	L– T - P	C
EECC18102	Solar and Bio Energy Technologies	2-2-0	3

Course Outcomes

CO1: Acquire understanding of the basic of biomass and bioenergy sources, different characterization techniques to study the feasibility as energy sources.

CO2: Develop analytical capabilities in the design and principle of different biomass conversion technologies, asses their environmental, economical and technological impact
CO3: Comprehend the principles of solar energy and thermal conversion, design and analysis of solar thermal power systems.
CO4: Impart knowledge of solar photovoltaic system, PV system designs, off-grid and grid connected system

Course Content:

Biomass Conversion Technologies:

Bio energy sources: Introduction, classification, composition, characterization and utilization, Properties of biomass, Energy Plantation, Drying, Storage and handling of biomass, Briquetting

Thermo-chemical and Biochemical Conversion of Biomass:

Biomass Pyrolysis, Combustion, Gasification, Liquification. Biomass gasifier types, Design study of gasification plant: effect of operating parameters on gasification, Applications of Gasifiers to thermal power plants and Engines

Conventional and Advanced Biofuels: Types, Production processes and technologies, Biofuel applications, Life Cycle Analysis of biofuels - Environmental aspects of biofuel utilization - Techno-economic features of bio-fuels, Relevance with Indian Economy Biochemical Conversion: Aerobic anmd Anaerobic conversion, Fermentation, Feedstock for biogas, Microbial and biochemical aspects - operating parameters for biogas production. Kinetics and mechanism- High rate digesters for industrial waste water treatment,Biogas Purification, Importance of biogas technology, Different Types of Biogas Plants, Applications of biogas

Biorefineries; Biohydrogen production, Waste to Energy production; Incineration- for liquid fuel production.

Solar radiation: Availability,Measurement and estimation of solar radiation on horizontal and tilted surfaces, Solar radiation measurement devices, Solar radiation data analysis

Solar Thermal Conversions:

Theory and design aspects offlat plate solar collectors, concentrating solar collectors, advanced collectors and solar concentrators

Solar water heating, Solar cooking, Solar drying, Solar distillation, Solar refrigeration, Active and passive heating and cooling of buildings, Solar Chimney, Solar drying

Solar thermal power generation, Industrial process heat systems, Solar thermal power generation and sterling engine, Solar economics, Solar Energy Mission

Solar Photovoltaic Conversion:

Basics of Photovoltaic (PV) cell, characteristics- cell arrays-power electric circuits for output of solarpanels-choppers-inverters-batteries-charge regulators, material types (crystalline silicon, tandom, thin film etc); Constructional concepts; off grid and grid connected PV systems, PV system design and economics

Solar Photocatalysis: Mechanism; Kinetics; Performance parameters; Applications.

Solar Energy Storage: Concept of Solar pond technology

Text Books:

1. Biomass Renegerable Energy – D.O.hall and R.P. Overeed (John Wiley and Sons, New york)
2. Biomass for energy in the developing countries – D.O.Hall, G.W.barnard and P.A.Moss (Pergamon Press Ltd. 1982)
3. Biomass as Fuel – L.P.White (Academic press1981)
4. S.P. Sukhatme, *Solar Energy: principles of Thermal Collection and Storage*, Tata McGraw-Hill
5. J. A. Duffie and W. A. Beckman, (2006); *Solar Engineering of Thermal Processes,* Johnn Wiley
6. Green, Martin (2005), 3rd Generation Photovoltaic: Advance Solar Energy, Springer
7. Goswami D Y, Frank Kreith and J F Kreider, Taylor & Francis (1999) ; Principles of Solar Engineering, Taylor & Francis, USA
8. Garg H.P. and Prakash S (1997) ; Solar Energy: Fundamental and Application Tata McGrow-Hill, New Delhi

References:

1. Anthony San Pietro (1980); Biochemical and Photosynthetic aspects of Energy Production, Academic Press, New York,
2. Parker, Colin & Roberts, (1985); Energy from Waste- An Evaluation of Conversion Technologies, Elsevier Applied Science London
3. Ralph E.H. Sims ed. (2004); Bioenergy options for cleaner environment by World Renewable Energy Network.
4. Ravindranath N.H. and Hall D.O. (1995); Biomass, Energy and Environment, A developing country perspective from India by, Oxford University Press,
5. Brown Robert C. (2003); Biorenewable Resources: Engineering New Products from Agriculture, Iowa State University Press ,USA
6. Khandelwal KC, Mahdi SS, (1986); Biogas Technology - A Practical Handbook, Tat Mcgraw Hill
7. Kreith F. and J. F. Kreider, (1978); *Principles of Solar Engineering* , McGraw-Hill
8. Kreider J.F. and F. Kreith, (1981) ;*Solar Energy Handbook* McGraw-Hill

Course code	Course Name	L– T - P	C
EECC18103	**Energy System Modeling and Optimization**	**2-2-0**	**3**

Course Outcomes

CO1: Illustrate the major theories used in numerical methods
CO2: Analyze and apply methodologies used in numerical techniques for solving problems
CO3: Formulate and solve the simple problems involving governing equations of parabolic type, hyperbolic type and elliptic type with incorporation of boundary conditions/ initial conditions
CO4: Develop perception of major theories, approaches and methodologies used in CFD

Course Content:

Introduction & Solution of Simultaneous Equations: Introduction to Numerical Methods, Concept of Mathematical Modelling , Conservation laws and Engineering problems.

Solution of Simultaneous Equations: Gauss Elimination Method, Decomposition Methods, Gauss-Seidal Method, Over Relaxation and Under Relaxation Methods

Numerical Differentiation, Integration and ODE Solution: Numerical Differentiation: First, Second and higher order derivatives. Numerical Integration: Trapezoidal Rule, Simpsion's 1/3 Rule.

Solution of Ordinary Differential Equations: Taylor Series Methods, Eulers's Methods, Runge-Kutta Methods

Discretization: Numerical Representation of Partial Differential Equations: Types of equations, Fundamentals of Finite Difference Methods, Basic Discretization techniques, Representation of Derivatives as Difference Expression, Formation of difference equations. Concept of Consistency, Stability and Convergency. Errors in Numerical Computations. Various Boundary Conditions.

Equations of Parabolic Types: Application of Finite Difference Methods for Solution of parabolic types of equations using Explicit Schemes, Implicit Schemes. FTCS, Leap frog, Dufort-Frankel, Crank-Nicholson Schemes, Thomas Algorithm for Tri-diagonal System of equations.

Equation of Hyperbolic Type: Application of Finite Difference Methods for Solution of Hyperbolic Types of Equations.

Solution of first order wave equation using Explicit Schemes.

Equation of Elliptic Type: Application of Finite Difference Methods for Solution of Laplace and passion Equation in two dimension.

Computational Fluid Dynamics (CFD) Applications: Governing Equations of Fluid Flow, Finite Difference, Finite Volume, Finite Element Methods, Laplace Equation, Diffusion Equation or Wave Equation

Application of Finite Volume Method to Fluid Flow problems - Pressure Correction Techniques-Gauss Siedel, Gauss Jordan. Introduction to Multi grid Methods. Boundary Conditions

Structured and Unstructured Mesh- Introduction to CAD systems and Different Standards used for DATA Exchange. Governing Equations for Turbulent Flow, Rotating Machinery, Combusting Flow, Multiphase Flow.

Simple Internal Flows: T-Junction, Driven Cavity, Manifold, Valves, External Flows: Flow Over Ahmed Body, Car-Reacting Flow in a Gas Burner, Multiphase Flow in an Air Lift Reactor.

Text Books:

1. Steven C. Chapra and Raymond P. Canale , (2012), "Numerical Methods for Engineers" , Tata McGraw Hill Education (India) Pvt. Ltd., New Delhi
2. P. Niyogi, S.K. Chakrabarty and M.K. Laha, (2005), "Introduction to Computational Fluid Dynamics", Pearson Education Pte. Ltd, Indian Branch, New Delhi.

3. P.B.Patil and U.P. Verma , (2010), “Numerical Computational Methods”, Narosa Publishing House
4. H.K. Versteeg & W. Malalasekera, "An Introduction to Computational Fluid Dynamics - The finite volume approach" Longman, 1995
5. L. J Segerlind .., "Applied finite Element Analysis", 2nd edition, John Wiley, 198

References:

1. Anderson, “Computational Fluid Dynamics” McGraw Hill Company, 1995
2. D.A. Caughey and M.M. Hafez, "Frontiers of Computational Fluid Dynamics 1994" JohnWiley& Sons, 1994

Course code	Course Name	L– T - P	C
EERM18101	Research Methodology and IPR	2-0-0	2

Course Outcomes:

CO1: Understand research problem formulation.
CO2: Analyze research related information
CO3: Follow research ethics
CO4: Understand that today’s world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
CO5: Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
CO6: Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits

Course Content:

Unit 1: Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Unit 2: Effective literature studies approaches, analysis. Plagiarism, Research ethics,

Unit 3: 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 4: 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 5: Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Unit 6: New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

References:

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
3. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"
4. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
5. Mayall, "Industrial Design", McGraw Hill, 1992.
6. Niebel, "Product Design", McGraw Hill, 1974.
7. Asimov, "Introduction to Design", Prentice Hall, 1962.
8. Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016.
9. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

Laboratory Courses

Course code	Course Name	L– T - P	C
EELC18101	**Energy Lab-I**	**0-0-4**	**2**

Course Outcomes:

CO1: Modelling of 2D and 3D design
CO2: Understand the different mesh generation techniques
CO3: Understand the importance of boundary conditions
CO4: Demonstrate modelling of complex geometries.

Course Content:

Energy System Modeling & Optimization Lab-I

Major Experimental Analysis: development of 2D and 3D design, mesh designing of generation techniques, boundary conditions and complex geometries

Course code	Course Name	L– T - P	C
EELC18102	**Energy Lab-II**	**0-0-4**	**2**

Course Outcomes:

CO1: Operate measuring devices for estimation of solar radiation
CO2: Analyze the characteristics of biomass and biofuels using different instruments and chemical treatment processes
CO3: Interpret the experimental results related to performance of photovoltaic system

Course Content:

Renewable Energy Lab-I:

Major Experiments:

Biomass: proximate and ultimate analysis, biochemical composition analysis, determination of physicochemical characteristics of liquid biofuels, understand the mechanism of thermal conversion processes

Solar: measurements of solar radiations, performance analysis of photovoltaic system

New Experiments will be included from time to time

ELECTIVE-I

Program Specific Elective Course Content

Course code	Course Name	L– T - P	C
EEPE18101	**Energy Scenario and Energy Policy**	**3-0-0**	**3**

Course Outcomes:

CO1: Understand and energy scenario in Indian and global context.
CO2: Review energy policy in the context of energy security and management in India
CO3: Identify future energy options in line with international treaties, policies on energy and environment
CO4: Assess relevancy of new and renewable energy sources for sustainable developments

Course Content:

Global Energy Scenario: Role of energy in economic development and social transformation: Energy & GDP, GNP and its dynamics.

Discovery of various energy sources: Energy Sources and Overall Energy demand and availability, Energy Consumption in various sectors and its changing pattern, Exponential increase in energy consumption and Projected future demands.

Energy Resources: Coal, Oil, Natural Gas, Nuclear Power and Hydroelectricity, Solar and Other Renewable etc. Depletion of energy sources and impact exponential rise in energy consumption on economies of countries and on international relations.

Energy Security: Chemical and Nuclear: Non Proliferation, Energy Security, Energy Consumption and its impact on environmental climatic change.

International Energy Policies of G-8 Countries, G-20 Countries, OPEC Countries, EUCountries.

International Energy Treaties (Rio, Montreal, Kyoto), INDO-US Nuclear Deal.

Future Energy Options: Sustainable Development, Energy Crisis: Transition from carbon rich and nuclear to carbon free technologies, parameters of transition.

Indian Energy Scenario: Energy resources & Consumption: Commercial and noncommercial forms of energy, Fossil fuels, Renewable sources including Bio-fuels in India, their utilization pattern in the past, present and future projections of consumption pattern, Sector wise energy consumption

Impact of Energy on Economy, Development and Environment, Energy for Sustainable Development, Energy and Environmental policies, Need for use of new and renewable energy sources.

Status of Nuclear and Renewable Energy: Present Status and future promise.

Energy Policy Issues: Fossil Fuels, Renewable Energy, Power sector reforms, restructuring of energy supply sector, energy strategy for future.

Energy Conservation Act-2001 & its features, Electricity Act-2003 & its features. Framework of Central Electricity Authority (CEA), Central & States Electricity Regulatory Commissions (CERC & ERCs)

Energy Policy: Global Energy Issues, National & State Level Energy Issues, National& State Energy Policy, Industrial Energy Policy, Energy Security, Energy Vision, Energy Pricing & Impact of Global Variations, Energy Productivity (National & Sector wise productivity).

Reference Books:

1. Energy for a sustainable world: Jose Goldenberg, Thomas Johanselsson, A.K.N.Reddy, Robert Williams (Wiley Eastern).
2. Energy policy for :B.V.Desai (Weiley Eastern),
3. Modeling approach to long term demand and energy implication :J.K.Parikh.
4. Energy Policy and Planning :B.Bukhootsow.
5. TEDDY Year Book Published by Tata Energy Research Institute (TERI),
6. World Energy Resources : Charles E. Brown, Springer2002.
7. 'International Energy Outlook' -EIA annual Publication
8. Heat and Thermodynamics – M.W. Zemansky (McGraw Hill Publication)
9. Principles of Energy Conversion: A.W. Culp (McGraw Hill International edition.)
10. BEE Reference book: no.1/2/3/4.

