NOORUL ISLAM CENTRE FOR HIGHER EDUCATION

(Deemed to be University Under Section 3 of the UGC Act, 1956)
Kumaracoil, Thuckalay

DEPARTMENT OF MECHANICAL ENGINEERING

M.E.THERMAL ENGINEERING

CURRICULUM AND SYLLABI

REGULATION 2021

NOORUL ISLAM CENTRE FOR HIGHER EDUCATION, Kumaracoil

Regulation : 2021

Curriculum and Syllabi

DEPARTMENT OF MECHANICAL ENGINEERING

M.E. THERMAL ENGINEERING

Vision of the University

To be recognized by the Government and society at large as an institution able to deliver excellence with relevance in the field of higher education and research focusing on the needs of the nation in tune with the technological revolution to cope with the knowledge explosion and global competence.

Mission of the University

To develop the institution as a Centre of Excellence, keeping pace with the advances in the field, so as to provide quality higher education to the students and instill in them high standards of discipline and ethics so that they become enlightened individuals in the service of humanity and to carry out focused research in the frontier areas of science and technology.

Faculty of Mechanical Engineering

Department of Mechanical Engineering

Vision of the Department

To become a centre of excellence in teaching, research & development by producing innovative and creative mechanical engineers to meet the global challenges.

Mission of the Department

To achieve National and International recognition by providing educational needs & Industry requirements through unique programs in Mechanical Engineering.

Description of the programme

Thermal engineering is a branch of engineering that focuses on the study, design, and optimization of systems and processes involving the transfer, conversion, and utilization of thermal energy. It encompasses various aspects such as thermodynamics, heat transfer, fluid mechanics, and energy conversion. Thermal engineers work on a wide range of applications including heating, ventilation, air conditioning (HVAC) systems, power generation, refrigeration, and renewable energy technologies. They design and analyze thermal systems to ensure efficient heat transfer, minimize energy losses, and meet performance requirements while considering factors such as environmental impact, cost-effectiveness, and safety. In addition to theoretical knowledge, thermal engineers often utilize computer simulations, experimental testing, and advanced materials to develop innovative solutions for diverse industrial and environmental challenges related to heat management and energy utilization.

Programme Educational Objectives - PEO	
PEO-01	To enhance the foundation and the knowledge-base of students in thermal science and to make them capable for effectively analyzing and solving the problems associated in this field.
PEO-02	To deliver comprehensive education in Thermal Engineering to ensure that the students have core competency to be successful in industry or research laboratory and motivate them to pursue higher studies and research in interrelated areas.
PEO-03	To encourage the students to take up real life and/or research related problems and to create innovative solutions of these problems through comprehensive analysis and designing
PEO-04	To inculcate a sense of ethics, professionalism and effective communication skills amongst graduates for their successful careers.
PEO-05	To provide an academic environment that gives adequate opportunity to the students to cultivate lifelong skills needed for their successful professional career.”

Graduate Attributes-GA	
GA-1	**Advanced Engineering Expertise** Master advanced engineering principles and apply them to design, analyze, and innovate systems that address both present and emerging global challenges across diverse industries.
GA-2	**Leadership in Research and Innovation** Lead groundbreaking research and foster innovation by identifying opportunities for technological advancements, contributing original ideas that push the boundaries of engineering knowledge.

GA-3	**Sustainable Engineering Practices** Develop and implement engineering solutions that integrate sustainability, environmental stewardship, and resource efficiency, ensuring the long-term impact and responsibility of all projects.
GA-4	**Ethical and Strategic Decision-Making** Make informed, ethical decisions in complex engineering contexts, considering societal needs, environmental implications, and the long-term consequences of engineering practices.
GA-5	**Global Competence in Engineering Solutions** Exhibit a deep understanding of global engineering standards and practices, addressing international challenges and cultural sensitivities in engineering projects to make a broader societal impact.
GA-6	**Technological Agility and Lifelong Learning** Stay ahead of technological trends and exhibit agility in learning new tools, methodologies, and technologies, ensuring continuous professional growth in a rapidly evolving engineering landscape.
GA-7	**Interdisciplinary and Collaborative Innovation** Excel in multidisciplinary collaborations, leveraging knowledge from multiple fields to solve complex, large-scale engineering problems that require comprehensive and innovative solutions.
GA-8	**Data-Driven Decision Making** Employ advanced data analytics, machine learning, and computational tools to derive insights and make informed engineering decisions that improve performance, efficiency, and sustainability.
GA-9	**Entrepreneurial Mindset and Innovation Leadership** Cultivate an entrepreneurial mindset, translating engineering innovations into viable products, solutions, or services, and leading teams toward commercialization and societal impact.
GA-10	**Safety, Risk, and Crisis Management** Implement and manage advanced safety protocols and risk mitigation strategies to protect individuals, communities, and ecosystems in engineering practices, particularly in high-stakes and crisis environments.

