PC	ADVANCED FLUID MECHANICS	L	T	P	C
		3	1	0	4

Pre-requisite: Fluid Mechanics, Engineering Mathematics

Course Objectives: The objectives of this course are to:

1. Enhanced understanding of fluid mechanics, including the equations of motion in differential/integral form.
2. How to apply fluid dynamical equations and conservation laws to solve advanced hydrodynamic problems.

Course Outcome: After successful completion of this course, the students will be able to

CO1: apply various physical principles to get the governing equations of the fluid flow.

CO2: obtain the exact solutions to N-S equations for incompressible flow.

CO3: solve the boundary layer equations for laminar flows.

CO4: understand the concept of compressible flow.

CO5: solve the equations for turbulent flow and its models.

Module 1	**15 hours**
Concept of fundamental physical principles, Models of the flow, Substantial Derivatives, The Divergence of the velocity, Continuity equation in different forms, Constitutive equations-Stokes law of viscosity, Derivation of Navier Stokes equations, Simplification of Navier-Stokes Equation.	
Module 2	**12 hours**
Exact solutions of Navier-Stokes equations for incompressible flow; plane Poiseuille flow and Couette flow, Hagen-Poiseuille flow, theory of hydrodynamic lubrication.	
Module 3	**12 hours**
Hydrodynamic and Thermal Boundary Layers, derivations, exact solutions, Blasius solution and numerical solutions. Approximate methods: Momentum integral method, Introduction to hydrodynamic stability**.**	
Module 4	**12 hours**
Concept of compressible flow, Normal & Oblique shocks, Prandtle – Meyer expansion; Fanno & Rayleigh flows.	
Module 5	**9 hours**
Description of turbulent flow, velocity correlations, Reynolds stresses. Equations for turbulence kinetic energy and kinetic energy of mean flow. Prandtls Mixing Length Theory.	
Total Lecture hours	**60 hours**

Text Book(s)

1	F.M.White, Henry Xue, Fluid Mechanics, McGraw Hill.
2	S. K. Som, G. Biswas & S. Chakraborty, Introduction to Fluid Mechanics and Fluid Machines.

Reference Books

1	P. K. Kundu & Ira M. Cohen, Fluid Mechanics
2	G. K. Batchelor, Fluid Dynamics
3	Schlichting, Boundary Layer Theory
4	F. M. White, Viscous Fluid Flow

5	Rathakrishnan, E., Gas Dynamics, PHI
6	John D. Anderson, Jr. Computational Fluid Dyanmics

Internal Member/BoS

External Member/BoS

PC	ADVANCED THERMODYNAMICS	L	T	P	C
		3	1	0	4

Pre-requisite: Basic Thermodynamics, Engineering Mathematics

Course Objectives: The objectives of this course are to:

1. enhance the understanding of thermodynamics principles and their relevance to the problems of humankind;
2. provide the student with experience in applying thermodynamic principles to predict physical phenomena and to solve engineering problems.

Course Outcome: After successful completion of this course, the students will be able to

CO1: apply the knowledge of mathematics, science and engineering fundamentals to model the energy conversion phenomenon and assess performance of thermodynamic systems in industry.

CO2: investigate the effectiveness of energy conversion process in mechanical power generation for the benefit of mankind.

CO3: develop conceptual designs of improved thermal systems.

CO4: apply the principles of energy analysis, real gas behavior and thermodynamic property relations to solve thermodynamic problems.

Module 1	**15 hours**
Review of basic thermodynamics: Laws of thermodynamics, entropy, entropy balance for closed and open systems. Exergy: Concept of reversible work & irreversibility; Second law efficiency: Exergy change of a system: closed & open systems, exergy transfer by heat, work and mass, exergy destruction, exergy balance in closed & open systems.	
Module 2	**15 hours**
Cycle analysis and optimization: Regenerative reheat Rankine cycle and Brayton cycle, combined cycle power plants.	
Module 3	**15 hours**
Thermodynamic optimization of irreversible systems: Minimization of entropy generation principle.	
Module 4	**15 hours**
Thermodynamic Property Relations: Maxwell relations, Clapeyron equation, Clapeyron Clausius equation, Mayer equation, thermodynamic potentials, residual property functions, Helmoholtz and Gibbs functions, Tds equations, fugacity of gases, Henry and Rault's law, Gibbs phase rule, Hess's law, properties of multiphase systems.	
Total Lecture hours	**60 hours**

Text Book(s)

1	P. K. Nag, Basic and Applied Thermodynamics.
2	R. E. Sonntag, C. Borgnakke & G.J. Van Wylen, Fundamentals of Thermodynamics.

Reference Book (s)

1	K. Annamalai, I.K. Puri & M. A. Jop, Advanced Thermodynamics Engineering.
2	Bejan, Entropy Generation Minimization.
3	Bejan, Entropy Generation through Heat and Fluid Flow.

4	M. J. Moran, H. N. Shapiro, D.B.Boettner & M. N. Bailey, Principles of Engineering Thermodynamics.

Internal Member/BoS

External Member/BoS

AU	ENGLISH FOR RESEARCH PAPER WRITING	L	T	P	C
		2	0	0	0

Prerequisite: English Communication & Draft skill

Course Objectives:

Students will be able to:
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

Module:1	**5 Hours**
Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness	
Module:2	**5 Hours**
Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction.	
Module:3	**5 Hours**
Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.	
Module:4	**5 Hours**
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	
Module:5	**5 Hours**
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	
Module:6	**5 Hours**
Useful phrases, how to ensure paper is as good as it could possibly be the first-time submission	
Total hours	**30 hours**

Text Book

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.

Reference Books

1. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book .
2. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

AU	DISASTER MANAGEMENT	L	T	P	C
		2	0	0	0

Prerequisite: Environmental Science

Course Objectives:

Students will be able to:

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.