Course code	Course Name	L– T - P	C
EEPE18102	**Energy and Society**	**3-0-0**	**3**

Course Outcomes:

CO1: Understand contemporary issues related to energy, environment and climate change

CO2: Examine feasibility of renewable energy technology from the perspectives of energy conservation and management

CO3: Discuss the prospects of clean energy technology for combating climate change

CO4: Assess socio- and techno-economic aspects of renewable energy technology deployment

Course Content:

Introduction:

History of development of life in Earth, earth temperature and atmosphere, geochemical cycles, ecological principles of nature Global energy scenario, Fuel & energy substitution

Energy Implications:

Earth resources, energy extraction, conversion and utilization- Solar, biomass, hydro power , wind and other sources of energy. Power generation from different energy sources Ener gy demand across space and time; Economics importance of utilization of different energy sources Energy conservation and management-basic concepts, Energy conservation oppor tunities in household, transport, lighting etc. Energy Conservation Act Global warming; Gre en House Gas emissions, impacts, mitigation; Sustainability; Externalities

Clean Energy Technology:

Clean energy technologies; United Nations Framework Convention on Climate Change (UN FCCC); Sustainable development; Kyoto Protocol; Conference of Parties (COP); Clean Deve lopment Mechanism (CDM); Prototype Carbon Fund (PCF)

Societal Aspect:

Uncertainties and social cost-benefit analysis of renewable energy systems; conflicts betwe en energy and food security, factors that impact selection of energy technologies and policy instruments

Text Books:

1. Hodge B. K. Alternative Energy Systems, Publisher: Wiley; New Edition
2. Hinrichs & Kleinbach. Energy: Its Use and the Environment, Fourth edition, Thomps on Learning, 2005

References

1.Sukhatme, Solar Energy: principles of Thermal Collection and Storage, Tata McGrAw-Hi ll
2.Craig R. Humphrey, Tammy L. Lewis, and Frederick H. Buttel Belmont. Environment, E nergy, and Society: A New Synthesis. CA: Wadsworth Group, 2002.
3.Kandpal T.C., H. P. Garg (2003) ; Financial Evaluation of Renewable Energy Technology, Macmilan India Ltd. New Delhi

Course code	Course Name	L– T - P	C
EEPE18103	**Energy Economics and Planning**	**3-0-0**	**3**

Course Outcomes:

CO1: Understand the principles of energy economics and planning
CO2: Review energy policy in the context of energy conservation and environmental protection
CO3: Formulate policy and planning for energy security and environmental management
CO4: Assess feasibility of energy projects from economic aspects

Course Content:

Introduction: Energy Economics: Basic concepts, Energy data and energy framework; Economic theory demand, production and cost market structure; National Energy map of India

Economic Attributes: Concepts of economic attributes involving renewable energy,

Calculation of unit cost of power generation from different sources with examples, energy technology diffusion modeling

Applications: Application of economics; input and output optimization and simulation methods to energy planning and forecasting problems Dynamic models of the economy and simple theory of business fluctuation

Energy Policies: Evaluation of National and Regional energy policies; Oil import, energy conservation, rural energy economics, integrated energy planning, Conflict between energy consumption and environmental planning

Energy-Environment Interactions: Economic approach to environmental protection and management, Energy-Environment interactions at different levels, energy efficiency, cost-benefit risk analysis; Project planning and implementation

Text Book :

1. Bhattacharyya S.C. (2011): Energy Economics, Springer
2. Ferdinand E.B. (2000): Energy Economics: A Modern Introduction, First Edition, Kluwer

Course code	Course Name	L– T - P	C
EEPE18104	**Electricity Regulations and Reforms in India**	**3-0-0**	**3**

Course Outcomes:

CO1: Review the power sector scenario in Indian and global context.
CO2: Understand power sector regulations and need for their restructuring
CO3: Assess different models and salient features of electricity markets in India
CO4: Identify transmission pricing & transmission congestion issues
CO5: Provide recommendation for power sector policy reforms in India

Course content

Power Sector in India

Institutional structure before reforms. Roles of various key entities in India. Necessity of Deregulation or Restructuring. RC Act 1998 and Electricity Act 2003 and its implications for Restructuring & Deregulation. Institutional structure during reform. National Energy policy. Introduction to Energy Exchange and trading of Renewable Energy Credits and Carbon Credits.

Power Sector Regulation

Regulatory process in India, types and methods of Regulation, cost plus, performance-based regulation, price cap, revenue cap regulation, rate of return regulation, benchmarking or yardstick regulation. Role of regulatory commission. Considerations of socio economic aspects in regulation.

Introduction to Power Sector Restructuring

Introduction, models based on energy trading or structural models – monopoly, single buyer, wholesale competition, retail competition. Models based on contractual arrangements – pool model, bilateral dispatch, pool and bilateral trades, multilateral trades, ownership models, ISO models. Competition for the market vs competition in the market, International experience with electricity reform – Latin America, Nordic Pool, UK, USA, China and India. California Energy Crisis

Electricity Markets

Trading – electricity market places, rules that govern electricity markets, peculiarity of electricity as a commodity, various models of trading arrangements – integrated trading model, wheeling trading model, decentralized trading model. Various electricity markets such as spot, day ahead, forward, future options, reserve, ancillary services market. Market operation, settlement process, Market Clearing Price (MCP), Market power, market efficiency. Spot, dynamic and locational pricing.

Transmission Pricing & Transmission Congestion Issues

Cost components of transmission system, Transmission pricing methods. Cost of transmission services, physical transmission rights. Pricing and related issues. Congestion in power network, reasons for congestion, classification of congestion management, useful definitions. Methods of congestion management, Locational marginal Pricing (LMR), Firm Transmission Right (FTR). Availability based Tariff (ABT) in India.

Text Books:

1. Lei Lee Lai, " Power System Restructuring and Deregulation" John Wiley and Sons UK, 2001 2. "Know Your Power:, A citizen Primer on the electricity Sector, Prayas Energy Group, Pune

Reference books:

1. Sally Hunt, "Making Competition Work in Electricity", 2002, John Wiley Inc
2. Steven Stoft, " Power System Economics: Designing Markets for Electricity", John Wiley & Sons, 2002 3. Mohammad Shahidehpour, Muwaffaq Alomoush, "Restructured Electrical Power Systems: Operation Trading and Volatility" CRC Press, 06-Jun-2001.
4. Kankar Bhattacharya, Math Bollen, Jaap E. Daalder, "Operation of Restructured Power Systems" Springer US, 2012.

2ND SEMESTER

Course code	Course Name	L– T - P	C
EECC18201	Alternative Energy Technologies	3-0-0	3

Course Outcomes:

CO1: Discuss the potential of renewable resources for energy production
CO2: Assess renewable energy conversion technologies for power generation

CO3: Analyze technoeconomic feasibility of renewable energy conversion systems
CO4: Evaluate the environmental management opportunities related to alternative energy technologies

Course Content:

Wind Energy: Wind Energy: Basics & Power Analysis, Wind resource assessment, Power Conversion Technologies and applications, Wind Power estimation techniques, Principles of Aerodynamics of wind turbine blade, Various aspects of wind turbine design, Wind Turbine Generators: Induction, Synchronous machine, constant V & F and variable V & F generations, Reactive power compensation. Site Selection, Concept of wind form & project cycle, Cost economics & viability of wind farm.

Hydro Energy: Classification of Hydropower Plants, Overview of micro, mini and small hydro systems; Hydrology; Elements of turbine; Assessment of Hydro Power; Selection and design criteria of turbines; Site selection and civil works; Speed and voltage regulation; Investment issues load management and tariff collection; Distribution and marketing issues: case studies; Potential of hydro power in North East India.

Ocean energy: Ocean energy resources, ocean energy routes. Principle of ocean thermal energy conversion systems, ocean thermal power plants. Principles of ocean wave energy and tidal energy conversion

Geothermal energy: Origin of geothermal resources, types of geothermal energy deposits, site selection, geothermal power plants.

Nuclear energy: Fundamental of nuclear fission and fusion energy, Fundamental of thermonuclear fusion energy and reactor, important characteristics of fusion plasma, advantages of nuclear fusion energy and different challenges, surface conditioning techniques and its importance, Thermonuclear fusion energy, Tokamak, plasma in solar industry, environmental safety with nuclear fusion.

Other new and renewable energy: Hydrogen as a source of energy, fuel cell. Batteries, Capacitors, and Magnetic Energy Storage Magneto hydro-dynamic energy conversion system

Text Books:

1. Kruger P. (2006) Alternative Energy Resources: The Quest for Sustainable Energy, Wiley publication
2. Rosa Aldo V. (2009) Fundamentals of Renewable Energy Processes, Second Edition, Academic Press
3. Boyle G. (2004) Renewable Energy: Power for a Sustainable Future, Second Edition, Oxford University Press
4. Zohuri, Bahman (2017) Magnetic Confinement Fusion Driven Thermonuclear EnergySpringer International Publishing.
5. Harms A A, Kingdon D R, Schoepf K F, Miley G H (2000) Principles of Fusion Energy, World Scientific, 2000.

References:

1. Freris L. L., (1990), Wind Energy Conversion Systems, Prentice Hall.

2. Maheswari R.C., (1997); Bio Energy for Rural Energisation , Concepts Publication
3. Davis S. (2003) Microhydro: Clean Power from Water. New Society Publishers
4. Sarangpani, S. J. A. Kosek and A. B. LaConti(1995) Handbook of Solid State Batteries and Capacitors, World Scientific Publications, NJ, USA.
5. Harris, Peter J. F. (1999) Carbon Nanotubes and Related Structures-New Materials for the Twenty-first Century, Cambridge University Press, UK.
6. Sorensen Bent (2nd Ed. 2000) ; Renewable Energy, Academic press, New York
7. Johansson Thomas B. ed (1993) ; Renewable energy: sources for fuels and electricity, Earthscan Publishers, London.
8. Harvey A. & Brown A. (1993) Micro-Hydro Design Manual: A Guide to Small-Scale Water Power Schemes. Practical Action publication
9. Newman, J. (1991) Electrochemical systems, Prentice Hall, Engelwood Cliffs, NJ,USA.
10. Reich, Stefan, C. Thomsen, and J. Maultzsch(2004) Carbon nanotubes – Basic Concepts and Physical Properties, John Wiley and sons, Canada.

ELECTIVE-II

Course code	Course Name	L– T - P	C
EEPE18201	Environmental Science and Engineering	3-0-0	3

Course Outcomes:

CO1: Analyze the types of ecosystems, biodiversity values, threats to biodiversity, and conservations strategies
CO2: Understand the impact of population growth on environment though different models
CO3: Explain the composition of atmosphere and impart the knowledge of the standards of different environmental pollutions, their mechanism, impact on human and ecosystem and control measures.
CO4: Critically discuss the environmental policies and their salient feature

Course Content:

Introduction: Components of environment; People, Society and environment; Environmental problems and sustainable development.

Resources – Renewable and non-renewable; Water, food and land resources; Energy balance; Simple global temperature model; Albedo.

Population explosion; Mathematics of population growth and its associated problems; Effects of population growth on resources.

Ecology & Biodiversity: Ecosystem; Food chain; Food web: Types of ecosystems; Energy flow; Trophic levels; Position of human beings in the food chain; Environment, flora and fauna: interrelations and interactions; Ecological pyramids; Ecological balance and consequences of change.

Social, ethical and aesthetic values of biodiversity; Biodiversity at the global, national and local levels; India as a mega-diversity nation; Hotspots of biodiversity; Threats to biodiversity; Endangered and endemic species in India; Conservation of biodiversity.

Air pollution: Composition and structure of atmosphere; types and sources of air pollutants; Effects of air pollutants; Accidental pollution; Control of air pollution; Analysis (Monitoring) of air pollutants; Consequences of air pollution; Atmospheric dispersion; Air quality standards.

Water pollution: Pollution of lakes, reservoirs, rivers and groundwater; Speciation; Sources of water pollution; Parameters of water quality; Water treatment systems; Wastewater treatment; Sewage; Water quality standards.

Land pollution: Soil; sources and effects of sol pollution; Solid wastes; Control of soil pollution; Soil degradation; Solid waste management; Recovery and conversion methods.

Noise: Physical properties of sound; Noise criteria; Noise and people; Noise standards; Noise measurement; Noise contours; Noise control.

Environmental legislation (Acts): Various prevention and control acts: Water, air, environment, land, wildlife; The Indian Forest Act, 1980; Issues involved in the enforcement of environmental legislation; ISO-14000 & 14001.

Social issues: Water conservation; Watershed management; Disasters; Nuclear accidents; Human rights; HIV/AIDS; Women and child welfare; role of IT and NGO in protecting environment; Green bench.

Reference books:

1. *Environmental Engineering*, Gerard Kiely; Tata-McGraw Hill publication; Special Indian Edn, 2007.

2. *Air pollution*, M N Rao & H V N Rao, McGraw Hill Education, 43rd reprint, 2013.

Course code	Course Name	L– T - P	C
EEPE18202	**Energy, Ecology and Environment**	**3-0-0**	**3**

Course Outcomes:

CO1: Understand the components and principles of ecology and environment
CO2: Identify the effects of climate change on ecosystem
CO3: Analyze the methods of carbon sequestration
CO4: Assess interactions between energy and environment

Course Content:

Introduction: Components of environment; People, society and environment; Environmental problems and sustainable development.

Resources – renewable and non-renewable; Water, food and land resources; Energy balance; Simple global temperature model; Albedo.

Population explosion; Mathematics of population growth and its associated problems; Effects of population growth on resources.

Ecology: Ecosystem; Food chain; Food web: Types of ecosystems; Energy flow; Trophic levels; Position of human beings in the food chain; Environment, flora and fauna: interrelations and interactions; Ecological pyramids; Ecological balance and consequences

of change

Carbon cycle: Natural systems; autotrops, heterotrops, energy flows, pre-industrial humanity; Photosynthesis – efficiency of natural ecosystems, forests and various crops,; Respiration, combustion and other oxidation processes; Biomethanation

Climate Science: Climate history; Greenhouse gas effect; Causes for generation of greenhouse effect; Anthropogenic climate change; Role of different gases: Global problem; Integrated assessment models; Impacts and adaptation; Uncertainties; Precautionary principle.

Carbon sequestration: Biological pathways; Physico-chemical methods; CO_2 capture from large point sources; Pre-, Post-, and oxy-combustion technology; Transport, storage and monitoring; Feasibility; Economics and public perceptions; Case studies

Legislation and social issues: Environmental legislations (Acts); Various prevention and control acts.

Social issues; Water conservation; Watershed management; Disasters; Nuclear accidents; Human rights; HIV/AIDS; Women and child welfare; role of IT and NGO in protecting environment; Green bench.

Reference books:

1. *Environmental Engineering*, Gerard Kiely; Tata-McGraw Hill publication; Special Indian Edn, 2007.

2.*Air pollution*, M N Rao & H V N Rao, McGraw Hill Education, 43rd reprint, 2013.

Course code	Course Name	L– T - P	C
EEPE18203	**Energy, Environment and Climate Change**	**3-0-0**	**3**

Course Outcomes:

CO1: Understand the evolution of energy technologies and their correlations with the broader issues of materials and manufacturing and their consequent impact on and correlations with the environment.

CO2: Impart knowledge about natural resource, its importance and environmental impacts of human activities on natural resource.

CO3: Distinguish between natural and anthropogenic greenhouse gas emissions and resultant warming.