Programme Outcome - PO	
PO-A	Graduates will demonstrate knowledge of mathematics, science and engineering
PO-B	Graduates will demonstrate an ability to identify, formulate and solve engineering problems.
PO-C	Graduates will demonstrate an ability to design and conduct experiments, analyze and interpret data.

P0-D	Graduates will demonstrate about a system, component or process as per need and specifications.
PO-E	Graduates will demonstrate an ability to visualize and work on laboratory and multi-disciplinary tasks.
PO-F	Graduates will demonstrate skills to use modern engineering tools, software and equipment to analyze problems.
PO-G	Graduates will demonstrate knowledge of professional and ethical responsibilities.
PO-H	Graduates will be able to communicate effectively in both verbal and written form.
PO-I	Graduates will show the understanding of impact of engineering solutions on the society and also will be aware of contemporary issues.
PO-J	Graduates will develop confidence for self-education and ability for lifelong learning.

Mapping of Graduate Attributes and Programme Educational Objectives(PEO)

GAs / PEOs	GA-01	GA-02	GA-03	GA-04	GA-05	GA-06	GA-07	GA-08	GA-09	GA-10
PEO-01	**A**	**H**	**A**	**A**	**H**	**A**	**H**	**A**	**A**	**H**
PEO-02	**H**	**H**	**A**	**A**	**H**	**A**	**A**	**A**	**A**	**A**
PEO-03	**A**	**H**	**A**	**A**	**H**	**H**	**H**	**H**	**A**	**A**
PE0-04	**A**	**H**	**A**	**A**	**H**	**A**	**A**	**A**	**H**	**H**
PEO-05	**A**	**A**	**A**	**A**	**H**	**H**	**H**	**H**	**A**	**H**

H- Highly Associated A- Associated Not – Not Associated

Mapping of Graduate Attributes and Programme Outcomes (PO)

GAs / POs	GA-01	GA-02	GA-03	GA-04	GA-05	GA-06	GA-07	GA-08	GA-09	GA-10
PO-A	**H**	**A**	**A**	**H**	**A**	**A**	**H**	**A**	**A**	**H**
PO-B	**A**	**A**	**A**	**A**	A	**A**	**A**	**A**	**A**	**A**
PO-C	**H**	**H**	**A**	**A**	**A**	**H**	**H**	**H**	**A**	**A**
P0-D	**A**	**A**	**H**	**H**	**H**	**A**	**A**	**A**	**H**	**H**
PO-E	**H**	**H**	**A**	**H**	**A**	**A**	**H**	**H**	**A**	**H**
PO-F	**H**	**A**	**A**	**A**	**H**	**A**	**A**	**H**	**H**	**A**
PO-G	**H**	**A**	**A**	**H**	**A**	**A**	**H**	**A**	**A**	**H**
PO-H	**A**	**A**	**A**	**A**	A	**A**	**A**	**A**	**A**	**A**
PO-I	**H**	**H**	**A**	**A**	**A**	**H**	**H**	**H**	**A**	**A**
PO-J	**H**	**H**	**A**	**H**	**A**	**A**	**H**	**H**	**A**	**H**

H- Highly Associated A- Associated Not – Not Associated

Mapping of Programme Educational Objective (PEOs) and Programme Outcomes (POs)

PEO / PO	PEO-01	PEO-02	PEO-03	PEO-04	PEO-05
PO-A	H	H	A	A	H
PO-B	A	A	A	H	H
PO-C	A	H	A	H	A
P0-D	A	H	A	A	A
PO-E	A	H	H	H	H
PO-F	H	A	A	A	H
PO-G	H	A	A	H	H
PO-H	A	H	H	A	A
PO-I	H	A	H	A	A
PO-J	A	A	H	H	H