Module:1 Introduction — **5 Hours**

Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.

Module:2 Repercussions Of Disasters And Hazards — **5 Hours**

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.

Module:3 Disaster Prone Areas In India — **5 Hours**

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.

Module:4 Disaster Preparedness And Management — **5 Hours**

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.

Module:5 Risk Assessment — **5 Hours**

Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And 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.

Module:6 Disaster Mitigation — **5 Hours**

Useful phrases, how to ensure paper is as good as it could possibly be the first-time submission

Total hours — **30 hours**

Text Book

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company.

Reference Books

1. Sahni, PardeepEt.Al. (Eds.)," Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi.
2. Goel S. L. , Disaster Administration And Management Text And Case Studies" ,Deep &Deep Publication Pvt. Ltd., New Delhi.

AU	VALUE EDUCATION	L	T	P	C
		2	0	0	0

Prerequisite: Universal Human Value

Course Objectives:

Students will be able to:
1. Understand value of education and self- development
2. Imbibe good values in students
3. Let the should know about the importance of character

Course Outcome:

At the end of the course, the student should be able to
1. Knowledge of self-development
2. Learn the importance of Human values
3. Developing the overall personality

Module:1	**8 Hours**

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.

Module:2	**8 Hours**

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

Module:3	**8 Hours**

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

Module:4	**6 Hours**

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.

Total hours	**30 hours**

Text Book

1. Chakroborty, S.K. “Values and Ethics for organizations Theory and practice”, Oxford University

AU	PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS	L	T	P	C
		2	0	0	0

Prerequisite: Universal Human Value

Course Objectives:

Students will be able to:

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 Outcome:

At the end of the course, the student should be able to

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

Module:1	**10 Hours**
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)	
Module:2	**10 Hours**
Approach to day to day work and duties. Shrimad BhagwadGeeta: 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.	
Module:3	**10 Hours**
Statements of basic knowledge. Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68 Chapter 12 -Verses 13, 14, 15, 16,17, 18 Personality of Role model. Shrimad BhagwadGeeta: Chapter2-Verses 17, Chapter 3-Verses 36,37,42, Chapter 4-Verses 18, 38,39 Chapter18 – Verses 37,38,63	
Total hours	**30 hours**

Text Book

1.	"Srimad Bhagavad Gita" by Swami SwarupanandaAdvaita Ashram (Publication Department), Kolkata

Reference Book

1.	Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.

AU	CONSTITUTION OF INDIA	L	T	P	C
		2	0	0	0

Prerequisite: History

Course Objectives:

Students will be able to:

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 in 1917 and its impact on the initial drafting of the Indian Constitution.

Course Outcome:

At the end of the course, the student should be able to

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. 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.
4. Discuss the passage of the Hindu Code Bill of 1956.

Module:1 History of Making of the Indian Constitution	**5 Hours**
History Drafting Committee, (Composition & Working)	
Module:2 Philosophy of the Indian Constitution	**5 Hours**
Preamble Salient Features.	
Module:3 Contours of Constitutional Rights & Duties	**5 Hours**
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.	
Module:4 Organs of Governance	**5 Hours**
Parliament Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.	
Module:5 Local Administration	**5 Hours**
District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation. Pachayati raj: Introduction, PRI: ZilaPachayat. Elected officials and their roles, CEO ZilaPachayat: Position and role. Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy.	
Module:6 Election Commission	**5 Hours**
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.	
Total hours	**30 hours**

Text Book

1.	The Constitution of India, 1950 (Bare Act), Government Publication.

Reference Books

1.	Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
2..	M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.

AU	PEDAGOGY STUDIES	L	T	P	C
		2	0	0	0

Prerequisite: Social Science

Course Objectives:

Students will be able to:

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 Outcome:

At the end of the course, the student should be able to

1. What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
3. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

Module:1	**6 Hours**

Aims and rationale, Policy background, Conceptual framework and terminology Theories of learning, Curriculum, Teacher education. Conceptual framework, Research questions. Overview of methodology and Searching.

Module:2	**6 Hours**

Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries. Curriculum, Teacher education.

Module:3	**6 Hours**

Evidence on the effectiveness of pedagogical practices Methodology for the in depth stage: quality assessment of included studies. Model Curriculum of Engineering & Technology PG Courses [Volume -II] [39] 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.

Module:4	**6 Hours**

Professional development: alignment with classroom practices and followup support Peer support. Support from the head teacher and the community. Curriculum and assessment Barriers to learning: limited resources and large class sizes.

Module:5	**6 Hours**

Research design Contexts, Pedagogy, Teacher education, Curriculum and assessment, Dissemination and research impact.

Total hours	**30 hours**

Text Book

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.

Reference Books

1. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.
2. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.

PC	FLUID MECHANICS AND HYDRAULIC LABORATORY	L	T	P	C
		0	0	4	2

Pre-requisite: Fundamentals of Fluid mechanics and Hydraulic Machinery.

Course Objectives: the objectives of this course are to:

1. Enrich the concept of fluid mechanics and hydraulic machines.
2. Demonstrate the classical experiments in fluid mechanics and hydraulic machinery.
3. Understand laws of hydraulic mechanics and evaluate pressure, velocity and acceleration fields for various fluid flows and performance parameters for hydraulic machinery.
4. Discuss the performance characteristics of turbines.

Course Outcome: After successful completion of this course, the students will be able to

1. Utilize basic measurement techniques of fluid Mechanics.
2. Examining behavior of fluid flow parameters related to pipe flow and boundary layer.
3. Compare surface profile of a free-forced vortex.
4. Evaluate the performance characteristics of hydraulic turbines.