CO4: Discuss methods that are required for a sustainable future and put them into practice

Course contents:

Energy and Climate Change:

Global Consensus, evidence and predictions and impacts, Clean Energy Technologies, Energ y economy, Role of Renewable Energy,Risk and opportunities; GHGs: GHGs emission and en ergy activities

Dealing with Climate change Consequences:
Emission targets; Measures to reduce GHGs; Climate Change Act; International responses, Kyoto Protocol and CDM, CDM activities in Industries; Emission benchmarks; Greenex

Governments policies for mitigation and adaptation:
Price-based mechanisms such as cap-and-trade and carbon taxes, complementary non-pric e policies, and concepts of justice that frame the political negotiations; Carbon Market; Co mmerce of Carbon Market, Environmental Transformation Fund

Climatic change: The greenhouse gases, Consequences of climate change, Recent developments

Technology Perspective: Strategies for technology innovation and transformation, carbon sequestration, strategic management of carbon emissions

Carbon Trading: The concept of carbon credits, standard and branched credits and mechanisms, alternative trading models, global and Indian scenarios

Text Books:

[1] Stern, N.(2007). The Economics of Climate Change. The Stern Review. Cambridge Univer sity Press, New York.
[2] Barrett,S.(2007). Why Cooperate? The Incentive to Supply Global Public Goods. Oxford U niversity Press, Oxford.
[3] Capoor, K., Ambrosi, P.(2008). State and Trends Of The Carbon Market (2008). The Worl d Bank, Washington D.C.,May 2008. Available at: /http://siteresources. worldbank.org/ NE WS /Resources /State &Trends formatted 06 May10pm.pdf.

ELECTIVE-III

Course code	Course Name	L– T - P	C
EEPE18204	Electrical and Mechanical Energy Utility Systems	3-0-0	3

Course Outcomes

CO1: Review basics of electrical engineering and energy conversion processes
CO2: Understand the principles of electricity generation from various renewable and non-renewable sources
CO3: Analyze performance of electrical and mechanical energy utility systems
CO4: Identify the working principles of instruments used in energy systems

Course Content:

Basics of Electrical Engineering: Fundamentals of Electricity: Concepts of different electrical parameters like voltage, current, frequency, D.C and A.C circuits, Electrical power and energy.

Electrical loads – Resistive, Inductive and Capacitive.

Phasor Notation, Power in A.C. Circuits, Single and Three Phase A.C. Power, Star and Delta connections, Voltage levels.

Transformers, Generators, Alternators etc.

Conversion of Thermal, Chemical, Electromagnetic and Mechanical energy into electricity.

Electrical Energy Sources: Importance of Electrical energy in modern industrial society, Production of electricity using coal, oil, natural gas, nuclear fuels and hydel ,-its relative advantages and disadvantages (i.e. conversion of Thermal, Nuclear, hydel energy into electric energy)

Electricity generation using Renewable Energy Sources: Basic Principles and Applications. (Conversion of Electromagnetic energy and natural energy sources like solar radiation, Wind, Ocean waves, Solid waste etc. to electricity)

Conversion of chemical energy into electrical energy (fuel cell)

Thermal power plant, nuclear power plants and hydroelectric power plant, Transmission and distribution of electricity, Villages electrification program and problems in India.

Electrical and Mechanical Energy Utility Systems: Transmission and Distribution losses, Pilferage, Transformer losses. Electricity tariff, Load management and maximum demand control, power factor improvement and its benefits, Selection and location of capacitors etc.

Conversion of Electrical Energy to Mechanical Energy (Electric Motors).

Electric Motors: Types, Losses in induction motors, motor efficiency, factors affecting motor performance, rewinding and motor replacement issues, Energy efficient motors.

Compressed Air System: Types of air compressors, compressors efficiency, efficient compressors operation, Compressed air system components, capacity assessment, and leakage test, factors affecting the performance.

Fans and blowers: Types, performance evaluation, efficient system operation, flow control strategies.

Pumps and Pumping Systems: Types, performance evaluation, efficient system operation, flow control strategies, variable speed drives.

Cooling Towers: Types and performance evaluation, efficient system operations, flow control strategies, assessment of saving opportunities.

Illumination / Lighting Systems: Light source, choice of lighting, luminance requirements, electronic ballast, occupancy sensors, energy efficient lighting control.

Diesel generating systems: Factors affecting selection, energy performance assessment of diesel conservation avenues.

Energy Audit Instruments: Basic measurements – Electrical measurements, Light, Pressure, Temperature and heat flux, Velocity and Flow rate, Vibrations, etc.

Instruments Used in Energy systems: Load and power factor measuring equipments, Wattmeter, flue gas analysis, Temperature and thermal loss measurements, air quality analysis etc.

Mathematical and statistical modeling and analysis.

Energy Measurement & Verification: Electrical Energy Measurements, Thermal Energy Measurements, Mechanical & Utility System Measurements, Measurement & Verification, M & V Protocol,

Reference Books:

1. Principles of Energy Conversion : A.W. Culp.
2. Direct Energy Conversion : M.A. Kettani
3. Energy Conversion systems :Begamudre, Rakoshdas
4. Direct Energy Conversion :W.R.Corliss
5. Alternative Liquid fuels : B.V. Desai
6. TEDDY year book published by TERI, .
7. The Watt Committee on Energy (Reports)
8. Energy Management Workbook -
9. NIFES Report -Computers in Energy Audits.
10. Efficient Use of Energy :I.E.C.Dryden (Butterworths)
11. Instrument Engineers handbook (VolI,II,III)– B.G. Liptak Chintan Book Comp /CRC Publication
12. Analysis and design of Energy Systems - Hogdeb.K. (Prentice hall 1988)
13. Energy management and control system –Vol-I, II –M.C.Macedo (John Willy)
14. Energy Conservation guide book Patrick/Patrick/Fardo(Prentice hall1993)
15. Handbook on Energy efficiency – .
16. ASHRAEE Energy Use (4 Volumes), 17. CIBSI –guide –Users Manual (U.K.)

Course code	Course Name	L– T - P	C
EEPE18205	**Power Plant Engineering**	**3-0-0**	**3**

Course Outcomes

CO1: Assess the feasibility of power plant installation and power generation
CO2: Analyse performance of thermal power plants
CO3: Understand the working principles of different types of power plants
CO4: Compare performances of different types of power plants
CO5: Interpret fuel combustion performances with respect to power plants

Course Content:

Introduction: Choice of power generation; Load & Load duration curves; Load factor; Diversity factor; Load deviation curve; Load management; Number and size of generating unit; Cost of electrical energy; Tariff-Power factor improvement.

Thermal Power Stations: Types of thermal power plants; elements of thermal power plant: Boiler, superheater, economiser, condenser, combustion chamber, gas loops and turbines etc., Site selection of Steam power plant, Principles of Electric Power station. General lay out. Instrumentation and control

Gas Turbine Power plant: Types, Open and close cycle gas turbines; Components of the plant, Plant lay out, Combined cycle power plant

Fuel and Combustion: Types of fuels (solid, liquid and gaseous), characterization, proximate and ultimate analysis, theory of combustion process, fuel stoichiometry, burner design and furnaces, Advanced Fuels (Clean Coal Technology, Coal Bed Methane, Gas

Hydrates and Shale Gas/Oil etc)

Hydropower Plant: Mass curve and storage capacity; Classification; Components; Turbines- Characteristics and their selection; Governor; Plant layout and design; Auxiliaries; Underground, automatic, remote controlled, and pumped storage plants.

Nuclear Power Plant: Basic principles, Elements of Nuclear power plant, Nuclear reactor and fuels, Hazards due to Nuclear power plants, Nuclear Instrumentation.

Diesel-electric Power Plant: Working principle, Elements of the plant, Starting and stopping; Efficiency and Heat balance; Plant layout.

References:

1. E L Wakil, "Power Plant Engineering", McGraw-hill Book Co, N.Y. 2001
2.Arora and Domkundwar, A course in Power Plant Engineering, Dhanpat Rai, N.Delhi.2003
3. Nag, P.K., "Power Plant Engineering", 2 nd Edition, TMH, 2001
4. Thomas C. Elliott ,"Standard Hand Book of Power Plant Engineering"

Course code	Course Name	L– T - P	C
EEPE18206	**Decentralized Energy System**	**3-0-0**	**3**

Course Outcomes

CO1: Review distributed energy generation systems
CO2: Analyze Wind/PV System modeling for decentralized energy generation
CO3: Explain micro-grid configuration
CO4: Assess the feasibility of decentralized energy systems
CO5: Identify the factors effecting the performance of energy storages systems

Course Content:

Distributed Generation: Reasons for growth, extent of DGs, Issues with DGs, Policy/institutional issues, market/financial issues, social/environmental issues, DG Plant Types, DG Machinery & its control, Integration issues, Technical impacts of DGs, Economic impact of DGs, Impact on transmission and generation systems, Security and reliability. International DG Integration Experience.

• **Wind/PV System Modelling:** Wind/PV variability and uncertainty. Forecasting methods and applications.

• **System studies**: Power flow studies, Fault studies, Stability studies, Transient studies, Inertia and Frequency Response studies. Power Quality Issues.

• **System balancing & imbalance handling:** Flexibility Issues, Ramping issues, Inertia and Frequency Response Issues, Role of storage and DR and related issues, Large scale storage for grid stability / Backup.

• **Technical regulations for the interconnection of DGs to the power systems:** Overview of technical regulations, Active power control, Frequency control, Voltage control, Technical solutions for new interconnection rules. Protection of DGs. Feasibility of integrating Large-Scale Grid Connected DG, Policy, Market and Regulatory Interventions, Regulatory challenges, Viability of DG integration in deregulated electricity market.

• **Economics of DG:** Value of power from DGs, Market value of power from DGs, Loss

reduction, Investment reduction, Connection costs and charges, Distribution use of system charges, Allocation of losses in distribution networks with DG, Alternative framework for distribution tariff development.

• DGs in areas of limited transmission capacity. DGs in distribution networks. Active Management of Distribution systems. Ancillary Services with DGs, Markets for Ancillary Services. DER Management, Virtual Power Plants.

• **Micro Grids:** Concept, Design, Modelling, Operation and Analysis. Role in Energy Reliability, Cold Load Pick Up and Sustainability.

• **Energy Storage**: Type and modelling of storage systems. Scheduling issues, Ancillary services from energy storage, Role in Energy Security, Reliability and Stability.

- **Optimal design tool:**
  Optimal design of hybrid energy systems, energy economics and cost optimization of integrated energy systems; Sample problems and case studies, Simulation tools like H OMER, RETSCREEN etc. renewable energy based Micro-grid

Text Books:

1. Math H. Bollen, Fainan Hassan, "Integration of Distributed Generation in the Power System", WileyIEEE Press, 2011.

2. Willis H. Lee and Scott W. G., "Distributed Power Generation Planning and Evaluation", Marcel Dekker, Inc, New York, 2000.

3.B. Fox, D. Flynn L. Bryans, N. Jenkins, M. O' Malley, R. Watson and D. Milborrow, "Wind Power Integration: Connection and System Operational Aspects" IET, 2007.

4.Loi Lei Lai, Tze Fun Chan, "Distributed Generation: Induction and Permanent Magnet Generators" Wiley-IEEE Press, 2007.

5. Komarnicki, Przemyslaw, Lombardi, Pio, Styczynski, Zbigniew , "Electric Energy Storage Systems", Springer, 2017.

6. Garcia-Valle, Rodrigo, Peças Lopes, João A, "Electric Vehicle Integration into Modern Power Networks", Springer, 2012.

Course code	Course Name	L– T - P	C
EEPE18207	**Instrumentation and Control for Energy Systems**	**3-0-0**	**3**

Course Outcomes

CO1: Review classification and functions of different measuring instruments
CO2: Explain components of control systems
CO3: Analyze monitoring, signal conditioning and control circuits
CO4: Understand the applications of digital electronics in instrumentation and control in energy systems
CO5: Develop micro controller programmes relevant to instruments used in energy systems

Course Content:

Introduction: Overview of instruments and measurement systems: Principles of measurements and methods, Elements of measurements system, Errors in measurement.

Measuring Systems: Classification of instruments, Modes of operation, Functions and applications, Static and Dynamic characteristics; Input output configurations of measuring instruments and measurement system, Primary sensing elements and transducers: Mechanical devices : Types, Pressure, Flow rate sensing elements and their applications; Electric transducers: Types and characteristics, resistive, capacitive, piezoelectric, optoelectronic transducers and their applications; Modern sensors.

Control Systems: Introduction to control systems: Control Systems : Feedback and non-feedback systems, Reduction of parameter variations, Block Diagram of control system, Regenerative feedback; Control systems and components.

Digital Electronics: Introduction to digital Electronics Basics: Number systems, Logic families, Boolean Algebra, Combinational logic designs, Multiplexers and De-multiplexers, Registers Signal conditioning: Operational amplifier types and characteristics, Application circuits inverter, Adder, Substracter, Multiplier and Divider, Analog/digital/analog conversion techniques.

Instrumentation Systems: Data Acquisition Systems: Types of instrumentation systems, components, applications, single channel and multichannel analog to digital and digital to analog converter (0804/0808/0809).

Microprocessors and Microcontrollers: Microprocessors and applications of microcontrollers: Overview of microprocessor, Microcontroller (8951) Architecture and application for monitoring and control of parameter and processes.

Instruments: Typical measuring and control instruments/devices for non-electric quantities: Electronic voltmeter, Digital power analyser, Annemometer, Rotameter, Exhaust gas analyser, 25 automatic Bomb Calorimeter, Zunkers Calorimeter, Pyranometer, Pyrheliometer, Oxidation stability apparatus, Maximum demand controller, Automatic light dimmer and on-off controller.

Text Book:

1. Morris A.S. (1998); Principles of Measurements and Instrumentation, Prentice Hall of India
2. Sawhney A.K. (2011); A Course in Electrical and Electronics Measurements and Instrumentation, Dhanpat Rai

Reference Book:

1. Jain R.P. (1998); Modern Digital Electronics, McGraw Hill
2. Gaonkar R. (2012); Microprocessor Architecture, Programming and Applications with 8085, Penram International Publishing
3. Raman C.S. Sharma G.R. and Mani V.S.V. (1983); Instrumentation Devices and Systems, Tata McGraw Hill
4. Kalsi H.S. (1995); Electronic Instrumentation, Tata McGraw Hill
5. Babu J.C. and Xavier S.E. (2004); Principles of Control Systems, S. Chand and Co. Lt.

Course code	Course Name	L– T - P	C
EEPE18208	Power Generation and System Planning	3-0-0	3

Course Outcomes

CO1: Understand principles of power generation planning
CO2: Analyze business models for power industry
CO3: Design advanced models for power transmission and distribution

Course Content:

Modeling of Power System Components

The need for modeling of power system, different areas of power system analysis. Models of non-electrical components like boiler, steam & hydro-turbine & governor system. Transformer modeling such as auto-transformer, tap-changing & phase shifting transformer.

System Planning

Introduction, Objectives & Factors affecting to System Planning , Short Term Planning, Medium Term Planning, Long Term Planning, Reactive Power Planning.

Load Forecasting

Introduction, Factors affecting Load Forecasting, Load Growth Characteristics, Classification of Load and Its Characteristics, Load Forecasting Methods (i) Extrapolation (ii) Co-Relation Techniques, Energy Forecasting, Peak Load Forecasting, Reactive Load Forecasting, NonWeather Forecasting, Weather Forecasting, Annual Forecasting, Monthly Forecasting, Total Forecasting.