H- Highly Associated A- Associated Not – Not Associated

Duration of the programme: 2 Years/ 4 Semesters

Total credit: 67

CURRICULUM & SYLLABUS

SEMESTER I

Sl. No	Course Code	Course Title	L	T	P	C
THEORY						
1.	MA3503	Applied Mathematics	3	1	0	4
2.	TE3501	Advanced Fluid Mechanics	3	0	0	3
3.	TE3502	Advanced Thermodynamics	3	0	0	3
4.	TE35XX	Elective I (Core)	3	0	0	3
5.	TE35XX	Elective II (Core)	3	0	0	3
6.	TE35XX	Elective III (Core)	3	0	0	3
PRACTICAL						
7.	TE3571	Thermal Engineering Laboratory - I	0	0	3	1
TOTAL			**18**	**1**	**3**	**20**

SEMESTER II

Sl. No	Course Code	Course Title	L	T	P	C
THEORY						
1.	TE3503	Design of Heat Exchangers	3	0	0	3
2.	TE3504	Advanced Heat and Mass Transfer	3	0	0	3
3.	TE3505	Heating Ventilation Air Conditioning (HVAC)	3	0	0	3
4.	TE3506	Fuels and Combustion	3	0	0	3
5.	TE35XX	Elective IV (Core)	3	0	0	3
6.	TE35XX	Elective V (Core)	3	0	0	3
PRACTICAL						
7.	TE3572	Thermal Engineering Laboratory - II	0	0	3	1
TOTAL			**18**	**0**	**3**	**19**

SEMESTER III

Sl. No	Course Code	Course Title	L	T	P	C
THEORY						
1.	TE3507	Advanced Power Plant Engineering	3	0	0	3
2.	TE35XX	Elective VI (Open)	3	0	0	3
3.		Audit	2	0	0	0
PRACTICAL						
4.	TE35P1	Project work – Phase I	0	0	12	6
TOTAL			**8**	**0**	**12**	**12**

SEMESTER IV

Sl. No	Course Code	Course Title	L	T	P	C
1.	TE35P2	Project work – Phase II	0	0	32	16
TOTAL			**0**	**0**	**32**	**16**

LIST OF ELECTIVES

CORE ELECTIVES

Sl. No	Course Code	Course Title	L	T	P	C
1.	TE35A1	Renewable Energy Systems	3	0	0	3
2.	TE35A2	Cogeneration and Waste Heat Recovery Systems	3	0	0	3
3.	TE35A3	Instrumentation for Thermal system	3	0	0	3
4.	TE35A4	Computational Fluid Dynamics	3	0	0	3
5.	TE35A5	Cold Chain Technology	3	0	0	3
6.	TE35A6	Cryogenic Engineering	3	0	0	3
7.	TE35A7	Air Conditioning System Design	3	0	0	3
8.	TE35A8	Advanced Internal Combustion Engineering	3	0	0	3
9.	TE35A9	Transport phenomena	3	0	0	3

10.	TE35B1	Fluidized Bed System Design	3	0	0	3
11.	TE35B2	Advanced Finite Element Analysis	3	0	0	3
12.	TE35B3	Jet Propulsion And Rocketry	3	0	0	3
13.	TE35B4	Fans, Blowers and Compressors	3	0	0	3

OPEN ELECTIVES

Sl. No	Course Code	Course Title	L	T	P	C
1.	TE35B5	Environmental Pollution and Abatement	3	0	0	3
2.	TE35B6	Technology Management	3	0	0	3
3.	TE35B7	Performance Assessment of Mechanical Equipments	3	0	0	3
4.	TE35B8	Energy Systems Modeling and Analysis	3	0	0	3
5.	GE35A1	Business Analytics	3	0	0	3
6.	GE35A2	Industrial Safety	3	0	0	3
7.	GE35A3	Operations Research	3	0	0	3
8.	GE35A4	Cost Management of Engineering Projects	3	0	0	3
9.	GE35A5	Composite Materials	3	0	0	3
10.	GE35A6	Waste to Energy	3	0	0	3