Experiment No-1	**5 hours**
Determination of Reynold's Number for laminar, turbulent and transition flow.	
Experiment No-2	**5 hours**
Free vortex flow.	
Experiment No-3	**5 hours**
Forced vortex flow.	
Experiment No-4	**5 hours**
Performance test on Francis Turbine.	
Experiment No-5	**5 hours**
Performance test on Kaplan Turbine.	
Experiment No-6	**5 hours**
Performance test on Pelton Wheel Turbine.	
Total Practical hours	**30 hours**

Text Book(s)

1	Bansal R. K., "Fluid Mechanics and Hydraulic Machines".
2	R.K. Rajput, "A Text Book of Fluid Mechanics and Hydraulic Machines".
3	R V Raikar, "Laboratory Manual Hydraulics and Hydraulic Machines"
4	Fluid Mechanics and Hydraulic Machines Lab Manual, Lap Lambert Academic Publishing

Reference Books

1	Frank. M. White, "Fluid Mechanics"
2	P.N.Modi and Seth, "Fluid Mechanics and Hydraulic Machines".
3	R. Yadav, "Steam and Gas Turbines and Power Plant Engineering", Central Publication house
4	G. I. Krivchenko**,** "Hydraulic Machines: Turbines and Pumps.

Internal Member/BoS External Member/BoS

PC	GAS TURBINES	L	T	P	C
		3	1	0	4

Pre-requisite: Thermodynamics, Fluid Mechanics, Heat Transfer

Course Objectives: The objectives of this course are to:

1. Develop an advanced understanding of the theory and operation of gas turbine engines.
2. Apply thermodynamic principles to calculate parameters such as pressure and temperature in Gas Turbine Engines as used in aircraft.

Course Outcome: After successful completion of this course, the students will be able to

1. Understand construction and design features of gas turbines as used for power generation.
2. Understand thermodynamics cycles and different sizes and layouts of gas turbine plant.
3. Understand thermodynamics and fluid mechanics component for enhancing the efficiency and effectiveness of gas turbines.

Module 1:	**15 hours**
Introduction, Cycles, Performance characteristics and improvement	
Module 2:	**15 hours**
Introduction and flow analysis of Centrifugal compressor and axial flow compressors, different factors, degree of reaction, Complete analysis of Radial flow and axial flow turbines, Blade materials, blade fixing	
Module 3:	**15 hours**
Problems of high temperature operation, blade cooling, Combustion Systems, various fuels and fuel systems	
Module 4:	**15 hours**
Introduction and performance parameters of propulsion system, thrust augmentation, environmental considerations and applications.	
Total Lecture hours	**60 hours**

Text Book(s)

1. Ganesan, V., "Gas Turbines", 3rd edition, 2017, Tata McGraw-Hill.
2. Jain, J. K., 'Gas Turbine Theory & Jet Propulsion', Khanna Publishers
3. Lefebvre, A. H., 'Gas Turbine Combustion', CRC Press
4. Walsh & Fletcher, 'Gas Turbine Performance', Wiley India Pvt Ltd

Reference Books

1. H Cohen, GFC Rogers and HIH Saravanamuttoo, "Gas Turbine Theory", Pearson Education, 2000
2. Breeze, P., "Gas-Turbine Power Generation", 2016, Academic Press.

Internal Member/BoS External Member/BoS

OE	OPERATION RESEARCH	L	T	P	C
		3	0	0	3

Pre-requisite: Engineering Mathematics, Numerical Methods & Computation

Course Objectives: The objectives of this course are to:

1. Identify and develop operational research models from the verbal description of the real system.
2. Understand the mathematical tools that are needed to solve optimisation problems.
3. Propose the best strategy using decision making methods.

Course Outcome: After successful completion of this course, the students should be able to

1. Understand the fundamentals of OR including optimization, decision making and modeling.
2. Apply the techniques to real life problems in a variety of fields such as manufacturing, transportation, finance, healthcare and logistics.
3. Develop critical thinking abilities through the use of mathematical models, statistical analysis, and simulation methodologies based on quantitative analysis and data-driven insights.
4. Communicate the results of the analysis and findings effectively, both orally and in writing, to various stakeholders.

Module 1: Introduction to Operation Research — **4 hours**

- Definition and Scope of Operations Research
- Historical Overview of Operations Research
- Importance and Applications of Operations Research

Module 2: Linear Programming Problems — **8 hours**

- Formulation of Linear Programming Problems
- Graphical Solution Method
- Simplex Method
- Duality Theory
- Dual Simplex Method

Module 3: Special Linear Programming Problems — **8 hours**

- Integer Programming Problem
- Transportation Problems
- Assignment Problems
- Travelling Salesman Problem

Module 4: Non-Linear Programming Problems — **8 hours**

- Unconstrained Optimization Methods
- Constrained Optimization Methods
- Quadratic Programming

Module 5: Project Management — **8 hours**

- Project Planning and Control
- Critical Path Method (CPM)
- Program Evaluation and Review Technique (PERT)

Module 6: Goal Programming Problem	**4 hours**
• Introduction to Goal Programming Problem • Graphical Solution Method for GPP • Modified Simplex Method of GPP • Alternative Simplex Method of GPP	
Module 7: Game Theory	**5 hours**
• Introduction to Game Theory • Two-Person Zero-Sum Games • Mixed Strategies and Nash Equilibrium • Linear Programming Approach to Solve Games	
Total Lecture hours	**45 hours**

Text Book(s)

1.	H.A. Taha, Operations Research, An Introduction, Pearson Education, 9th Edition
2.	J.K. Sharma, Operations Research: Theory and Applications, Laxmi Publications, 6th Edition
3.	P.K. Gupta & D.S. Hira, Operations Research, S. Chand, 7th Edition

Reference Books

1.	H.M. Wagner, Principles of Operations Research, PHI, Delhi, 2nd Edition
2.	J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, 7th Edition
3.	Frederick S. Hillier & Gerald J. Lieberman, Introduction to Operations Research, McGraw Hill, 7th Edition

Internal Member/BoS

External Member/BoS

OE	WASTE TO ENERGY	L	T	P	C
		3	0	0	3

Pre-requisite: Chemistry, Basic Thermodynamics, Heat Transfer

Course Objectives: The objectives of this course are to:

1. To enable students to understand of the concept of Waste to Energy.
2. To learn about the best available technologies for waste to energy.
3. To understand the theory behind Gasifier and its operational aspect.
4. To comprehend the operational aspect of biomass combustor.
5. To grasp basic design of a Biogas plant and its operational aspect.