Generation Planning

Objectives & Factors affecting Generation Planning, Generation Sources, Generation System Model, Loss of Load (Calculation and Approaches), Outage Rate, Capacity Expansion, Scheduled Outage, Loss of Energy, Evaluation Methods. Interconnected System, Factors Affecting Interconnection under Emergency Assistance.

Transmission Planning

Introduction, Objectives of Transmission Planning, Network Reconfiguration, System and Load Point Indices, Data required for Composite System Reliability.

Distribution Planning

Radial Networks - Introduction, Network Reconfiguration, Evaluation Techniques, Interruption Indices, Effects of Lateral Distribution Protection, Effects of Disconnects, Effects of Protection Failure, Effects of Transferring Loads, Distribution Reliability Indices. Parallel & Meshed Networks - Introduction, Basic Evaluation Techniques, Bus Bar Failure, Scheduled Maintenance, Temporary and Transient Failure, Weather Effects, Breaker Failure.

Text Books:

1. Modern Power System Planning - X. Wang & J.R. McDonald, McGraw Hill Book Company
2. Power System Planning - R.N. Sullivan, Tata McGraw Hill Publishing Company Ltd.

References:

1. Electrical Power Distribution Engineering - T. Gonen, McGraw Hill Book Company
2. Reliability Evaluation of Power System - Roy Billinton & Ronald N. Allan, Springer Publication
3. Generation of Electrical Energy - B.R. Gupta, S. Chand Publications
4. Electrical Power Distribution A.S. Pabla Tata McGraw Hill Publishing Company Ltd.
5.Electricity Economics & Planning - T.W.Berrie, Peter Peregrinus Ltd., London

Course code	Course Name	L– T - P	C
EEPE18209	**Energy Conservation and Waste Heat Recovery**	**3-0-0**	**3**

Course Outcomes

CO1: Understand different approach for waste heat recovery
CO2: Design strategies for enhancing performance of energy systems using waste heat recovery techniques
CO3: Analyze energy conservation, management and planning of industrial processes incorporating waste heat recovery

Course Content:

Principle of energy conservation: Introduction; Quality of energy; Importance of exergy analysis; Available Energy referred to a cycle; Availability in a finite process; Available Energy from a finite energy source; Demonstration of quality of energy based on exergy; Exergy balance for closed and open system; Tools for exergy analysis

Recovery of Waste Heat: Introduction; Methods of utilization of waste heat; Total energy approach; Combined plant; GT-ST power plant; MHD-Steam power plant; Thermionic Generation; Thermoelectric generators

Performance criteria for CHP: Energy Utilization factor, Fuel Energy saving ratio, Rational efficiency, Rational criteria

Waste heat recovery through Heat Exchanger: Sources of waste heat recovery, Potential application of waste heat, Essential consideration in making optional choice of waste heat recovery device, Waste heat recovery system, Some concepts on Heat exchanger, Classification of waste heat recovery exchangers, Gas to Gas waste heat recovery, Spiral plate heat exchanger, Heat wheels/Rotary regenerator, Storage type of Regenerative Heat Exchanger, Rothemuhle Regenerator, Pebble bed heat exchanger, Plate heat exchanger, Shell and tube heat exchanger, Metallic Radiative recuperators, Run around coil

Gas to Liquid Heat Recovery: Introduction, Classification of WHRB

Waste Heat Recovery Devices: Introduction, Thermal conductivity of a heat pipe, Characteristics of a heat pipe, Application of heat pipe, Limitation of Heat Pipe, pressure drop analysis for 1-D incompressible flow in a heat pipe, Condition for flow in a heat pipe, Working fluid, Desirable properties of Working fluid, Factor responsible for performance of

heat pipe, Construction material, wick material, Rating of Heat pipe
Heat pump : Introduction, Working fluid, Heat pipe size, Type of Heat Pumps, Different type of heat pump
Heat recovery from incineration plant : Introduction, Classification of incinerator
Organic Rankine Cycle : Introduction, Daimler Benz Organic Rankine cycle
Energy Storage: Introduction, Energy Management, Energy Storage system, Pumped hydro energy storage system, Compressed air energy storage, Energy Storage by Fly wheels, Electrical Battery storage system, Super Conducting Magnetic Energy storage, Thermal energy Storage, Pressurized Water thermal sensible energy storage system, Latent Heat Energy Storage, Chemical Reaction Storage, Storage in Chemical reaction
Energy Economics: Pay Back period, Return of Investment Method, Straight line depreciation, Reducing Balance depreciation, Sinking fund depreciation

References:

1. Proceedings of CD Programme, QIP by P. Mahanta, Associate Professor Dept. of ME, IITG.
2. K. Annamalai and I.K. Puri , Advanced Thermodynamics Engineering, CRC Press, 2002.
3. A Bejan, Advance Engineering Thermodynamics, John Wiley, New York, 1988.
4. P.K. Nag, Power Plant Engineering 2nd Edition, Tata Mc Graw Hill Publishing Company Limited, New Delhi 2007.
5. G Wall, Exergy – A useful concept, Physical Resource Theory Group, Goteborg , 3rd Edition, 1986.
6. M.M. El-Wakil, Power Plant Technology, Mc-Graw Hill, 1985.

Course code	Course Name	L– T - P	C
EEPE18210	**Project Management**	**3-0-0**	**3**

Course Outcomes

CO1: Recognize issues in a realistic project scenario.
CO2: Employ work breakdown structures (WBS) in a project application.
CO3: Demonstrate the use of appropriate network scheduling techniques.
CO4: Analyze the project planning activities that will predict project costs, time schedule, and quality.

Course Content:

Unit I : Introduction – Concept of Project – Characteristics and classification – aspect of project : Project identification – selection criteria and feasibility analysis. Project Formulation – Steps – Planning and Evaluation.

Unit II : Project appraisal : Concept and scope – stages in project appraisal – appraisal criteria and Methodology.

Unit III : Financial analysis and Project Finance : significance of Financial analysis ;

Financial Tools – preparation of fund flow statement, Cash flow measurement ; ratio analysis – Advantages and limitations – Break-Even analysis. Project Financing – Sources.

Unit IV : Analysis of Project Networks -- PERT and CPM -- Network representation – Rules to setup Networks – Analysis. Structuring of PERT Data – Arrow diagram, Work break down structure.

Unit V : Project Monitoring and control Aspects ; Project Management under risk and uncertainty – using computer for project management. Towards better project management – Bottlenecks and remedies

REFERENCES

1. Shtub, Bard and Globerson, Project Management: Engineering, Technology, and Implementation, PH Inc.
2. Lock, Gower, Project Management Handbook.
3. Cleland and King, VNR Project Management Handbook.
4. Wiest and Levy, Management guide to PERT/CPM, PHI.
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.
7. P. K. Joy, Total Project Management: The Indian Context, Macmillan India Ltd

ELECTIVE-IV

Course code	Course Name	L– T - P	C
EEPE18211	**Fuel & Combustion Technology**	**3-0-0**	**3**

Course Outcomes

CO1: Identify the characteristics of solid, liquid and gaseous fuels
CO2: Understand the importance of advanced fuels and their properties
CO3: Analyse the performance of combustion processes
CO4: Assess the design and efficiency of combustion devices
CO5: Examine the emission characteristics in combustion systems

Course Content:

Solid Fuels: Coal: Family, origin, classification of coal; Analysis and properties; Action of heat on coal; Gasification; Oxidation; Hydrogenation and liquefaction of coal- Efficient use of solid fuels-Manufactured fuels-Agro fuels- Solid fuel handling- Properties related to combustion - handling and storage

Liquid and Gaseous Fuels: Origin and classification of petroleum; Refining; Properties & testing of petroleum products; various petroleum products; Petroleum refining in India; Liquid fuels from other sources; Storage and handling of liquid fuels. Types of gaseous fuels: natural gases, methane from coal mines, manufactured gases, producer gas, water gas, biogas, refinery gas, LPG; Cleaning and purification of gaseous fuels.

Advanced Fuels: Clean Coal Technology, Coal Bed Methane, Gas Hydrates and Shale Gas/Oil

Theory of Combustion Process: Ignition: Concept, auto ignition, ignition temperature; Burners: Stoichiometry and thermodynamics; Combustion stoichiometry: Methods of combustion - Combustion thermodynamics.

Fuel stoichiometry and analysis: Fuel stoichiometry relations; Estimation of air required for complete combustion; Estimation of minimum amount of air required for a fuel of known composition; Estimation of dry flue gases for known fuel composition; Calculation of the composition of fuel & excess air supplied, from exhaust gas analysis; Dew point of products; Flue gas analysis (O2, CO2, CO, NOx, SOx).

Burner Design and Furnaces: Fluidized bed combustion process; Burners: Propagation, various methods of flame stabilization; Basic features and design of burners for solid, liquid, and gaseous fuels; Furnaces: Industrial furnaces, process furnaces, batch & continuous furnaces; Advantages of ceramic coating; Heat source; Distributions of heat source in furnaces; Blast furnace; Open hearth furnace, Kilns; Pot & crucible furnaces; Waste heat recovery in furnaces: Recuperates and regenerators; Furnace insulation; Furnace heat balance computations; Efficiency considerations.

References:

1. Liquid Fuels for Internal Combustion Engines: A Practical Treatise for Engineers & Chemists, by Harold Moore, ISBN: 9781146203067, Publisher: Nabu Press, 2008.
2. Gas and Oil Engines, and Gas-Producers: A Treatise on the Modern Development of the Internal Combustion Motor and Efficient Methods of Fuel Economy, Lionel Simeon Marks, Nabu Press, 2007.
3. Blokh A.G, Heat Transmission in Steam Boiler furnaces, Hemisphere Publishing Corpn., 1988.
4. S.P. Sharma &Chander Mohan, Fuels & Combustion, Tata McGraw Hill Publishing Co.Ltd.,1984. E
5. J. D. Gilchrist , Fuels, Furnaces & Refractories, Pergamon Press.

Course code	Course Name	L– T - P	C
EEPE18212	Energy Generation from Waste	3-0-0	3

Course Outcomes

CO1: Understand solid wastes generated from different sources and due to human activities
CO2: Identify appropriate technology for conversion of solid waste to energy
CO3: Design waste management strategies for simultaneous energy generation and value addition
CO4: Assess feasibility of different waste to energy conversion processes

Course Content:

Solid Waste Sources: Solid Waste Sources, types, composition, Properties, Municipal Solid Waste: Physical, chemical and biological properties , Waste Collection and, Transfer stations, Waste minimization and recycling of municipal waste, Segregation of waste, Size

Reduction , Managing Waste, Status of technologies for generation of Energy from Waste

Waste Treatment and Disposal: Aerobic composting, incineration, Furnace type and design, Medical waste /Pharmaceutical waste treatment Technologies, incineration, Environmental impacts, Measures to mitigate environmental effects due to incineration

Land Fill method of Solid waste disposal: Land fill classification, Types, methods and Sitting consideration, Layout and preliminary design of landfills: Composition, characteristics, generation, Movement and control of landfill leachate and gases, Environmental monitoring system for land fill gases

Energy Generation from Waste: Bio-chemical Conversion: Sources of energy generation, Anaerobic digestion of sewage and municipal wastes, Direct combustion of MSW-refuse derived solid fuel, Industrial waste, agro residues, Anaerobic Digestion: Biogas production, Land fill gas generation and utilization, Thermo-chemical conversion: Sources of energy generation, Gasification of waste using Gasifiers , Briquetting, Utilization and advantages of briquetting , Case studies of Commercial Waste to Energy Plants , Present status ,[National and International] of Technologies for Conversion of Waste into Energy, Design of Waste to Energy Plants for Cities, small Townships and Villages

Environmental benefits of Bio-chemical and Thermo-chemical conversion: Basics of Bio-chemical and Thermochemical conversion and its environmental benefits

Plasma pyrolysis: Plasma pyrolysis process for waste disposal and energy conversion, advantages of pyrolysis process for waste disposal, description of plasma pyrolysis reactor

Text Books/References:

1. C Parker and T Roberts (Ed), Energy from Waste - An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985

2. KL Shah, Basics of Solid and Hazardous Waste Management Technology, Prentice Hall, 2000

3. M Datta, Waste Disposal in Engineered Landfills, Narosa Publishing House, 1997

4. G Rich et.al, Hazardous Waste Management Technology, Podvan Publishers, 1987 5. AD Bhide, BB Sundaresan, Solid Waste Management in Developing Countries, INSDOC, New Delhi,1983

5. Naomi B Klinghoffer and Marco J Castaldi,"Waste to Energy Conversion Technology" Woodhead Publishing, 2018.

6. Lisa Branchini, "Waste-to-Energy: Advanced Cycles and New Design Concepts for Efficient Power Plants"**,** Springer, 2015.

7. P. Basu, "Biomass Gasification and Pyrolysis: Practical Design and Theory", Academic Press, 2010.

8. Gary C. Young, "Municipal Solid Waste to Energy Conversion Processes: Economic, Technical, and Renewable Comparisons", Wiley, 2010.

Course code	Course Name	L– T - P	C

EEPE18213	Alternative Fuels for IC Engine	3-0-0	3

Course Outcomes

CO1: Review working principle of Internal Combustion (IC) Engine
CO2: Assess the combustion performance and emission characteristics of IC engine for alternative fuel
CO3: Analyze fuel quality of biofuels on the basis of their physicochemical properties
CO4: Develop sustainable alternative fuels for automobile and power generation applications

Course Content:

Introduction: IC engine: classification, operating principles and their applications
Cycles: Ideal and actual cycles of IC engine operations. Assessment of engine performance: efficiencies, bsfc, exhaust emission. Systems and their components (CI, SI, 2-stroke and 4str oke): fuel supply, lubrication cooling, intake and exhaust, combustion and power transmission
FuelCharacteristics:
Introduction to fuel characterization and Standards. Characteristics of alternate fuels (biodi esel, ethanol, biogas, producer gas, hydrogen)
Alternative Fuels for Automobile: Alternate fuels for automobile: technological issues in connection with handling and storage, delivery, combus tion, emission & pollution, corrosion
Alternative Fuels for Power Generation: Alternative fuels for electrical power generation: technological issues in connection with handling and storage, delivery, combustion, emission & pollution, corrosion

Text Books

1. Heywood, J., Internal Combustion Engine Fundamentals, McGraw Hill Publication

Reference:

1. Ferguseaon, Internal Combustion Engines, John Wiley & Sons, 1986.
2. Ganesan, V., Internal Combustion Engines, Tata McGraw Hill, New Delhi, 2001.
3. ASTM and EN standards for Alternate Fuel Characteristics, 2007

Course code	Course Name	L– T - P	C
EEPE18214	Energy Storage System	3-0-0	3

Course Outcomes

CO1: Understand the concept of different forms of energy storage
CO2: Analyze energy storage potential of advanced materials and systems
CO3: Design sustainable solutions for energy storage applications
CO4: Compare the performance and production costs of different energy storage **solutions**

Course Content:

Introduction: Energy Demand and Storage, Different types of energy storage; Mechanical, Chemical, Biological, Magnetic, Comparison of Energy Storage technologies

Thermal Storage: Thermal energy storage: Principles and applications, Sensible and Latent heat, Phase Change Materials; Energy and Exergy analysis of thermal energy storage, solar energy and thermal energy storage, case studies

Mechanical and Electrical Storage: Flywheel and compressed air storage; Pumped hydro storage; Hydrogen energy storage, Capacitor and super capacitor, Electrical double layer Capacitor: Principles, performance and applications

Other Storage Types: Hydrogen as energy carrier and storage; Hydrogen resources and production; Basic principle of direct energy conversion using fuel cells; Thermodynamics of fuel cells; Fuel cell types: AFC, PAFC, PEMFC, MCFC, SOFC, Microbial Fuel cell; Fuel cell performance, characterization and modeling; Fuel cell system design and technology, application for power and transportation

Battery: Battery: fundamentals and technologies, characteristics and performance comparison: Leadacid, Nickel-Metal hydride, Lithium Ion; Battery system model, emerging trends in batteries

Applications: Application of Energy Storage: Food preservation, Waste heat recovery, Solar energy storage: Greenhouse heating; Drying and heating for process industries.