SEMESTER I

Sl. No	Course Code	Course Title	L	T	P	C
THEORY						
1.	MA3503	Applied Mathematics	3	1	0	4
2.	TE3501	Advanced Fluid Mechanics	3	0	0	3
3.	TE3502	Advanced Thermodynamics	3	0	0	3
4.	TE35XX	Elective I (Core)	3	0	0	3
5.	TE35XX	Elective II (Core)	3	0	0	3
6.	TE35XX	Elective III (Core)	3	0	0	3
PRACTICAL						
7.	TE3571	Thermal Engineering Laboratory - I	0	0	3	1
TOTAL			**18**	**1**	**3**	**20**

MA3503	Applied Mathematics	L	T	P	C
		3	1	0	4

OBJECTIVES

To impart the basic knowledge about Matrices, Transforms, Conformal Mappings and Numerical problems so that those concepts could be adopted in their concerned branch.

Course Outcome		Cognitive Skill
CO-01	Students will gain a comprehensive understanding of generalized eigenvectors and their applications.	R, A, An
CO-02	Ability to solve Isoperimetric Problems using calculus of variations.	R, A, An
CO-03	Understanding the principles and techniques of discrete event simulation.	U, A, An
CO-04	Understanding physical applications of conformal mapping.	U, A, An
CO-05	Understanding the Bender-Schmidt Method for solving one-dimensional wave equations.	U, A, An

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J
CO-01	S	M	M	L	L	N	N	N	M	M
CO-02	S	M	M	L	L	N	N	N	M	M
CO-03	S	M	M	L	L	N	N	N	M	M
CO-04	S	M	M	L	L	N	N	N	M	M
CO-05	S	M	M	L	L	N	N	N	M	M

S-Strong, M- Medium, L-Low, N-Not relevant

Unit I: Advanced Matrix Theory **9**

Generalised Eigen vectors– Jordan canonical form — Matrix norms – Singular value decomposition – Pseudo inverse – Least square approximations – QR decomposition

Unit II: Calculus of Variations **9**

Euler's equation – Functional dependent on first and higher order derivatives – Functional dependent on functions of several independent variables —Isoperimetric Problems.

Unit III: Simulation **9**

Discrete Event Simulation – Stochastic Simulation - Monte Carlo Simulation – Generation of Random Numbers using Congruent method – Applications to Queueing systems.

Unit IV: Conformal Mapping **9**

Schwarz – Christoffel Transformation – Transformation of boundaries in parametric form – Physical applications – Application to fluid flow and heat flow

Unit V: First and Second Order Ordinary and Partial Differential Equations **9**

Solution of first order differential equations – Single step Methods: Taylor's Series – Fourth order Runge-Kutta method – Finite difference solution of one dimensional heat equation: Bender Schmidt Method – One dimensional wave equation – two dimensional Poisson equations.

L: 45 + T: 15, TOTAL: 60 HOURS

REFERENCES:

1. Bronson, R., "Matrix Operations", Schaum's Outline Series, McGraw–Hill, New York, 1989.
2. Spiegel, M.R.," Theory and Problems of complex variables with an introduction to conformal mapping and its applications. Schaum's outline series" McGraw-Hill Book Co, 1964.
3. Gupta, A.S., "Calculus of Variations with Applications", Prentice-Hall of India, New Delhi, 1997.

4. Dr.Venkataraman, M.K., "Higher Mathematics for Engineering and Science", National Publishing Company, 1992.
5. Jain M.K., Iyengar. S.R.K and Jain. R.K, "Numerical method for scientific and Engineering Computations", New Age International (P) Ltd., Publishers, 2003.
6. Grewal B.S., "Higher Engineering Mathematics"- 40th Edition, Khanna Publishers, Delhi 2007.
7. Taha, H.A. "Operations Research: An Introduction", Ninth Edition, Pearson Education Edition, Asia, New Delhi, 2002.
8. K Sharma "Operations Research" Macmillan, 2003.

TE3501	Advanced Fluid Mechanics	L	T	P	C
		3	0	0	3

OBJECTIVES

This course is intended to consolidate your knowledge of fluid mechanics and to develop a critical and mature approach to the subject. It will supply the background preparation for more specialized courses on fluid mechanics.