Course Outcome: After successful completion of this course, the students will be able to

1. Understand the types of waste and various wastes to energy technologies
2. Compare the different types of gasification and pyrolysis processes for waste to energy
3. Analyze the bio waste utilization and to avoid the environmental pollution
4. Determine the regimes of fluidization of combustion of solid fuels

Module 1:	**5 hours**
Introduction to Energy from Waste: Biomass & its constituents, Thermal properties: Proximate, Ultimate and heating value analysis, Classification of waste as fuel – Agro based, Forest residue, Industrial waste, MSW – Refuse-derived fuel (RDF), Conversion devices – Incinerators, gasifiers, digestors	
Module 2:	**8 hours**
Biomass Pyrolysis: Pyrolysis – Types, Manufacture of charcoal – Methods -Yields and application – Manufacture of pyrolytic oils and gases, yields and applications. Torrefaction process.	
Module 3:	**8 hours**
Biomass Gasification: Chemistry & process of Gasification, Types of Gasifiers, Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.	
Module 4:	**8 hours**
Biomass Combustion: Biomass stoves – Improved chullahs, types, fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors-Regimes of fluidization, Geldart particle, Design, construction and operation.	
Module 5:	**8 hours**
Biogas: Properties of biogas - Biogas plant technology and status - Bio energy system - Design and constructional features – 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.	
Module 6:	**8 hours**
Hydro thermal Processing of Biomass: Fundamentals of Hydro thermal Process, Types of Hydro thermal Process, TORWASH, Hydrothermal Carbonization, Hydrothermal Liquefaction, Hydrothermal Gasification, Engineering obstacles and challenges.	
Total Lecture hours	**45 hours**

Text Book(s)

1.	Non-Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.

2.	Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.
3.	Biomass Processing Technologies - Vladimir Strezov, Tim J. Evans (CRC Press, 2014)
4.	An Introduction to Bioenergy - Nigel G Halford (World Scientific Publishing Company, 2015)
5.	Biofuels and Bioenergy: Processes and Technologies - Sunggyu Lee, Y.T. Shah (CRC Press, 2012)
Reference Books	
1.	Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
2.	Torrefaction and Fermentation - Erik Dahlquist (CRC Press, 2013)
3.	Bioenergy Research: Advances and Applications - Vijai G. Gupta, Maria Tuohy, Christian P Kubicek, Jack Saddler, Feng Xu (Newnes, 2013)
4.	Technologies for Converting Biomass to Useful Energy: Combustion, Gasification, Pyrolysis

Internal Member/BoS

External Member/BoS

OE	Composite Materials	L	T	P	C
		3	0	0	3

Pre-requisite: Material Science, Strength of Materials

Course Objectives: The objectives of this course are to:

1. Describe key processing techniques for producing metal, ceramic, and polymer matrix composites.
2. Demonstrate the relationship among synthesis, processing, and properties in composite materials.

Course Outcome: After successful completion of this course, the students will be able to

1. Select matrices for composite materials in different applications.
2. Understand the use of reinforcements in the composite materials
3. Comprehend the micromechanics layered composites, design of composite structure and failure analysis

Module 1:	**8 hours**
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.	
Module 2:	**10 hours**
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, Comparison of fibres. Role of interfaces: Wettability and Bonding, The interface in Composites, Interactions and Types of bonding at the Interface, Tests for measuring Interfacial strength.	
Module 3:	**10 hours**
Fabrication of Polymeric Matrix Composites, Structure and properties of Polymeric Matrix Composites, Interface in Polymeric Matrix Composites, Applications; Fabrication of Ceramic Matrix Composites, Properties of Ceramic Matrix Composites, Interface in Ceramic Matrix Composites, Toughness of Ceramic Matrix Composites, Applications of Ceramic Matrix Composites.	
Module 4:	**10 hours**
Fabrication of Metal Matrix Composites: Solid state fabrication, Liquid state fabrication and In-situ fabrication techniques; Interface in Metal Matrix Composites: Mechanical bonding, Chemical bonding and Interfaces in In-situ Composites; Discontinuously reinforced Metal Matrix Composites, Properties and Applications. Fabrication of Carbon fiber composites, properties, interface and applications.	
Module 5:	**7 hours**
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.	
Total Lecture hours	**45 hours**

Text Book(s)

1.	Composite Materials – Science & Engineering, K.K. Chawla, Springer-Verlag, New York, 1987
2.	An Introduction to Composite Materials, D. Hull, Cambridge, 2nd Edt. 1997.
3.	Mechanics of Composite Materials and Structures, M. Mukhopadhyay, Universities Press

4.	Damage and Failure of Composite Materials, Ramesh Talreja & Chandra Veer Singh, Cambridge University Press
Reference Books	
1.	Composite Material : Production, Properties, Testing, K. Srinivasan, Narosa Publication
2.	Composite Materials and Structural Analysis, N. G. R. Iyengar, Viva Books Originals

Internal Member/BoS

External Member/BoS

MC	RESEARCH METHODOLOGY	L	T	P	C
		2	0	0	2

Prerequisite: Professional Ethics

Course Outcome:

At the end of the course, the student should be able to

1. Understand research problem formulation
2. Analyze research related information
3. Follow research ethics
4. Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
5. 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.
6. 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.

Module:1	**5 Hours**

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.

Module:2	**5 Hours**

Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations. Effective literature studies approaches, analysis. Plagiarism, Research ethics.