Text Book:

1. Huggins R. (2010); Energy Storage, Springer

2. Ter-Gazarian A. (2011); Energy Storage for Power System, Second Edition, The Institution of Engineering and Technology

Reference Book:

1. O'Hayre R. Cha S. Colella W. and Prinz F.B. (2009); Fuel Cell Fundamentals, Second Edition, Wiley

2. Narayan R. and Viswanathan B. (1998); Chemical and Electrochemical Energy System, Universities Press

3. Dincer I. and Rosen M.A. (2010), Thermal Energy Storage: System and Applications, Second Edition, Wiley

4. Rahn C.D. and Wang C. (2013); Battery Systems Engineering, First Edition, Wiley

Course code	Course Name	L– T - P	C
EEPE18215	**Energy Efficient Building**	**3-0-0**	**3**

Course Outcomes

CO1: Review the principles of energy conservation opportunities in buildings
CO2: Analyze thermal comfort of buildings based on engineering principles
CO3: Design feasible solution for thermal energy management in building
CO4: Assess thermal performance of building architecture and building materials

Course Content:

Introduction: Energy management concept in building, Energy auditing in buildings

Climatic Aspects: Classification of climate zones, Bioclimatic classification of India; Climate analysis for Nat-Vent Buildings, Mixed Mode Buildings and conditioned buildings; Passive

design concept for various climatic zones; Integrations of landscape to building design; Urban Heat Island, Case studies on typical design of selected buildings in various zones

Architecture: Vernacular architecture: Vernacular architecture in Indian context, factors which shape the architecture, Building material and construction techniques; Case studies on vernacular architecture of Rajasthan, Northeast India; Low cost buildings, alternate building materials, climate responsive buildings

Energy Efficient Building: Energy efficient buildings, Green buildings, Intelligent buildings, Building integrated photovoltaics (BIPV), Building codes and rating systems: LEED, GRIHA, ECBC, Thermal properties and Energy content of building materials

Simulations: Building energy simulations, Tool like TRNSYS etc, building management systems/automation, Artificial and Day lighting in buildings

Energy Conservation Techniques: Energy conservation techniques in Air Conditioning Systems; Estimation of building loads, passive and low energy concepts and applications, 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; Design of efficient day lighting systems

Green Buildings: Green buildings – definition and attributes; Genesis of green buildings; Design aspects of green building, Economic aspects of green buildings, Energy and environmental management; Green buildings in India; Case studies.

Text Book:

1. Sodha M.S. Bansal N.K. Bansal P.K. Kumar A. and Malik M.A.S. (1986); Solar Passive Building, Science and Design, Pergamon Press
2. Gallo C. Sala M. and Saying A.A.M. (1988); Architecture: Comfort and Energy, Elsevier Science

Reference Book:

1. Nayak J.K. and Prajapati J.A. (2006); Handbook on Energy Conscious Buildings; Solar Energy Centre, New Delhi
2. Underwood C.P. and Yik F.W.H. (2004); Modelling Methods for Energy in Buildings, Blackwell Publishing
3. Parsons K.C. (2003); Human Thermal Environments, Second Edition, Taylor and Francis
4. Majumder M. (2009); Energy Efficient Buildings, TERI, New Delhi

Course code	Course Name	L– T - P	C
EEPE18216	Renewable Energy Grid Integration	3-0-0	3

Course Outcomes

CO1: Review the operation of grid integrated power system
CO2: Analyze features of power generation from renewable energy grid system
CO3: Assess power quality and stability in grid integrated renewable energy based system

Course Content:

Power system operation:

Introduction on electric grid, Supply guarantees, power quality and Stability, Introduction t o renewable energy grid integration, concept of mini/micro grids and smart grids;

Renewable energy grid system:

Wind, Solar, Biomass power generation profiles, generation electric features, Load scheduling Introduction to basic analysis and operation techniques on power ele ctronic systems; Functional analysis of power converters, Power conversion schemes between electric machines and the grid, Power systems control using power converters; E lectronic conversion systems application to renewable energy generation systems, Basic s chemes and functional advantages; Wind Power and Photovoltaic Power applications.

Power control and management systems for grid integration,

island detection systems, synchronizing with the grid; Issues in integration of convert er based sources; Network voltage management; Power quality management and Freque ncy management; Influence of PV/WECS on system transient response Simulation tools, Simulation of grid connected/off grid renewable energy system (PV/WECS); Design of grid -interactive photovoltaic systems for house hold applications.

Text Books

[1] Kersting W. H. (2004); Distribution System Modeling and Analysis, Second Edition, CRC Press [2] Vittal V. and Ayyanar R. (2012); Grid Integration and Dynamic Impact of Wind Energy, Springer

Reference Books

[1] Bollen M. H. and Hassan F. (2011); Integration of Distributed Generation in the Power System, Wiley-IEEE Press

[2] Keyhani A. (2011); Design of Smart Power Grid Renewable Energy Systems, Wiley–IEEE Press

[3] Muhannad H. R. (2004); Power Electronics: Circuits, Devices and Applications, Pearson Prentice Hall

[4] Gellings C. W. (2009); The Smart Grid: Enabling Energy Efficiency and Demand Response, First Edition, CRC Press

Course code	Course Name	L– T - P	C
EEPE18217	**Energy Audit and Management**	**3-0-0**	**3**

Course Outcomes:

CO1: Understand and apply the concept of energy management and energy management opportunities

CO2: Identify energy auditing methodologies for preparing a sample energy audit report (walk through and detailed)

CO3: Evaluate performance and efficiency of machines, devices, industrial equipments and systems

CO4: Assess energy conservation opportunities in households, MSMEs and large scale industries

Course Content:

Introduction: Definition and objective, Need & Scope for Energy Audit

Electrical Energy Management: Conservation in motors, pumps and fan systems; energy efficient motors.

Thermal Energy Management: Energy conservation in boilers, steam turbines and industrial heating systems;; Cogeneration and waste heat recovery; Thermal insulation; Heat exchangers and heat pumps; Building Energy Management.

Energy Audit Methodology: Need for energy audit, Type of energy audit, Ten step methodology for detailed energy audit, Pre audit phase activities, Detailed energy audit activities

Identification of Energy Conservation Opportunities: Fuel substitution, Energy generation, Energy distribution, Energy uses by processes, Technical and economical feasibility, Sample worksheet for economic feasibility, Classification of Energy Conservation Measures

Energy Audit Reporting Format: Report on detailed energy audit, Content, Energy Costs, Bench marking, & energy performance, Matching energy uses to requirement, Maximizing system efficiency

Energy Audit Instruments: Key Instruments for Energy Audit : Electrical Measuring Instrument, Combustion analyser, Fuel efficiency monitor, Fyrite, Contact thermometer, Infrared Thermometer, Pitot Tube and Manometer, Water flow meter, Speed measurements, Leak detector, Lux meters

References:

1. CB Smith, Energy Management Principles, Pergamon Press, NewYork, 1981
2. P. O'Callaghan: Energy Management, McGraw - Hill Book Company, 1993.
3. Y P Abbi and Shashank Jain. Handbook on Energy Audit and Environment Management, TERI Publications, 2006
4. NPC Energy Audit manual and report
5. Energy management handbook, John Wiley and Sons – Wayne C. Turner
6. Guide to energy management, Cape Hart, Turner and Kennedy
7. Cleaner production – Energy Efficiency Manual for GERIAP, UNEP, Bangkok prepared by National Production Council.

Course code	Course Name	L– T - P	C
EEPE18218	Vacuum Technology	3-0-0	3

Course Outcomes

CO1: Review the basic principle of vacuum generation
CO2: Understand the factors effecting vacuum generation in different systems
CO3: Analyze performance of vacuum generating devices and systems

Course Content:

Basic: Fundamental of vacuum, different ranges of vacuum, vacuum application: Freeze drying, food processing industry, lamp industry, vacuum metallurgy, vacuum impregnation
Gas Flow: Elementary Gas Transport Phenomenon, Viscous, molecular and Transition flow regimes, gas throughput, conductance, mass flow, pumping speed; Gas release from Solids: outgassing, Vaporization, thermal desorption, virtual leaks, permeation, vacuum baking
Production of Vacuum: Mechanical pumps (Rotary, roots and Turbomolecular pumps), Diffusion pump, Getter and Ion pumps, Cryopumps, Pump Fluids; Materials in Vacuum: Vaporization, out-gassing, glasses and Ceramics. Joints, Seals and Components, Gaskets and Motion feed through.
Measurement of Pressure: McLeod gauge, thermal conductivity gauges, spin rotor gauge, diaphragm/capacitance gauges manometer, Ionization gauges, hot cathode, cold cathode gauges; Flow Meters and Residual Gas Analyzer, Leak Detection.
Significance of Low Temperature: Properties of engineering materials at low temperatures; Cryogenic Fluids: Hydrogen, Helium 3, Helium 4, Superfluidity; Liquifaction of Gases; Helium Liquifaction system, Heat leak considerations, Cryogenic insulation, Cryogenics Vessels, Cryogenic level sensors.

Text Books/Reference:

1. Vacuum Technology", 1983, A. Roth, Pergamon Press (Oxford).
2. "Basic Vacuum Technology," 1998, A Chambers, R K Fitch & B S Halliday, Int. of Phys. Publishing, (Bristol & Philedelphia).
3. "Vacuum Technology and Applications, "1991, David J. Hucknall, Butterworth-Heinemann (Oxford).
4. "Low-temperature physics: an introduction for scientists and engineers, "1992, P V E McClintock, D J Meredith and J K Wigmore, Blackie (Glasgow).
5. "Experimental techniques in condensed matter physics at low temperatures," 1988, Robert C Richardson and Eric N Smith, Addison-Wesley (CA).
6. "Matter at Low Temperatures," 1984, P V E McClintock, D J Meredith, and J K Wigmore, Blackie & Son (Glasgow).

Laboratory Courses

Course code	Course Name	L– T - P	C
EELC18201	**Energy Lab-III**	**0-0-4**	**2**

Course Outcomes:

CO1: Understand the Ansys CFD software
CO2: Demonstrate modelling and simulation of pin fin heat exchanger
CO3: Demonstrate modelling and simulation of wind turbine

Course Content:

Computational Fluid Dynamics (CFD) Lab

Major Experimental Analysis: modeling and simulation of heat exchangers, wind turbine and other energy conversion systems and equipments with CFD software.

Course code	Course Name	L– T - P	C
EELC18202	Energy Lab-IV	0-0-4	2

Course Outcomes:

CO1: Operate and control the steps in biodiesel production from different sources.
CO2: Analyze the performance of CRDI VCR engine using different biodiesel
CO3: Interpret the experimental results for different parameters of solar thermal systems

Course Content:

Renewable Energy Lab-II

Major Experiments:

Bioenergy: characterization of biodiesel, evaluate the performance of the CRDI VCR engine with diesel and biodiesel.

Solar: Evaluate the performance of different solar thermal devices and systems

New Experiments will be included from time to time

MINI PROJECT

Course code	Course Name	L– T - P	C
EEMP18201	Factory/Industry/Site Visit	0-0-4	1

Course Outcomes:

CO1: Understand the industrial process and working principles of various components
CO2: Assess the impact of energy related and environmental factors due to the industrial process
CO3: Analyze performance of different equipments, devices, systems and processes of the factory/industry/site from techno-economic aspect
CO4: Interact with industrial personnel and follow engineering practices and discipline prescribed in industry

Suggested Activities

To understand the importance of energy in various industrial applications, the learners will visit a relevant factory/industry/site. During this visit, the student should learn about the operation of different equipments, devices, systems and processes of the factory/industry/site. The practices adopted by the factory or industry for management of energy based and environmental issues are also to be learnt by the students. After completion of the visit/study, the students shall submit a report in prescribed format.

Course code	Course Name	L– T - P	C
EEMP18201	Studies with Community	0-0-4	1

Course Outcomes:

CO1: Understand the interaction of energy and environmental issues with socio-economic factors through community engagement
CO2: Assess the impact of energy related and environmental factors on livelihood of a community or locality.
CO3: Explore possibilities for sustainable development by ensuring energy and environmental managements in a locality/ community/ enterprises/industry
CO4: Learn how to work effectively as an individual and team member among communities and other diverse settings

Suggested Activities

- The learners will first select a broad thematic area of study through field visit and community engagement individually or in groups (maximum three students per group). Some of the suggestive thematic areas of study, but not limited to, may be: study on energy consumption pattern of a particular locality/community/enterprise/industry, study on ecosystem sustainability, environmental protection and management, renewable energy generation potential, energy conversion technologies, economics related to energy and ecosystem services; assessment of renewable resources etc. The selection of the topic should be completed by second month of the semester.
- The student will then prepare the work plan including: objectives of study, locality or area of study, schedule of visit, method of analysis, expected outcomes, etc. The proposed plan of work to be submitted (by mid-term) by a power point presentation
- The Execution part of the study shall include (but not limited to): data collection and interpretation, assessment of results, conclusions and recommendations. The study shall be conducted by taking into consideration the present practices and requirements of the locally/community/enterprise/industry.
- After completion of the study, a viva-voce examination with power point presentation will be held. A report on the study shall be submitted by the students in prescribed format (by end-term).