Course Outcome		Cognitive Skill
CO-01	Students learn about governing equations and potential flow.	R, U
CO-02	Students learn about boundary layer equations.	A, U
CO-03	Students learn about turbulent flow.	A, U
CO-04	Students learn about compressible flows.	A, U
CO-05	Students learn about introduction to CFD.	A, U

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J
CO-01	S	M	S	M	M	S	N	N	L	M
CO-02	S	M	S	M	M	S	N	N	L	M
CO-03	S	M	S	M	M	S	N	N	L	M
CO-04	S	M	S	M	M	S	N	N	L	M
CO-05	S	M	S	M	M	S	N	N	L	M

S-Strong, M- Medium, L-Low, N-Not relevant

Unit I: Governing Equations & Potential Flow **9**

Reynolds transport theorem – Integral and differential forms of governing equations: mass, momentum and energy conservation equations – Navier-Stokes equations – Euler's equation – Bernoulli's Equation – Revisit of fluid kinematics – Stream and Velocity potential function – Circulation – Irrotational vortex – Basic plane potential flows: Uniform stream; Source and Sink; Vortex flow, Doublet, Superposition of basic plane potential flows – Flow past a circular cylinder – Magnus effect – Kutta-Joukowski lift theorem – Concept of lift and drag.

Unit II: Boundary Layer **9**

Boundary layer equations – Boundary layer thickness – Boundary layer on a flat plate – similarity solutions – Integral form of boundary layer equations – Approximate Methods – Flow separation – Entry flow into a duct.

Unit III: Turbulent Flow **9**

Introduction – Fluctuations and time-averaging – General equations of turbulent flow – Turbulent boundary layer equation – Flat plate turbulent boundary layer – Turbulent pipe flow – Prandtl mixing hypothesis – Turbulence modeling – Free turbulent flows.

Unit IV: Compressible Flows **9**

Speed of sound – Mach number – Basic equations for one dimensional flows – Isentropic relations – Normal-shock wave – Rankine-Hugoniot relations – Fanno and Rayleigh curve – Mach waves – Oblique shock wave – Prandtl-Meyer expansion waves – Quasi-one dimensional flows – Compressible viscous flows – Compressible boundary layers.

Unit V: Introduction to CFD **9**

Boundary conditions – Basic discretization – Finite difference method – Finite volume method – Finite element method.

TOTAL: 45 HOURS

REFERENCES:

1. Currie, LG., Fundamental Mechanics of Fluids, 3rd ed., CRC Press, 2002.
2. White, P.M., Viscous Fluid Flow, 2nd ed., McGraw-Hill, 1991.
3. Ockendon, H. and Ockendon, J., Viscous Flow, Cambridge Uni. Press 1995.
4. Shapiro A. F, The Dynamics of Compressible flow Vd 1, The Ronald Press Company 1963.
5. Shames, Mechanics of Fluids, MC grow Hill 1962 Book Company 1962.
6. Schlichting H, Boundary layer theory MC Grow Hill Book company 1979.
7. Hoffmann, K.A. and Chiang, S.T., Computational Fluid Dynamics for Engineers, Engineering Education Systems, 2000.

TE3502	Advanced Thermodynamics	L	T	P	C
		3	0	0	3

OBJECTIVES

- To Analyze the equilibrium and kinetics of combustion of different fuels
- To Apply the fundamental principles of thermodynamics to numerous engineering devices
- To use a systems approach to simplify a complex problem.

Course Outcome		Cognitive Skill
CO-01	Study the Availability analysis of simple cycles, Maxwell relations, Cp and CV Clausius Clayperon equation	A, An, E
CO-02	Understand the fugacity, Kesler generalized three parameter tables, Partial molar properties, Gibbs phase rule for non – reactive components.	A, An, E
CO-03	To understand the First law analysis of reacting systems, Second law analysis of reacting systems - Criterion for reaction equilibrium.	A, An, E
CO-04	To study the energy states and energy levels, macro and microscales, Tetrode equation, Rigid rotor harmonic – oscillator approximation	A, An, E
CO-05	To study the Irrevesible processes, Phenomenological laws, Application of onsager - reciprocal relations, Seebeek effect, Peltier effect	A, An, E

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J
CO-01	S	M	S	M	M	S	N	N	L	M
CO-02	S	M	S	M	M	S	N	N	L	M
CO-03	S	M	S	M	M	S	N	N	L	M
CO-04	S	M	S	M	M	S	N	N	L	M
CO-05	S	M	S	M	M	S	N	N	L	M

S-Strong, M- Medium, L-Low, N-Not relevant

Unit I: Availability Analysis and Thermodynamic Property Relations 9

Reversible work – availability – irreversibility and second – law efficiency for a closed system and steady – state control volume – Availability analysis of simple cycles – Thermodynamic potentials – Maxwell relations – Generalized relations for changes in entropy - internal energy

and enthalpy - generalized relations for Cp and CV Clausius Clayperon equation – Joule – Thomson coefficient – Bridgeman tables for thermodynamic relations.