Module:3	**5 Hours**

Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.

Module:4	**5 Hours**

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.

Module:5	**5 Hours**

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Module:6	**5 Hours**

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.

Total hours	**30 hours**

Text Book

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students''

2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"

Reference Books

1. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"

2.	Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd , 2007.

Internal Member/BoS

External Member/BoS

PC	ADVANCED HEAT TRANSFER	L	T	P	C
		3	1	0	4

Pre-requisite: Heat Transfer, Thermodynamics

Course Objectives: The objectives of this course are to:

1. Impart knowledge on the various modes of heat transfer and heat transfer mechanisms.
2. To formulate the models necessary to study and analyze heat transfer system.

Course Outcome: After successful completion of this course, the students will be able to

1. Formulate and solve steady and unsteady heat transfer problems.
2. Analyze heat transfer using natural and forced convection.
3. Understand and evaluate heat transfer rate in phase change process.
4. Analyze radiation heat transfer between surfaces.

Module 1: Introduction — **15 hours**

Modes of Heat transfer- Governing equations–1-D steady state conduction-Fins of Uniform and Non Uniform cross sections, Heat transfer with internal heat generation.

Module 2: Transient heat conduction — **15 hours**

General Lumped capacitance analysis, Transient heat flow in finite and semi-infinite solid, Multidimensional systems, use of Heisler chart, Schmidt's method.
2-D steady state conduction: Method of separation of variables, FDM.

Module 3: Forced-convection — **15 hours**

General review, Laminar Flow: a similarity solution, Turbulent flow, mixed boundary layer conditions, flow across cylinders and spheres, tube banks – inline and staggered arrangement.
Free convection: Inclined and horizontal plates – the flow pattern and heat transfer, tubes, enclosures, simplified free convection relations for air, combined free and forced convection, External flows, Internal flows.

Module 4: Heat transfer with Phase change — **15 hours**

Boiling modes, Pool boiling, flow boiling, condensation: Nusselt's theory, Film condensation, drop-wise condensation.
Radiation: Review of radiation principles - laws of thermal radiation - Surface properties - radiative heat exchange among diffuse, gray and non-gray surfaces separated by nonparticipating media.
Gas Radiation: Radiation transfer in enclosures containing absorbing and emitting media - interaction of radiation with conduction and convection.

Total Lecture hours — **60**

Text Book(s)

1. Yunus A.Cengal, Heat and Mass Transfer – A practical Approach, 3rd edition, Tata McGraw - Hill, 2007.
2. Holman.J.P, Heat Transfer, Tata Mc Graw Hill, 2002.
3. Incropera F.P. and DeWitt. D.P., Fundamentals of Heat & Mass Transfer, John Wiley & Sons, 2002
4. Ghoshdastidar. P.S., Heat Transfer, Oxford University Press, 2004

Reference Books

1. Heat & Mass Transfer by D. S. Kumar, S.K.Kataria & Sons
2. Mahesh M. Rathore, Engineering Heat Transfer , Jones & Bartlett Learning, 2011

PC	DESIGN OF HEAT EXCHANGERS	L	T	P	C
		3	1	0	4

Pre-requisite: Engineering Thermodynamics, Fluid Mechanics, Heat Transfer

Course Objectives: The objectives of this course are to:

1. To provide fundamental knowledge of different types of heat exchangers used for thermal application.
2. To learn the sizing of heat exchangers and thermal analysis for various heat exchange applications.

Course Outcome: After successful completion of this course, the students will be able to

1. Demonstrate a basic understanding of several types of heat exchangers that will include shell-and-tube, double pipe, plate-and-frame, finned tube, and plate-fin heat exchangers, Heat pipes.
2. Design and analyze shell-and-tube, double pipe, compact, plate heat exchangers**.**
3. Determine the performance degradation of heat exchangers subject to fouling.

Module 1:	**12 hours**
Heat Exchangers – Classification of Heat exchanger, Heat exchanger design methodology, assumption for heat transfer analysis, problem formulation, e-NTU method, LMTD method for heat exchanger analysis, fouling of heat exchanger, effects of fouling, categories of fouling, fundamental processes of fouling, rating and sizing problems	
Module 2:	**12 hours**
Double Pipe Heat Exchangers: Thermal and Hydraulic design and analysis of inner tube and Annulus, hair pin heat exchanger with bare and finned inner tube, Total pressure drop	
Module 3:	**12 hours**
Shell and Tube heat exchangers –Thermal and hydraulic design of Shell and Tube heat exchangers, TEMA code, J-factors, Bell Delaware method	
Module 4:	**12 hours**
Compact Heat Exchangers: Thermal and Hydraulic design of compact heat exchanger, plate fin heat exchanger, tube fin heat exchanger, heat transfer and pressure drop	
Module 5:	**12 hours**
Mechanical Design of Heat Exchangers – design standards and codes, key terms in heat exchanger design, material selection, and thickness calculation for major components such as tube sheet, shell, tubes, flanges and nozzles.	
Total Lecture hours	**60 hours**

Text Book(s)

1.	Ramesh K. Shah and Dusan P. Sekulic, “Fundamentals of Heat Exchanger Design” John Wiley & sons Inc., 2003
2.	Sadik Kakac and Hongton Liu, “Heat Exchangers: Selection, Rating and Thermal Design” CRC Press, 1998.
3.	A. P. Frass and M.N. Ozisik, “Heat Exchanger Design”, McGraw Hill, 1984

Reference Books

1.	T. Kuppan, “Hand Book of Heat Exchanger Design”, CRC Press
2.	D.C. Kern, “Process Heat Transfer”, McGraw Hill, 1950.
3.	T.E.M.A. Standard”, New York, 1999. G. Walkers, “Industrial Heat Exchangers-A Basic Guide”, McGraw Hill, 1982.