3RD SEMESTER

ELECTIVE-V

Course code	Course Name	L– T - P	C
EEPE18301	**Fuel Cells and Hydrogen Energy**	**3-0-0**	**3**

Course Outcomes

CO1: Identify different methods of hydrogen production and storage
CO2: Understand working principle of fuel cell
CO3: Identify suitable components for design of fuel cell systems

CO4: Compare performance of different types of fuel cell
CO5: Design and Fabricate fuel cell system considering its techno-economic feasibility study

Course Content:

Fuel Cell Basics: Fuel cell definition, Difference between batteries and fuel cells, fuel cell history, components of fuel cells, principle of working of fuel cells Fuel cell thermodynamics - second law analysis of fuel cells, efficiency of fuel cells fuel cell electrochemistry - Nernst equation, Electrochemical kinetics, Butler-Volmer equation

Fuel cell classification and performance: Classification by operating temperature/electrolyte type, Fuel Cell Performance, Activation, Ohmic and Concentration over potential

Fuel cell design and components: Cell components, stack components, system components Overview of intermediate/high temperature fuel cells - Solid oxide fuel cells (SOFC), Molten carbonate fuel cells (MCFC), Phosphoric acid fuel cells (PAFC) Polymer Electrolyte fuel cells ,Heat and mass transfer in polymer electrolyte fuel cells, water management in PEFCs, Current issues in PEFCs, Direct methanol fuel cells (DMFC) - Electrochemical kinetics methanol oxidation, Current issues in MFCs, Fuel crossover in DMFCs, Water management in DMFCs, high methanol concentration operation, limiting current density

Hydrogen Energy: Production of hydrogen from fossil fuels, electrolysis, thermal decomposition, photochemical and photo-catalytic methods

Hydrogen production methods: Production of hydrogen from fossil fuels, electrolysis, thermal decomposition, photochemical and photo-catalytic methods

Hydrogen storage methods: Metal hydrides, metallic alloy hydrides, carbon nano-tubes, sea as source of deuterium

Text Books/Reference:

1. J Larminie and A Dicks, Fuel Cell Systems Explained, 2nd Edition, Wiley,2003
2. Xianguo Li, Principles of Fuel Cells, Taylor and Francis, 2005
3. S Srinivasan, Fuel Cells: From Fundamentals to Applications, Springer €
4. O'Hayre, SW Cha, W Colella and FB Prinz, Fuel Cell Fundamentals, Wiley, 2005
5. A Faghri and Y Zhang, Transport Phenomena in Multiphase Systems, Elsevier 2006

Course code	Course Name	L– T - P	C
EEPE18302	Hydro Power Management	3-0-0	3

Course Outcomes

CO1: Review the basics of hydro power generation
CO2: Understand working principle of different components of hydroelectic power plant
CO3: Assess the reliability and environmental impact of hydro power projects
CO4: Develop a roadmap for hydro power management in global and Indian context

Course Content:

Basic Hydro Power Concepts: History of Hydro Power development , Importance of Hydro energy in the National Economy, Hydro Power Concepts , World and, Indian Hydro

Energy Potential , Calculation of Hydro energy Potential of a Water Source , Hydro Power R & D Centres/ Institutions, Component Manufacturing Industry at International and National level

Water Mills: Designs of Traditional Water Mills Worldwide , Improved Water Mills : Turbines 1-5KW, , Relevance for hilly regions, Design considerations of a Water Mill System , MNRE Scheme, Present Status of Improved Water Mills

Hydro Power Plants: Design considerations of a Hydro Energy Power Plant ,Components of hydroelectric power plant, Various types of Turbines, hydro potential and exploitation in India, Micro hydal Power Projects , Major hydroelectric Power Plants in India, Hydro power projects in Western Himalayas, Environmental Impact of Large Hydro power Projects, Case studies

Economics, Policy, Organization, Regulations: Economic and financial assessments, planning process, Economics of hydro policies and initiatives of Government for promotion of hydropower, organizations involved in hydropower development, Financing of hydropower projects, Legal issues, , Implications of hydropower development from privatization, Sustainable use of natural resources and its implications on project economy, Implications on project development from Environmental Impact Assessment [EIA processes, Design, cost estimates and cost benefit analysis, Economic risk- and sensitivity analyses, corporate social responsibility

Text Books/References:

1. G Brown, Hydro Electric Engineering: Vol. I, II, III

2. Nigam, A Hand Book of Hydro Electric Engineering, Nem Chand.

3. B Honningsvåg, Hydropower in the New Millennium, Proceedings of the 4th International Conference on Hydropower Development, Hydropower '01, Bergen, Norway, Taylor and Francis, 20-22 June 2001

4. F Koester, Hydroelectric Developments and Engineering: A Practical and Theoretical Treatise on the Development, Design, Construction, Equipment and Operation of Hydroelectric Transmission Plants, D. Van Nostrand Co.,Original from the New York Public Library, 1909

5. BR Gupta, Generation Electrical Energy, S. Chand & Co.

Course code	Course Name	L– T - P	C
EEPE18303	**Advanced Solar Thermal and PV**	**3-0-0**	**3**

Course Outcomes

CO1: Review the basic principles of solar energy utilization
CO2: Discuss the materials and components used in solar thermal and PV systems
CO3: Design solar thermal systems for different applications
CO4: Evaluate performances of solar thermal and PV systems
CO5: Design feasible projects on solar PV and solar thermal plant installation and maintenance

Course Content:

Solar Radiation: Solar Constant, Global, Beam and Diffuse radiation, Hourly, Daily and Seasonal variation of solar radiation, Sun-earth angles, Instruments for measurement of solar radiation

Photo thermal systems: Flat-Plate Collectors, Solar Concentrators, Solar water heating systems, solar dryers, solar distillation, Solar space heating and cooling systems

Photovoltaic systems: Fundamentals of Semiconductor and Solar Cells, Generation of Solar Cell (Photovoltaic) Materials, Photovoltaic (PV) Module and PV Array, Photovoltaic Thermal (PVT) Systems, Degradation of Solar Cell Materials

Design and modeling of solar energy systems: F-chart method, φ -F Chart method, Utilizability modelling & simulation of solar energy systems

Economic analysis of solar energy systems: Life-Cycle Cost Analysis, Net Present Value (NPV), Analytical Expression for Payout Time, Benefit–Cost Analysis

Text Book:

1. SP Sukhatme, Solar Energy: Principles of Thermal Collection and Storage, Tata McGraw-Hill,1984
2. JA Duffie and WA Beckman, Solar Engineering of Thermal Processes, John Wiley, 1991

Reference:

1. GN Tiwari, Arvind Tiwari, Shyam : Handbook of Solar Energy – Springer
2. Garg HP, J Prakash, Solar Energy: Fundamentals and Applications, Tata McGraw Hill, New Delhi, 1997
3. DY Goswami, F Kreith and JF Kreider, Principles of Solar Engineering,Taylor and Francis
4. GN Tiwari, S Suneja, Solar Thermal Engineering System, Narosa Publishing House, New Delhi, 1997

Course code	Course Name	L– T - P	C
EEPE18304	**Wind Power Technology**	**3-0-0**	**3**

Course Outcomes

CO1: Review the basic principles of wind power generation
CO2: Discuss the materials and components used in wind power tecvhnology
CO3: Evaluate performances of wind energy conversion systems
CO4: Assess the design and environmental safety aspects of wind power plant installation

Course Content:

Wind Energy Basics: Global circulation, Forces influencing Wind - Pressure gradient force and Coriolis force, Local and Regional Wind systems, Atmospheric Boundary Layer, Atmospheric Stability, Surface Wind, Characteristic variables of wind and other related atmospheric parameters, Wind Data

Power extracted from wind – stream tube model, linear momentum theory, power coefficient, Betz limit. Extreme winds calculation of theoretical power developed by the

wind turbine

Wind Energy Atlas: Use of Wind Energy Data, Wind Speed Statistics, Weibull, Rayleigh and Normal distributions, Topographic Maps, Wind data of India

Measurement and Instrumentation: Concept of Measurement System, Anemometers, Wind sensing systems, Recording systems, Global Positioning System,

Wind Turbines: Types, Rotor elements, Horizontal and vertical axis wind turbines, slip stream theory. Calculation of axial thrust and efficiency, Pitch and stall regulation, Lift and drag coefficients, thrust and torque calculations, Tip losses, Characteristics of horizontal axis wind turbines and power curve. Concepts of blade design, Wind pumps. Matching of pump and turbine characteristics

Wind Turbine Siting: Basic approaches to Siting, Siting in homogeneous terrain and complex terrain

Wind Power farm Design: On land and offshore micro siting, Wind turbine energy production and Capacity Factor

Environment Safety: General Principles, guidelines and acceptable limits, Noise and Electro Magnetic Interference due to wind mills

Text Books /References:

1. Meteorological Aspects of the Utilization of Wind as an Energy Source, Technical Note No 175, World Meteorological Organization

2. EH Lysen, Introduction to Wind Energy, CWD Report 82-1, Consultancy Services Wind Energy Developing Countries, May 1983

3. T Burton, Handbook of Wind Energy, John Wiley and Sons

4. GL Johnson, Wind Energy Systems, Printice Hall Inc, New Jersy, 1985

5. www.windpower.dk

6. EH Lysen, Introduction to Wind Energy, CWD Report 82-1, Consultancy Services Wind Energy Developing Countries, May 1983

7. E Hau, Wind Turbines- Fundamentals: Technologies, Application, Economics, Springer - Verlag Berlin -Heidelbeg, 2000

8. DNV- Riso Guidelines for Design of Wind Turbines, 2nd Edition, RisoNationalLaboratory, Denmark, 2002

9. Hansen, Martin, O, L, Aerodynamics of Wind Turbine, James and James (Science Publishers) Ltd, London 2000

Course code	Course Name	L– T - P	C
EEPE18305	**Solar Thermal Technology**	**3-0-0**	**3**

Course Outcomes

CO1: Review the basic principles of solar energy utilization

CO2: Identify advanced methods of solar thermal energy storage

CO3: Analyze the performances of solar thermal systems specially designed for domestic level and small scale applications

CO4: Assess the techno-economic feasibility and environmental impacts of industrial processes incorporating solar thermal conversion technology

Course Content:

Overview of Solar thermal Energy Research Technology, and Industry: Introduction, Basics of solar thermal energy, application in industry and research

Flat-plate Collectors: Liquid Flat Collector, Materials for Flat plate Collectors , Energy balance for Flat Plate Collectors, Overall Heat Loss Coefficient , heat transfer between Parallel surfaces , Heat capacity effect, Testing methods, Types of Flat Plate Collectors: Liquid Flat Plate Collectors, Air flat-plate Collectors-Thermal analysis, Evacuated tubular collectors. Design of solar heating system

Solar Thermal Energy Storage: Solar Energy Storage, Sensible storage, Latent heat storage, Thermo-chemical storage, Design of storage system

Concentrating Collector Designs: Classification, design and performance parameters, tracking systems, Compound parabolic concentrators, parabolic trough concentrators, Concentrators with point focus, Heliostats

Vapor absorption Refrigeration cycle: Water, ammonia and lithium bromide-water absorption refrigeration systems, Solar operated refrigeration systems, solar desiccant cooling, Current Status of Solar cooling

Industrial Applications of Solar Heat: Temperature requirements, consumption pattern, Solar Passive Heating and Cooling, Solar Thermal Power Plant, Modeling of Solar Thermal Systems, Solar Desalination, Solar Drying, Solar Cooking, Solar Greenhouse technology: Fundamentals, design, modeling and applications in agriculture and space heating

Design of Solar Heating System: Design and Sizing of Solar Heating Systems f – chart method and utilizability methods of solar thermal system evaluation

Introduction to Solar Energy Soft wares: Introduction and Applications

Texts Books/References:

1. SP Sukhatme, Solar Energy: Principles of Thermal Collection and Storage, Tata McGraw-Hill,1984
2. JA Duffie and WA Beckman, Solar Engineering of Thermal Processes, John Wiley, 1991
3. B Sorensen, Renewable Energy, (2nd Ed), Academic press, New York, 2000
4. Garg HP, J Prakash, Solar Energy: Fundamentals and Applications, Tata McGraw Hill, New Delhi, 1997
5. DY Goswami, F Kreith and JF Kreider, Principles of Solar Engineering,Taylor and Francis
6. GN Tiwari, S Suneja, Solar Thermal Engineering System, Narosa Publishing House, New Delhi, 1997

Course code	Course Name	L– T - P	C
EEPE18306	Bioenergy Technology	3-0-0	3

Course Outcomes

CO1: Expand the understanding on modern bioenergy and advanced biofuels: raw materials, conversion technologies and applications
CO2: Identify suitable biomass waste and bio-resource for biofuel production
CO3: Design sustainable bio-refinery concept for conversion of locally available biomass to bioenergy and value-added products
CO4: Analyze the technoeconomic feasibility and life cycle assessment of biofuels

Course Content:

Bioenergy Status: Bioenergy Resources, World Bioenergy Potential, India's Bioenergy Potential, Current Technology and Research Status

Thermo-chemical conversions: Direct Combustion, Technology of Biomass gasification, Pyrolysis and Liquefaction, Bio- Chemical Conversion: anaerobic digestion, alcohol production from biomass, Chemical conversion process: hydrolysis and hydrogenation

Energy Efficient Wood Stoves: Traditional Stoves , Energy Efficient Cooking and Space heating Stoves, Metal Stoves Improved Gasifier Stoves , Current Research Status, Pollution due to smoke emissions

Biogas Technology: Technology of Biogas production, Biogas Plants , Digester types, Digester design, Chemical kinetics and mathematical modeling of bio- methanation process, Dung, Vegetable Waste and Night Soil and Municipal Waste based Biogas plants, Bio gas as fuel for transportation ,Lighting , Running Dual Fuel Engines, Electricity generation, Bio gas Bottling Plant Technology, Application of Bio gas slurry in agriculture , Design of Biogas for cold climates

Biomass Gasifiers: History , Principle , Design of Bio mass Gasifiers , updraft gasifier, down draft gasifier, zero carbon biomass gasification plants, Gasification of plastic-rich waste, applications for cooking, electricity generation, Gasifier Engines, Operation of spark ignition and compression ignition engine with wood gas, methanol, ethanol and biogas, Biomass integrated gasification/combined cycles systems

Environmental Policy Issues related to Bioenergy Technologies: Environmental policy on Bio-Energy technology and environmental impact analysis

Text Books /References:

1. KC Khandelwal, SS Mahdi, Biogas Technology - A Practical Handbook, Tata McGraw Hill, 1986
2. RC Maheswari, Bio Energy for Rural Energisation , Concepts Publication, 1997
3. J Twidelland T Weir, Renewable Energy Resources, Taylor and Francis (Ed), New York, USA, 2006
4. B Sorensen, Renewable Energy,2nd Ed, Academic press, New York, 2000
5. G Boyle (Ed), Renewable energy: Power for a sustainable future, Oxford, OUP, 1996
6. Thomas B Johansson et.al, (Ed), Renewable energy: Sources for Fuels and electricity, Earthscan Publishers, London, 1993
7. S Silveira , Bioenergy - Realizing The Potential ELSEVIER, 2005
8. DD Hall and RP Grover, Biomass Regenerable Energy, John Wiley, New York, 1987