Unit II: Multi Component Systems **9**

Different equations of state – fugacity – compressibility – principle of corresponding States - Use of generalized charts for enthalpy and entropy departure – fugacity coefficient – Lee- Kesler generalized three parameter tables – Fundamental property relations for systems of variable composition – Partial molar properties – Real gas mixtures - Ideal solution of real gases and liquid - activity - equilibrium in multi phase systems - Gibbs phase rule for non – reactive components.

Unit III: Chemical Thermodynamics and Equilibrium **9**

Thermo chemistry - First law analysis of reacting systems - Adiabatic flame temperature - entropy change of reacting systems - Second law analysis of reacting systems - Criterion for reaction equilibrium – Equilibrium constant for gaseous mixtures - evaluation of equilibrium composition.

Unit IV: Statistical Thermodynamics **9**

Statistical thermodynamics – introduction – energy states and energy levels – macro and micro scales – thermodynamic probability – Ideal Monatomic gas – Partition function, Calculation of the translational properties of an ideal monatomic gas – Sector - Tetrode equation – Potential energy function for a diatomic molecule – Rigid rotor harmonic – oscillator approximation – Rotational and vibrational partition functions of ideal polyatomic gases.

Unit V: Thermodynamic of Irreversible Processes **9**

Irrevesible processes – Phenomenological laws – Application of onsager - reciprocal relations – Seebeek effect – Peltier effect – Thompson effect – Conjugate fluxes and forces - entropy production – thermo – electric phenomena – formulations.

TOTAL: 45 HOURS

REFERENCES:

1. Kenneth Wark Jr., Advanced Thermodynamics for Engineers, McGraw-Hill Inc., 1995.
2. Bejan, A., Advanced Engineering Thermodynamics, John Wiley and Sons, 1998.
3. Holman, J.P., Thermodynamics, Fourth Ediction, McGraw-Hill Inc., 1998.
4. Smith, J.M and Van Ness., H.C., Introduction to chemical Engineering Thermodynamics, Fourth Edition, McGraw-Hill Inc., 1987.
5. Sonntag, R.E., and Vann Wylen, G, Introduction to Thermodynamics, Classical and Statistical, third Edition, John Wiley and Sons, 1991.
6. Sears, F.W. and Salinger G.I., Thermodynamics, Kinetic Theory and Statistical Thermodynamics, third Edition, Narosa Publishing House, New Delhi, 1993.
7. DeHoft, R.T. Thermodynamics in Materials Science, McGraw-Hill Inc., 1993.
8. Rao, Y.V.C., Postulational and Statistical thermodynamics, Allied Publisher Limited, New Delhi, 1994.

TE3571	Thermal Engineering Laboratory – I	L	T	P	C
		0	0	3	1

OBJECTIVES

- To determine the efficiency of boiler and Pumps
- To determine the COP of cooling towers and heat exchangers.

Course Outcome		Cognitive Skill
CO-01	Students will study the heat exchangers, variable speed drives, diesel generator set solar collector	A, An, E
CO-02	Students will determine the efficiency of boiler and pumping system	A, An, E
CO-03	Students will find COP of cooling towers	A, An, E
CO-04	Students will measure the power factor for the electrical utilities	A, An, E
CO-05	Students will calculate the performance evaluation of blower, air compressor s4-cylinder 4-stroke petrol engine and Flue gas analysis of petrol, diesel and LPG Engines.	A, An, E

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J
CO-01	S	S	S	S	S	S	N	N	M	M
CO-02	S	S	S	S	S	S	N	N	M	M
CO-03	S	S	S	S	S	S	N	N	M	M
CO-04	S	S	S	S	S	S	N	N	M	M
CO-05	S	S	S	S	S	S	N	N	M	M

S-Strong, M- Medium, L-Low, N-Not relevant

EXERCISES:

1. Determination of efficiency of boiler
2. Study of heat exchangers.
3. Study of variable speed drives
4. COP of cooling towers.