PC	FUEL AND COMBUSTION	L	T	P	C
		3	1	0	4

Pre-requisite: Basic UG-level Thermodynamics & Heat Transfer

Course Objectives: The objectives of this course are to:

1. To provide the sufficient knowledge of combustion engineering apply in real engineering problems
2. To understand different combustion process, its thermodynamics and kinetics
3. To learn combustion mechanism in different types of combustion
4. To enable the student the effect of quantity & quality of fuel and exhaust emissions from the engines
5. To understand the concept of laminar and turbulent flame propagation

Course Outcome: After successful completion of this course, the students will be able to

1. Explain the basic concepts of fuel and combustion, including classification of fuels and its properties, types of combustion.
2. Understand the thermodynamics behind combustion, flame propagation.
3. Apply stoichiometric principles to determine the composition of the reactants and products in combustion reactions
4. Determine the calorific value of fuels using bomb calorimeter and Junker's gas Calorimeter and also to determine the adiabatic flame temperature.

Module 1:	**12 hours**
Introduction to fuel and combustion - Definition, Classification of fuel, Properties of fuel - Calorific value, Proximate & Ultimate analysis, Physical Properties of fuels, Characteristics of ideal fuel, Desirable properties of coal, Raking of coal, Grading of coal, Fuel analysis, Calorific value, Combustion reaction and combustion analysis, Conversion of volumetric analysis to gravimetric analysis and vice versa, Types of combustion: complete and incomplete combustion, Concept of Biorefinery, H_2 fuel.	
Module 2:	**12 hours**
Combustion Fundamentals - Terminology, Physical law of combustion, Basic combustion reaction, Stoichiometry of Combustion, Flue gas analysis, Heat generation by combustion, Chemical Thermodynamics, Combustion Emissions-Formation of Pollutants, Control emissions, Environmental impact	
Module 3:	**12 hours**
Combustion Technology – Fundamentals of Thermochemistry, Experimental determination of calorific value of fuel- Bomb Calorimeter, Junker's Gas calorimeter, Fluidized bed Combustion, Adiabatic flame Temperature, Mechanism of combustion, Flame Properties, Combustion in engine Spark Ignition Engines, Compression ignition engines, Dual fuel engines	
Module 4:	**12 hours**
Combustion Process (kinetics) – Nature of Combustion Process, Types of Combustion Process, Mechanism of Combustion reaction, Velocity of flame propagation, kinetics of solid combustion fuel	
Module 5:	**12 hours**
Laminar premixed and non-premixed flame, Soot Formation, Counter-flow Flames, Turbulent pre-mixed flames, turbulent combustion, transition from laminar to turbulent diffusion flames, Droplet Combustion	
Total Lecture hours	**60 hours**

Text Book(s)	
1.	S. P. Sharma & Chander Mohan, "Fuels & Combustion", Tata McGraw Hill Publishing Co. Ltd.
2.	John Griswold, "Fuels Combustion and Furnaces", Mc-Graw Hill Book Company Inc.
3.	Samir Sarkar, "Fuels & Combustion", 3rd Edition, Orient Longman.
4	N.A.Chigier, Energy, Combustion and Environment, McGraw-Hill Co, New York, 1981.
Reference Books	
1.	Stone R. Introduction to internal combustion engines. 3rd ed. The Mac-Millian Press Limited: 1985.
2.	B.K.Sharma, "Fuels and Petroleum Processing", 1st ed. Goel publishing, Meerut
3.	Pudir BP. IC Engines: Combustion and Emissions. Narosa Publishing House, 2010.
4	S.R. Turns , Introduction to combustion, Tata McGraw-Hill

PC	**HEAT TRANSFER LABORATORY**	**L**	**T**	**P**	**C**
		0	**0**	**4**	**2**

Pre-requisite: Thermodynamics, Applied thermodynamics and Heat & mass transfer.

Course Objectives: the objectives of this course are to:

1. Define the fundamental concepts to students in the area of heat transfer and its applications.
2. Recognize the practical significance of various parameters those are involved in different modes of heat transfer.
3. Apply the knowledge of heat transfer in an effective manner for different applications.

Course Outcome: After successful completion of this course, the students will be able to

1. Apply the basic measurement techniques of heat transfer.
2. Examine the thermal conductivity of insulating powder.
3. Evaluate the Heat transfer coefficient for Pin Fin, Forced convection and Natural Convection and compare the theoretical with the experimental value.
4. Test Emissivity and Stefan Boltzmann Constant.

Experiment No-1	**5 hours**
To determine the thermal conductivity of insulating powder (asbestos) at various heat inputs.	
Experiment No-2	**5 hours**
To study the temperature distribution along the length of a pin fin under free and forced convection heat transfer.	
Experiment No-3	**5 hours**
To determine the convective heat transfer coefficient for heated vertical cylinder losing heat to the ambient by free or natural convection.	
Experiment No-4	**5 hours**
To determine the convective heat transfer coefficient for a horizontal & Vertical pipe through which air flows under for convection.	
Experiment No-5	**5 hours**
Determination of Emissivity of a Grey Surface.	
Experiment No-6	**5 hours**
Determination of the Value of Stefan–Boltzmann Constant for Radiation Heat Transfer.	
Total Contact hours	**30 hours**

Text Book(s)

1	Experiments in Heat Transfer and Thermodynamics by Robert Alan Granger, Cambridge University press.
2	Experiments in Heat Transfer and Thermodynamics by Robert Alan Granger, Cambridge University Press
3	Yunus A. Cengel, “Heat Transfer a Practical Approach”, Tata McGraw-Hill Education.
	Incropera F.P And De Witt, D.P., Fundamentals of Heat & Mass Transfer, John Wiley & Sons.