9. AS Pietro, Biochemical and Photosynthetic aspects of Energy Production, Academic Press, New York, 1980

Course code	Course Name	L– T - P	C
EEPE18307	Solar Photovoltaic Technology	3-0-0	3

Course Outcomes

CO1: Review the current trends in solar photovoltaic technology
CO2: Develop solar cells for solar photovoltaic applications
CO3: Assess performance of solar photovoltaic systems
CO4: Analyze quality of different components of centralized and decentralized solar photovoltaic systems
CO5: Design feasible projects on solar PV power plant installation and maintenance

Course Content:

Overview of Solar PV Research, Technology and Industry: Basics of solar PV technology, Its application to research and industry

Solar Cells: Conversion of Solar energy into Electricity - Photovoltaic Effect, Equivalent Circuit of the Solar Cell, Analysis of PV Cells: Dark and illumination characteristics, Figure of merits of solar cell, Efficiency limits, Variation of efficiency with bandgap and temperature, Efficiency measurements, High efficiency cells, Recent developments in Solar Cells, Role of nano-technology in Solar cells

Fabrication Technology for Solar Cells: High efficiency multi-junction solar cell, Quantum well solar cell, Technology for the fabrication of thin film cells, Optical concentration, Effect of temperature on Cell performance, Thermo photovoltaic effect

Solar Photovoltaic System Design: Solar cell array system analysis and performance prediction, Shadow analysis: Reliability, Solar cell array design concepts, PV system design, Design process and optimization: Detailed array design, Voltage regulation, Maximum tracking, Quick sizing method, Array protection

Solar Photo Voltaic System Testing: Sun Simulator, Testing and performance assessment of Solar PV generator, Electronic Control and Regulation, Power Conditioning, Converters and inverter, Concentrating system, System design and configuration

SPV Power Systems: Centralized and decentralized SPV systems, Stand alone, hybrid and, grid connected system, System installation, Operation and Maintenance, Application of PV for lighting, Water pumping. Refrigeration, Telecommunication, Cathodic Protection etc., Solar PV Power Plant Status-Case Studies, Hybridization Engineering, Hybrid systems, Grid integration. Building Integrated PV Systems, PV market analysis and Economics of SPV systems

Text Books/ References:

1. AL Fahrenbruch and RH Bube, Fundamentals of Solar Cells: PV Solar Energy Conversion, Academic Press, New York, 1983
2. T Bhattacharya, Terrestrial Solar Photovoltaic, Narosa Publishers Ltd, New Delhi LD

Partain (ed), Solar Cells and their Applications, John Wiley and Sons, Inc, New York, 1995
3. RH Bube, Photovoltaic Materials, Imperial College Press, 1998
4. HS Rauschenbach, Solar Cell Array Design Handbook, Van Nostrand Reinfold Company, New York, 1980
5. R Messenger and J Vnetre, Photovoltaic Systems Engineering, CRC Press Stand Alone PV Systems: A Handbook of Recommended Design Practices, Report No SAND 87-7023, Sandia National Lab USA 6. F Kreith and JF Kreider, Principles of Solar Engineering, McGraw-Hill (1978) 7. J Twidell and T Weir, Renewable Energy Resources, Taylor and Francis (Ed), New York, USA, 2006

Course code	Course Name	L– T - P	C
EEPE18308	**Petroleum Production & Refining**	**3-0-0**	**3**

Course Outcomes

CO1: Understand the prerequisites for petroleum exploration
CO2: Review modern techniques involved in petroleum production
CO3: Identify appropriate technologies and processes for refining of crude oil
CO4: Analyse petroleum refining processes from the aspects of energy and resource conservation
CO5: Assess the conversion efficiency of petroleum refinery

Course Content:

Upstream Operations:

Introduction: Origin, migration, and accumulation of oil and gas fields.
Methods of Petroleum Exploration: Geological, geophysical, geochemical, and hydrogeologi cal surveys. Classification of Traps: Structural, stratigraphic, and combination traps.
Drilling of Oil & gas Wells: Different methods, directional and horizontal drilling, offshore dr illing, drilling complications, formation evaluation. Drilling Fluids: Composition; Propertiesand types; Well completion methods
Reservoir Engineering: Consideration of different reservoir parameters for exploration, d evelopment, and exploitation of petroleum; Reservoir fluid characteristics; Gas reservoir.
Driving Mechanisms : Depletion drive, gas cap drive, water drive, combination drive; Gra vity drainage.
Gathering, Processing and Transportation: Surface gathering systems; Gas processing; L iquid processing; Transportation of oil and gas
Downstream Operations: Primary processing of crude oil: Classification of crude oil, Atmospheric distillation .Vacuum distillation of residue-products and distillation practice.
Secondary processing of crude oil:FCCU, Hydro cracking, Visbreaking, Thermal cracking. Coking, Reforming, Alkylation, Polymerization and Isomerisation process.
Treatment-techniques: Treatment techniques for removal of objectionable gases. Odours, to improve performance, .Storage stability. Extraction of aromatics, Olefins and recovery operations from petroleum products.

Text Books:

1. Mian, M. A., (1st ed., 1992); Petroleum Engineering Handbook of Practicing Engineer, P ennwell.
2. Speight James G., ed (1998), Petroleum Chemistry and Refining, Taylor & Francis, Was -hington

References:

1. Berger, Bill D. and Kenneth E. Anderson, (3rd ed., 1992); Modern Petroleum a Basic Pri mer of Industry, Pennwell,
2. Mitra, A K, (1987); Drilling Operation Manual, Institute of Drilling Technology, ONGC

Course code	Course Name	L– T - P	C
EEPE18309	Industrial Plasma Technology	3-0-0	3

Course Outcomes

CO1: Understand the basic principles of plasma technology
CO2: Review different techniques for plasma generation
CO3: Assess the effectiveness and performance of plasma based technologies in various industrial applications
CO4: Analyze the prospects and challenges of plasma pyrolysis process for solid waste management

Course Content:

Basics: Fundamental of plasma physics, important characteristics of plasma, Existence of Plasma in space and earth, different types of plasma, plasma sheath, LTE and non-LTE plasma
Gas discharge techniques: Direct current (d.c.) glow discharge, Capacitively coupled (cc)radio-frequency (rf) discharge, Pulsed glow discharge, Dielectric barrier discharge (DBD), Corona discharge, Magnetron discharge, Inductively coupled discharge, Filamentary discharge, Microwave induced discharge, plasma jet, Electron cyclotron resonance source and Helicon source.
Diagnostic techniques: Langmuir probe technique, Emissive probe, Double probe and optical emission spectroscopy- Corona, CR and LTE model.
Industrial application: plasma coating (sputtering and plasma spray coating), Nitriding, ion implementation, Cutting industry, plasma medicine, plasma in nanotechnology, plasma in solar industry, Food technology, plasma agriculture, fusion reactor, Tokamak,
Solid waste management: Overview of solid waste management, Techniques for solid waste disposal, Fundamental of plasma pyrolysis technique, Advantage of plasma pyrolysis, Reactor design, Waste to energy conversion through pyrolysis process.

Text Books/References:

1. "A User's Guide to Vacuum Technology, 3rd Edition" J. F. O'Hanlon, John Wiley and Sons, Inc., 2003.
2. "Plasma Etching: An Introduction" Edited by D. M. Manos and D. L. Flamm, Academic Press, Inc., 1989.

3. "Plasma engineering applications from aerospace to bio- and nanotechnology." By M. Keidar and I. Beilis Academic Press, Waltham, MA, 2013. (ISBN: 9780123859785.)
4. "Introduction to Plasma Technology" J. E. Harry, Wiley-VCH Verlag GmbH & Co. KGaA, 2010. (Available online at Library.)
5. J. R. Roth, Industrial Plasma engineering, Vol. 1, IoP, Bristol, 1995.
6. J. R. Roth, Industrial Plasma engineering, Vol. 2 IoP, Bristol, 2001.
7. F F Chen "Introduction to plasma physics and controlled fusion. Volume 1, Springer, 2nd Edition", 2010.
8. G. Schmidt, Physics of High Temperature Plasmas. 2nd Edition Burlington, MA: Academic Press (1979).
9. L. Spitzer, Jr. Physics of Fully Ionized Gases. 2nd ed. New York, Interscience ~ John Wiley (1962).

Course code	Course Name	L– T - P	C
EEPE18310	**Nuclear Energy Engineering**	**3-0-0**	**3**

Course Outcomes

CO1: Describe nuclear fission, nuclear fusion, and radioactive decay
CO2: Identify fuels and materials for nuclear reactors
CO3: Understand design aspects of nuclear fission and nuclear fusion power plants
CO4: Analyze the performance of nuclear reactors
CO5: Assess the environmental safety issues related to nuclear power plants

Course Content

Basics: Fundamentals of nuclear fission and nuclear fusion, Basic properties of the nucleus and n-p scattering cross section, Nuclear reactions, Binding energy and nuclear stability, Q value

Nuclear fission reactor: Fundamental of nuclear fission reactor, Principles of the conversion of nuclear energy to useful power - conversion principles, cycles and load-following characteristics, various types of nuclear fission power plants, Advanced future types of nuclear power plants. Reactor designs of fission reactor based power plants, Economics of nuclear vs. other types of power plants.

Reactor's materials: selection of fuel and cladding, corrosion, pressure vessel materials. Pressure Vessel: stress calculations, materials selection/thicknesses, ASIvIE codes. Safety: Safety design principles, Safety in operation, temperature and void coefficients, emergency cooling, hazards considerations. Thermal limits on reactor performance, thermal converters, and fast breeders.

Nuclear fusion reactor: Fundamental of thermonuclear fusion energy and reactor, important characteristics of fusion plasma, Tokamak, advantages of nuclear fusion energy and different challenges, surface conditioning techniques and its importance, plasma confinement, Heating mechanisms, Basics of ITER, Critical design criteria of ITER, Q value.

Environmental aspects: sustainability, proliferation, safety. Compare and contrast the relative merits of different types of power plant.

Text Book/References:

1. Kenneth S. Krane, Introductory Nuclear Physics. Hoboken: John Wiley & Sons, Inc. (1987).
2. Walter E. Meyerhof, Elements of Nuclear Physics. New York: McGraw-Hill, (1967).
3. Richard T. Lahey and Frederick J. Moody, The Thermal-Hydraulics of Boiling Water Reactors, 2nd Edition, American Nuclear Society (1993).
4. Edited by O.C. Jones, Nuclear Reactor Safety Heat Transfer, Hemisphere Pub (1981).
5. John R. Lamarsh and Anthony J. Baratta, Introduction to Nuclear Engineering, 314 Edition, Prentice Hall (2001).
6. M. M. El-Wakil, Nuclear Energy Conversion, American Nuclear Society; Revised edition (1982).
7. G. Schmidt, Physics of High Temperature Plasmas. 2nd Edition Burlington, MA: Academic Press (1979).
8. L. Spitzer, Jr. Physics of Fully Ionized Gases. 2nd ed. New York, Inter science, John Wiley (1962).

Course code	Course Name	L– T - P	C
EEPE1311	**Hybrid Renewable Energy Systems Design**	**3-0-0**	**3**

Course Outcomes

CO1: Identify possibilities for integration of renewable energy technologies and related systems
CO2: Design flexible energy storage hybrid systems incorporating renewable energy technologies
CO3: Analyze enhancement in system performance after integration of renewable energy systems
CO4: Assess technoeconomic feasibility of hybrid energy conversion system

Course Content

Introduction to Hybrid Energy System: Definition, Need for Hybrid Energy System, Hybrid System as Source of Renewable Energy, Benefits and Risk Issues.

Hybrid Renewable Energy System: Current Status of Research on Configurations of different hybrid renewable energy system (Wind + solar PV, Solar PV + fuel cells, Biomass + solar CSP, Biodiesel + wind, Gas + solar CSP, Coal + solar CSP and Geothermal + solar PV), Control and Sizing Methodologies, Techno economic feasibility analysis of different combination.

Grid Connected Wind & Solar Energy Conversion Systems Grid connectors:

Connection issues, Wind farm and its accessories, Grid related problems, Generator control, Performance improvements, Different schemes, Power converters for Grid connected, Wind Energy Conversion System and Grid connected Solar Energy Converter systems, Hybrid Systems, Types of Cogeneration processes.

Hybrid system based power generation for rural electrification: Demand Assessment, Resource Assessment, Barriers/Constraints, Power reliability analysis, Unit Sizing Optimization using tool such as HOMER, HOGA, and RESTSCREEN.

Energy storages for hybrid systems:

Overview of electrical energy storage technologies, Mechanical storage systems: pumped hydro storage (PHS), flywheel energy storage (FES), compressed air energy storage (CAES) and gravity energy storage systems (GES); Electostatic and magnetic energy storage systems: super capacitor energy storage (SCES) and super conducting magnetic energy storage (SMES); Thermal energy storage (tes) systems, Chemical energy storage (ces) systems.

Text Book:

1. Mukherjee D., Fundamental of Renewable Energy System, New Age International, 2004

2. Huggins, R., Energy Storage: Fundamentals, Materials and Applications, Springer, 2010.

OPEN ELECTIVES

Course code	Course Name	L– T - P	C
EE0E18-01	**Business Analytics**	**3-0-0**	**3**

Course Outcomes:

CO1: Understand and critically apply the concepts and methods of business analytics
CO2: Identify, model and solve decision problems in different settings
CO3: Interpret results/solutions and identify appropriate courses of action for a given managerial situation whether a problem or an opportunity
CO4: Create viable solutions to decision making problems

Course Content:

Business Analysis: Overview of Business Analysis, Overview of Requirements, Role of the Business Analyst. Stakeholders: the project team, management, and the front line, Handling Stakeholder Conflicts

Life Cycles: Systems Development Life Cycles, Project Life Cycles, Product Life Cycles, Requirement Life Cycles.

Forming Requirements: Overview of Requirements, Attributes of Good Requirements, Types of Requirements, Requirement Sources, Gathering Requirements from Stakeholders, Common Requirements Documents.

Transforming Requirements: Stakeholder Needs Analysis, Decomposition Analysis, Additive/Subtractive Analysis, Gap Analysis, Notations (UML & BPMN), Flowcharts, Swim Lane Flowcharts, Entity-Relationship Diagrams, State-Transition Diagrams, Data Flow Diagrams, Use Case Modeling, Business Process Modeling

Finalizing Requirements: Presenting Requirements, Socializing Requirements and Gaining Acceptance, Prioritizing Requirements. Managing Requirements Assets: Change Control, Requirements Tools

Recent Trands in: Embedded and colleborative business intelligence, Visual data recovery, Data Storytelling and Data Journalism.