5. Study of diesel generator set.
6. Measurement of load and power factor for the electrical utilities.
7. Determination of efficiency of pumping system.
8. Performance evaluation of blower
9. Performance evaluation of air compressors
10. Study of solar collector.
11. Flue gas analysis of petrol, diesel and LPG Engines.
12. Performance trial on 4-cylinder 4-stroke petrol engine

TOTAL: 45 HOURS

SEMESTER II

Sl. No	Course Code	Course Title	L	T	P	C
THEORY						
1.	TE3503	Design of Heat Exchangers	3	0	0	3
2.	TE3504	Advanced Heat and Mass Transfer	3	0	0	3
3.	TE3505	Heating Ventilation Air Conditioning (HVAC)	3	0	0	3
4.	TE3506	Fuels and Combustion	3	0	0	3
5.	TExxx4	Elective IV (Core)	3	0	0	3
6.	TExxx5	Elective V (Core)	3	0	0	3
PRACTICAL						
7.	TE3572	Thermal Engineering Laboratory - II	0	0	3	1
TOTAL			**18**	**0**	**3**	**19**

TE3503	Design of Heat Exchangers	L	T	P	C
		3	0	0	3

OBJECTIVES

- Understanding of chemical engineering and its relation to other disciplines
- Ability to list chemical processes, units, and the corresponding equipments
- Awareness of career options, potential job functions, contemporary and professional issues.
- Familiarity with computer applications in process industries

Course Outcome		Cognitive Skill
CO-01	students should be able to : have knowledge of advanced features of fluid mechanics, thermodynamics, heat and momentum transfer pertaining to thermo-fluid problem	U, A, An
CO-02	Understand the significance of course content for thermo-fluid problems,	U, A, An
CO-03	Apply knowledge in analysis and interpretation of thermo-fluid problem	U, A, An
CO-04	Analyze and evaluate an existing thermal system and recommend their ideas.	U, A, An
CO-05	Ability to design and analyze reactor heating and cooling systems	U, A, An

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J
CO-01	S	M	S	M	M	S	N	N	L	M
CO-02	S	M	S	M	M	S	N	N	L	M
CO-03	S	M	S	M	M	S	N	N	L	M
CO-04	S	M	S	M	M	S	N	N	L	M
CO-05	S	M	S	M	M	S	N	N	L	M

S-Strong, M- Medium, L-Low, N-Not relevant

Unit I: Constructional Details and Heat Transfer 9

Types - Shell and Tube Heat Exchangers - Regenerators and Recuperators - Industrial Applications Temperature Distribution and its Implications - LMTD - Effectiveness – NTU method.

Unit II: Flow Distribution and Stress Analysis 9

Effect of Turbulence - Friction Factor - Pressure Loss - Channel Divergence Stresses in Tubes - Heater Sheets and Pressure Vessels - Thermal Stresses - Shear Stresses - Types of Failures

Unit III: Design Aspects 9

Heat Transfer and Pressure Loss - Flow Configuration - Effect of Baffles - Effect of Deviations from Ideality - Design of Typical Liquid - Gas-Gas-Liquid Heat Exchangers , Design of Surface and Evaporative Condensers - Shell and Tube Heat Exchangers – Kern Method – Bell Delware method -- The stream analysis method

Unit IV: Recent Developments in Heat Exchangers 9

Codes of mechanical design of heat exchanger - Network of Heat exchangers - Computerized methods for design and analysis of Heat Exchangers - Power plant heat exchanger - heat exchanger for heat recovery at low - medium and high temperatures

Unit V: Cooling Towers 9

Types – counter flow – cross flow - Packings - Spray Design - Selection of Pumps - Fans and Pipes - Testing and Maintenance - Experimental Methods – Types of draft – natural and forced.