Reference Books

1	Holman J. P., “Heat transfer”, Tata McGraw Hill Publishing.
2	Amir Faghri, Yuwen Zhang, John Howel., Advanced Heat and Mass Transfer. 2010

PE	COMPUTATIONAL FLUID DYNAMICS (CFD)	L	T	P	C
		3	0	0	3

Pre-requisite: Fluid Mechanics (UG), Engineering Mathematics, Numerical Methods

Course Objectives: The objectives of this course are to

1. provide the student with a significant level of experience in the use of modern CFD software for the analysis of complex fluid-flow systems.
2. improve the student's understanding of the basic principles of fluid mechanics.
3. improve the student's research and communication skills using a self-directed, detailed study of a complex fluid-flow problem and to communicate the results.

Course Outcome: After successful completion of this course, the students will be able to

CO1: understand the basic knowledge of governing equations of Fluid flow applications.
CO2: recognize various solution methodologies to complex fluid dynamics problems.
CO3: apply appropriate solution strategy and estimate the accuracy of the results for a given flow case
CO4: select and formulate various CFD problems by considering appropriate boundary conditions.

Module 1: Introduction to CFD	**8 hours**
Computational approach to Fluid Dynamics and its comparison with experimental and analytical methods, Basics of PDE: Elliptic, Parabolic and Hyperbolic Equations.	
Module 2: Governing Equations	**8 hours**
Review of Navier-Stokes Equation and simplified forms, Solution Methodology: FDM and FVM, stability, Convergence and Accuracy.	
Module 3: Finite Volume Method	**8 hours**
Domain Discretization, types of mesh and quality of mesh, SIMPLE, pressure velocity coupling, checkboard pressure field and staggered grid approach.	
Module 4: Geometry Modeling and Grid Generation	**6 hours**
Practical aspects of computational modeling of flow domains, Grid Generation, Types of mesh and selection criteria, Mesh quality, Key parameters and their importance.	
Module 5: Methodology of CFDHT	**7 hours**
Objectives and Importance of CFDHT, CFDHT for Diffusion Equation, Convection Equation and Convection-Diffusion Equation.	
Module 6: Solution of N-S Equations for Incompressible Flows	**8 hours**
Semi-Explicit and Semi-Implicit Algorithms for staggered Grid System and Non Staggered Grid System of N-S Equations for incompressible Flows.	
Total Lecture hours	**45 hours**

Text Book(s)

1	John A.Anderson, Jr., Computational Fluid Dynamics, McGraw Hill.
2	Muralidhar and Sundarrajan, Computaional Fluid Flow and Heat Transfer, Narosa Publication.

Reference Books

1	Suhas Patankar, Numerical Methods in Fluid Flow and Heat Transfer.
2	H.K.Versteeg, W.Malalasekera, An Introduction to Computational Fluid Flow (Finite Volume Method), Printice Hall.
3	Ferziger J.H. & Peric M. (1999) Computational Methods for Fluid Dynamics, Springer, Berlin, Germany.

TE02PE02	**Advanced Internal Combustion Engines**	L	T	P	C
		3	0	0	3

Pre-requisite: Basic Thermodynamics, Internal Combustion Engine, Heat Transfer

Course Objectives: The objectives of this course are to:

1. To make the students familiar with the engine fuel and air supply systems, electronic injection systems used in modern automotive engines.
2. To make the students understand about the combustion phenomenon of SI and CI engines, engine pollutants
3. To teach the students on production and utilization of alternative solid, liquid and gaseous fuels.
4. To teach modern trends in IC engines.

Course Outcome: After successful completion of this course, the students will be able to

1. Demonstrate the ability to perform the thermodynamic analysis of Otto, Diesel, and Dual cycle models
2. Explain fuel supply systems, combustion and emission aspects of IC engines and recent developments in IC engines.
3. Design fuel and air supply systems and combustion and after treatment systems.
4. Apply concepts of different alternate fuels used for SI and CI engines.

Module 1:	**10 hours**
Air standard and fuel-air cycle analysis of Otto, Diesel and limited pressure cycles. Effect of design and operating parameters on cycle efficiency. Modified fuel-air cycle considering heat losses and valve timing	
Module 2:	**10 hours**
Fuels for I.C Engines and their characteristics, combustion in S.I Engines, spark, knock and other abnormalities, combustion chambers, pollutant formation and control including catalytic converters, combustion in C.I.Engines. Diesel knock, Delay, fuel spray and mixing, fuel injectors and injection system.	
Module 3:	**10 hours**
Advanced theory of carburetion, Cooling of engine and governing of engine. Ignition system and conventional and electronic, Supercharging, Variable compression ratio engine.	
Module 4:	**5 hours**
Exhaust emissions, its measurement and control, modeling of C.I engine Combustion	
Module 5:	**10 hours**
Introduction to alternate fuels-biofuels, thermochemical and biochemical conversion, Vegetable oils and Biodiesel, Ethanol, LPG, Natural gas, Hydrogen-Production and Utilization perspective.	
Total Lecture hours	**45 hours**

Text Book(s)

1.	J.B Heywood : Internal Combustion Engine Fundamental,McGraw Hill
2.	W.W. Pulkrabek: Engineering Fundamentals of I.C. Engines
3.	V. Ganeshan: I.C Engines.
4.	M.L. Mathur and R.P.Sharma, A course in internal Combustion Engines, Dhanapat Rai Publications, New Delhi.

5.	D. Smith, Auto fuel Systems, The Good Heart Willox Company, Inc.
Reference Books	
1.	G.D.Rai, *Non conventional energy courses*, Khanna Publishers
2.	K.K. Ramalingam, *Internal Combustion Engine Fundamentals*, Scitech Publications
3.	V. Ganesan, Computer simulation of spark ignition process: University process, Hyderabad 1993.
4.	V. Ganesan, Computer simulation of compression ignition engine. Orient Long man

PE	ENERGY CONSERVATION AND MANAGEMENT	L	T	P	C
		3	0	0	3

Pre-requisite: Thermodynamics, Heat Transfer

Course Objectives: The objectives of this course are to:

1. Present a problem oriented in depth knowledge of Energy conservation management.
2. Apply energy conservation principles and management techniques to different energy conversion systems.