References:

1. Business Analysis by James Cadle et al.
2. Project Management: The Managerial Process by Erik Larson and, Clifford Gray

Course code	Course Name	L– T - P	C
EE0E18-02	**Industrial Safety**	**3-0-0**	**3**

Course Outcomes:

CO1: Analyze the effect of release of toxic substances
CO2: Understand the industrial laws, regulations and source models.
CO3: Apply the methods of prevention of fire and explosions.
CO4: Understand the relief and its sizing methods.
CO5: Understand the methods of hazard identification and preventive measures.

Course Content:

Industrial safety:

Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

Fundamentals of maintenance engineering:

Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

Wear and Corrosion and their prevention:

Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

Fault tracing:

Fault tracing-concept and importance, decision treeconcept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic,automotive, thermal and electrical equipment's like,

I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

Periodic and preventive maintenance:

Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

Reference:

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3.Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

Course code	Course Name	L– T - P	C
EE0E18-03	Operations Research	3-0-0	3

Course Outcomes:

CO1: Formulate a linear programming problem for given problem and solve this problem by using Simplex techniques.
CO2: Evaluate sensitivity analysis to the given input data in order to know sensitive of the output.
CO3: Apply the concept of non-linear programming for solving the problems involving non-linear constraints and objectives.
CO4: Solve deterministic and Probabilistic inventory control models for known and unknown demand of the items.
CO5: Apply the dynamic programming to solve problems of discrete and continuous variables.

Course Content:

Unit 1: Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

Unit 2 : Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

Unit 3: Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

Unit 4: Scheduling and sequencing - single server and multiple server models -

deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

Unit 5 Competitive Models,Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

References:

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

Course code	Course Name	L– T - P	C
EE0E18-04	**Cost Management of Engineering Projects**	**3-0-0**	**3**

Course Outcomes:

CO1: Understand the concepts strategic cost management process.
CO2: Apply cost concepts in decision-making and cost management projects.
CO3: Implement various stages of project execution with a team project.
CO4: Analyze various decision-making problems.
CO5: Evaluate different qualitative techniques and cost behavior.

Course Content:

Unit I: Introduction and Overview of the Strategic Cost Management Process

Unit II: Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Unit III: Project-meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process.

Unit IV: Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets;

Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Unit V: Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

References:

1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2. Charles T. Horngren and George Foster, Advanced Management Accounting
3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
4. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
5. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

Course code	Course Name	L– T - P	C
EE0E18-05	**Composite Materials**	**3-0-0**	**3**

Course Outcomes:

CO1: Explain the advantages and applications of composite materials.
CO2: Describe the properties of various reinforcements of composite materials.
CO3: Summarize the manufacture of metal matrix, ceramic matrix and C-C composites.
CO4: Describe the manufacture of polymer matrix composites.
CO5: Formulate the failure theories of composite materials.

Course Content:

UNIT–I:

INTRODUCTION: Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT – II:

REINFORCEMENTS: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

UNIT – III:

Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

UNIT–IV:

Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and

prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

UNIT – V: S

trength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

TEXT BOOKS:

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

References:

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

Course code	Course Name	L– T - P	C
EE0E18-06	**Waste to Energy**	**3-0-0**	**3**

Course Outcomes:

CO1: Understand of the concept of Waste to Energy.
CO2: Identify the link of legal, technical and management principles for production of energy form waste.
CO3: Provide knowledge about the best available technologies for waste to energy.

Course Contents:

Unit-I:

Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

Unit-II:

Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

Unit-III:

Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

Unit-IV:

Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

Unit-V:

Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

References:

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

Dissertation Course

Course code	Course Name	L– T - P	C
EED18P-I	**Dissertation Phase – I**	**0-0-20**	**10**

The students will select a topic and prepare a plan of research. A seminar & viva-voce will be held to assess his progress at the end of the semester. The student will also have to submit the plan of research and progress report. Progress of the student is to be evaluated in regular interval during the semester by the supervisor and the department committee.

Course Outcomes:

CO1: Identify a research area for new and useful knowledge in the field of energy
CO2: Review previous literature and identify research gaps in the field of energy
CO3: Formulate objectives and design methodology for the proposed work
CO4: Conduct experimental/computational (including simulation based)/ field survey analysis related to the work
CO5: Prepare a progress report on the topic of research work

4TH SEMESTER

Dissertation Course

Course code	Course Name	L– T - P	C
EED18P-II	Dissertation Phase – II	0-0-32	16

Progress of the student is to be evaluated in regular interval during the semester by the supervisor and the department committee. A seminar & viva-voce will be held to assess his performance at the end of the semester. The student will have to submit his final thesis for partial fulfillment of his degree. The thesis and viva-voce will be evaluated by a committee consisting of external supervisor(s) and the concerned departmental committee.

Course Outcomes:

CO1: Demonstrate in-depth of knowledge through experimental investigations/ design fabrication/ field works activities.
CO2: Analyze, validate, and interpret the results of the research work
CO3: Prepare final thesis and publish articles for disseminating the research findings with academic community and society at large
CO4: Identify future research prospects on the area of work

AUDIT COURSES 1 & 2

Course code	Course Name	C
MAC202111	English for Research Paper Writing	0

Course Objectives:

1: Understand that how to improve your writing skills and level of readability
2: Learn about what to write in each section
3: Understand the skills needed when writing a Title
4: Ensure the good quality of paper at very first-time submission

Course Contents:

Units	CONTENTS	Hours
1	Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness	4
2	Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction	4
3	Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.	4

4	key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature,	4
5	skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions	4
6	Useful phrases, how to ensure paper is as good as it could possibly be the first-time submission	4

Suggested Studies:

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book .
4. Adrian Wallwork, English for Writing Research Papers, Springer NewYork Dordrecht Heidelberg London, 2011

Course code	Course Name	C
MAC202112	**Disaster Management**	**0**

Course Objectives:

1: Learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response

2: Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives

3: Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations

4: Critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries They work in

Course Contents:

Units	CONTENTS	Hours
1	**Introduction** Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.	4
2	**Repercussions Of Disasters And Hazards**: Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.	4

3	**Disaster Prone Areas In India** Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics	4
4	**Disaster Preparedness And Management** Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.	4
5	**Risk Assessment** Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And	4
	National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival.	
6	**Disaster Mitigation** Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India.	4

SUGGESTED READINGS:

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company.
2. Sahni, Pardeep Et.Al. (Eds.)," Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi.
3. Goel S.L., Disaster Administration And Management Text And Case Studies", Deep & Deep Publication Pvt. Ltd., New Delhi.

Course code	Course Name	C
MAC202113	**Sanskrit for Technical Knowledge**	**0**

Course Objectives:

1: To get a working knowledge in illustrious Sanskrit, the scientific language in the world
2: Learning of Sanskrit to improve brain functioning
3: Learning of Sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power
4: The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature

Course Outcomes:

CO1: Understand basic Sanskrit language
CO2: Understand Ancient Sanskrit literature about science & technology
CO3: Develop logic in students, since being a logical language

Course Contents:

Unit	*Content*	*Hours*

1	• Alphabets in Sanskrit, • Past/Present/Future Tense, • Simple Sentences	8
2	• Order • Introduction of roots • Technical information about Sanskrit Literature	8
3	• Technical concepts of Engineering- Electrical, Mechanical, Architecture, Mathematics	8

Suggested reading

1. "Abhyaspustakam"– Dr.Vishwas, Samskrita-Bharti Publication, NewDelhi
2. "Teach Yourself Sanskrit" Prathama Deeksha- Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi.

Course code	Course Name	C
MAC202114	**Value Education**	**0**

Course Objectives:

1: Understand value of education and self-development
2: Imbibe good values in students
3: Let the student should know about the importance of character

Course Outcomes:

CO1: Knowledge of self-development
CO2: Learn the importance of Human values
CO3: Developing the overall personality

Course Contents:

Unit	*Content*	*Hours*
1	• Values and self-development–Social values and individual attitudes. Work ethics, Indian vision of humanism. • Moral and non-moral valuation. Standards and principles. • Value judgements	4
2	• Importance of cultivation of values. • Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. • Honesty, Humanity. Power of faith, National Unity. • Patriotism. Love for nature, Discipline	6

3	• Personality and Behavior Development- Soul and Scientific attitude. Positive Thinking. Integrity and discipline. • Punctuality, Love and Kindness. • Avoid fault Thinking. • Free from anger, Dignity of labour. • Universal brotherhood and religious tolerance. • True friendship. • Happiness Vs suffering, love for truth. • Aware of self – destructive habits. • Association and Cooperation. • Doing best for saving nature	6
4	• Character and Competence – Holy books vs Blind faith. • Self-management and Good health. • Science of reincarnation. • Equality, Nonviolence, Humility, Role of Women. • All religions and same message. • Mind your Mind, Self-control. • Honesty, Studying effectively	6

Suggested reading

1 Chakroborty, S.K. "Values and Ethics for organizations Theory and practice", Oxford University Press, New Delhi

Course code	Course Name	C
MAC202115	Constitution of India	0

Course Objectives:

1: Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective

2: To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism

3: To address the role of socialism in India after the commencement of the Bolshevik Revolution in1917and its impact on the initial drafting of the Indian Constitution

Course Outcomes:

CO1: Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics

CO2: Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India

CO3: Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution

CO4: Discuss the passage of the Hindu Code Bill of 1956

Course Contents:

Units	Content	Hours
1	• **History of Making of the Indian Constitution:** History Drafting Committee, (Composition & Working)	4
2	• **Philosophy of the Indian Constitution:** Preamble Salient Features	4
3	• **Contours of Constitutional Rights &Duties:** • Fundamental Rights • Right to Equality • Right to Freedom • Right against Exploitation • Right to Freedom of Religion • Cultural and Educational Rights • Right to Constitutional Remedies • Directive Principles of State Policy • Fundamental Duties.	4
4	• **Organs of Governance:** • Parliament • Composition • Qualifications and Disqualifications • Powers and Functions • Executive • President • Governor • Council of Ministers • Judiciary, Appointment and Transfer of Judges, Qualifications • Powers and Functions	4
5	• **Local Administration:** • District's Administration head: Role and Importance, • Municipalities: Introduction, Mayor and role of Elected Representative CEO of Municipal Corporation. • Pachayatiraj: Introduction, PRI: Zila Pachayat. • Elected officials and their roles, CEO Zila Pachayat: Position and role. • Block level: Organizational Hierarchy (Different departments), • Village level: Role of Elected and Appointed officials, • Importance of grass root democracy	4
6	• **Election Commission:** • Election Commission: Role and Functioning. • Chief Election Commissioner and Election Commissioners. • State Election Commission: Role and Functioning. • Institute and Bodies for the welfare of SC/ST/OBC and women.	4

Suggested reading

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S.N. Busi, Dr. B.R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M.P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

Course code	Course Name	C
MAC202116	Pedagogy Studies	0

Course Objectives:

1: Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers

2: Identify critical evidence gaps to guide the development

Course Outcomes:

CO1: What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?

CO2: What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?

CO3: How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

Course Contents:

Units	Content	Hours
1	• **Introduction and Methodology:** • Aims and rationale, Policy background, Conceptual framework and terminology • Theories of learning, Curriculum, Teacher education. • Conceptual framework, Research questions. • Overview of methodology and Searching.	4
2	• Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries. • Curriculum, Teacher education.	2
3	• Evidence on the effectiveness of pedagogical practices • Methodology for the in depth stage: quality assessment of included studies. • How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? • Theory of change. • Strength and nature of the body of evidence for effective pedagogical practices. • Pedagogic theory and pedagogical approaches. • Teachers' attitudes and beliefs and Pedagogic strategies.	4
4	• Professional development: alignment with classroom practices and follow- up support	4

	• Peer support • Support from the head teacher and the community. • Curriculum and assessment • Barriers to learning: limited resources and large class sizes	
5	• **Research gaps and future directions** • Research design • Contexts • Pedagogy • Teacher education • Curriculum and assessment • Dissemination and research impact.	2

Suggested reading

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31(2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.
5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: Amassscale, rapid, 'learning to read' campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.

Course code	Course Name	C
MAC202117	**Stress Management by Yoga**	**0**

Course Objectives:

1: To achieve overall health of body and mind
2: To overcome stress

Course Outcomes:

CO1: Develop healthy mind in a healthy body thus improving social health also
CO2: Improve efficiency

Course Contents:

Unit	*Content*	*Hours*
1	• Definitions of Eight parts of yog. (Ashtanga)	8
2	• Yamand Niyam. Do`s and Don't's in life. i)Ahinsa, satya, astheya, bramhacharya and aparigraha ii)Shaucha, santosh, tapa, swadhyay, ishwarpranidhan	8

3	• Asan and Pranayam i) Various yog poses and their benefits for mind & body ii) Regularization of breathing techniques and its effects-Types of pranayam	8

Suggested reading

1. 'Yogic Asanas for Group Tarining - Part - I":Janardan Swami Yogabhyasi Mandal, Nagpur
2. "Raja yoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

Course code	Course Name	C
MAC202118	Personality Development Through Life Enlightenment Skills	0

Course Objectives:

1: To learn to achieve the highest goal happily
2: To become a person with stable mind, pleasing personality and determination
3: To awaken wisdom in students

Course Outcomes:

CO1: Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
CO2: The person who has studied Geeta will lead the nation and mankind to peace and prosperity
CO3: Study of Neetishatakam will help in developing versatile personality of students

Course Contents:

Unit	Content	Hours
1	Neetisatakam-Holistic development of personality • Verses- 19, 20, 21, 22 (wisdom) • Verses- 29, 31, 32 (pride & heroism) • Verses- 26, 28, 63, 65 (virtue) • Verses- 52, 53, 59 (dont's) • Verses- 71, 73, 75, 78 (do's)	8
2	• Approach to day to day work and duties. • Shrimad Bhagwad Geeta: Chapter 2 – Verses 41,47,48, • Chapter 3 – Verses 13, 21, 27, 35, Chapter 6 – Verses 5, 13, 17, 23, 35, • Chapter 18 – Verses 45, 46, 48.	8

3	• Statements of basic knowledge. • Shrimad Bhagwad Geeta: Chapter 2 – Verses 56, 62, 68 • Chapter 12 – Verses 13, 14, 15, 16, 17, 18 • Personality of Role model. Shrimad Bhagwad Geeta: Chapter 2 - Verses 17, Chapter 3-Verses 36, 37, 42, • Chapter 4 – Verses 18, 38, 39 • Chapter 18 – Verses 37, 38, 63	8

Suggested reading

1. "Srimad Bhagavad Gita" by Swami Swarupananda Advaita Ashram (Publication Department), Kolkata
2. Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P. Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.

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