Course Outcome: After successful completion of this course, the students will be able to

1. Understand the basic knowledge of different terms & principles of energy conservation, audit and management
2. Evaluate the energy saving & conservation in different mechanical utilities
3. Analyze the thermal systems for energy efficiency.

Module 1: Energy conservation and management	10 hours

Introduction to energy & power scenario of world, National Energy consumption data and environmental aspects associated with energy utilization; Energy Auditing- need, types, methodology and barriers, role of energy managers, instruments of energy auditing. Energy conservation Act 2001 and its features, notifications under the Act, Schemes of Bureau of Energy Efficiency (BEE) including Designated Consumers, State Designated Agencies, ECBC code for Building Construction.

Module 2: Energy monitoring and targeting	10 hours

Defining monitoring & targeting, elements of monitoring & targeting, data and information-analysis, techniques – energy consumption, production, cumulative sum of differences (CUSUM).

Module 3: Economic performance indices	10 hours

Payback – Simple and Discounted, Net Present Value, Internal Rate of Return, Benefit to Cost Ratio, Financial evaluation of energy projects, evaluation of proposals, profitability index, life cycle costing approach, investment decision and uncertainty.

Module 4: Energy auditing in thermal utilities	15 hours

Thermal systems, Boilers, Furnaces, Heat exchangers - efficiency computation and energy conservation measures; Steam distribution and usage, steam traps, condensate recovery, flash steam utilization; Insulation & Refractories. Energy conservation in major utilities; pumps, fans, blowers, compressed air systems, Refrigeration & Air Conditioning systems, Cooling Towers, DG sets.

Total Lecture hours	**45 hours**

Text Book(s)

1. L.C.Witte, P.S.Schmidt, D.R.Brown, Industrial Energy Management and Utilization, Hemisphere Publication, Washington,1988
2. Callaghan P.W., "Design and Management for Energy Conservation", Pergamum Press, Oxford.
3. Dale R Patrick, Stephen W Fardo, "Energy Conservation Guidebook", 2nd Edition, CRC Press.

Reference Books

1. Wayne C Turner, "Energy Management Handbook", The Fairmount Press, 2006.

Internal Member/BoS External Member/BoS

PE	DESIGN OF SOLAR AND WIND SYSTEM	L	T	P	C
		3	0	0	3

Pre-requisite: Basic Thermodynamics, Fluid Mechanics, Heat Transfer

Course Objectives: The objectives of this course are to:

1. The fundamental concepts of power generation and gain enough knowledge about the wind and solar energy sources.
2. The construction, principle of operation of various equipments used in power generation
3. The key aspects in the design and operation of photovoltaic along with solar thermal power energy systems.
4. The various factors affecting the power quality issues in integration of renewable energy resources.
5. The key aspects in the design and operation of photovoltaic along with solar thermal power energy systems.

Course Outcome: After successful completion of this course, the students will be able to

1. Gain knowledge about working principle of various solar energy systems
2. Understand the application of wind energy and wind energy conversion system.
3. Outline various components involved and their functionality in production of electricity from wind and Solar power plants.
4. Evaluate the performance of solar flat plate collectors

Module 1:	**5 hours**
World energy resources -Indian energy scenario -Environmental aspects of energy utilization. Renewable energy resources and their importance -Global solar resources. Solar spectrum – Electromagnetic spectrum, basic laws of radiation.	
Module 2:	**6 hours**
Solar radiation on the earth surface. Depletion of solar radiation. Measurement of solar radiation. Solar radiation geometry. Calculation of total solar radiation on horizontal and tilted surfaces. Prediction of solar radiation availability	
Module 3:	**10 hours**
Performance of Solar flat plate collectors, concentrating collectors, thermal storage. Solar thermal power plants -Parabolic trough system, distributed collector, hybrid solar-gas power plants, solar pond based electric-power plant, central tower receiver power plant.	
Module 4:	**12 hours**
Solar photovoltaic energy conversion -Principles -Physics and operation of solar cells. Classification of solar PV systems, Solar cell energy conversion efficiency, I-V characteristics, effect of variation of solar insolation and temperature, losses. Solar PV power plants	
Module 5:	**12 hours**
Wind speed, Wind direction, Data measurement and analysis, Performance evaluation of Wind energy system, Wind potential assessment, Wind Power-Turbine types & terms, Mechanical & Electrical Power from Wind Turbines. Upwind and downwind systems - transmission rotors – pump - generators - standalone system - grid system – batteries. Wind energy storage - wind farms - wheeling and banking - testing and certification procedures	
Total Lecture hours	**45 hours**

Text Book(s)

1.	Non-Conventional Energy Resources-B.H. Khan, T M H, 2010.

2.	Non-Conventional Energy Sources-G.D. Rai, Khanna Publishers.
3.	D.Y. Goswami, F. Kreith and J.F. Kreider, "Principle of Solar Engineering", Taylor and Francis, 2000.
4.	Sukhatme S.P., "Solar Energy", Tata McGraw Hill Publishing Co. Ltd., New Delhi,1994
5.	Mukund R Patel, "Wind and Solar Power Systems", CRC Press, 1st Edition, 1999
Reference Books	
1.	Bansal and othes, "Non-Conventional Energy Sources".
2.	J.F. Kreider, F. Kreith, "Solar Energy Handbook", McGraw Hill, 1981
3.	J.A. Duffie and W.A. Beckman, "Solar Engineering of Thermal Processes", John Wiley, 1991
4.	Daniel, Hunt. V Wind Power, A Hand Book of WECS, Van Nostrend Co., Newyork, 2nd Edition, 1998.