TOTAL: 45 HOURS

REFERENCES:

1. T. Taborek, G.F. Hewitt and N.Afgan, Heat Exchangers, Theory and Practice, McGraw Hill Book Company, 1980
2. Walker, Industrial Heat Exchangers - A Basic Guide, McGraw Hill Book Co., 1980
3. Nicholas Cheremisioff, Cooling Tower, Ann Arbor Science Pub 1981
4. Arthur P.Fraas, Heat Exchanger Design, John Wiley & Sons, 1988
5. Kern D.Q., Process Heat transfer, Tata McGraw -Hill, New Delhi, 1999.

TE3504	Advanced Heat and Mass Transfer	L	T	P	C
		3	0	0	3

OBJECTIVES

- Understand fundamentals of heat and mass transfer
- Understand the 2D and 3D heat and mass transfer principles
- Understand heat convection and mass diffusion principles
- Understand the transient heat transfer problem
- Understand radiation heat transfer principles

Course Outcome		Cognitive Skill
CO-01	Understand the basic laws of heat transfer	U, A, An
CO-02	Account for the consequence of heat transfer in thermal analyses of engineering systems.	U, A, An
CO-03	Analyze problems involving steady state heat conduction in simple geometries.	U, A, An
CO-04	Develop solutions for transient heat conduction in simple geometries.	U, A, An
CO-05	Obtain numerical solutions for conduction and radiation heat transfer problems.	U, A, An

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J
CO-01	S	M	S	M	M	S	N	N	L	M
CO-02	S	M	S	M	M	S	N	N	L	M
CO-03	S	M	S	M	M	S	N	N	L	M
CO-04	S	M	S	M	M	S	N	N	L	M
CO-05	S	M	S	M	M	S	N	N	L	M

S-Strong, M- Medium, L-Low, N-Not relevant

Unit I: Conduction and Radiation Heat Transfer **9**

One dimensional energy equations – boundary condition – three-dimensional heat conduction equations – extended surface heat transfer – Conduction with moving boundaries – Radiation in gases and vapour – Gas radiation and radiation heat transfer in enclosures containing absorbing and emitting media – interaction of radiation with conduction and convection.

Unit II: Turbulent Forced Convective Heat Transfer **9**

Momentum and Energy Equations – Turbulent Boundary Layer Heat Transfer – Mixing length concept – Turbulence Model – K Є Model – Analogy between Heat and Momentum Transfer – Reynolds, Colburn, Prandtl Turbulent flow in a Tube – High speed flows.

Unit III: Phase Change Heat Transfer and Heat Exchanger **9**

Condensation with shear edge on bank of tubes – Boiling – pool and flow boiling – Heat exchanger – Є – NTU approach – design procedure – compact heat exchangers.

Unit IV: Numerical Methods in Heat Transfer **9**

Finite difference formulation of steady and transient heat conduction problems – Discretization schemes – Explicit, Crank Nicolson and Fully Implicit schemes – Control volume formulation – Steady one dimensional convection – Diffusion Problems – Calculation of the flow field – SIMPLER Algorithm.

Unit V: Mass Transfer and Engine Heat Transfer Correlation **9**

Mass Transfer – Vaporization of droplets – Combined heat and mass transfer – Heat Transfer Correlations in various applications like I.C. Engines, Compressors & turbines.

TOTAL: 45 HOURS

REFERENCES:

1. Incropera F.P. and DeWitt. D.P., Fundamentals of Heat & Mass Transfer, John Wiley & Sons, 1996.
2. Ozisik. M.N., Heat Transfer – Basic Approach, McGraw-Hill Co., 1985.
3. Schlichting, Gersten, Boundarylayer Theory, Springer, 2000.
4. P.K. Nag, Heat Transfer, Tata McGraw-Hill, 2002.
5. Rohsenow. W.M., Harnett. J.P., and Ganic. E.N., Handbook of Heat Transfer Applications, McGraw-Hill, NY1985.
6. Ghoshdasdidar. P.S., Compiler simulation of flow and Heat Transfer, Tata McGraw-Hill, 1998.
7. Patankar. S.V.Numerical heat Transfer and Fluid flow, Hemisphere Publishing Corporation, 1980.

TE3505	Heating Ventilation Air Conditioning	L	T	P	C
		3	0	0	3

OBJECTIVES

Have the students understand the application of basic thermodynamics, fluid mechanics and heat transfer in sizing HVAC systems and estimating their operating costs, and have the students perform HVAC load and energy calculation.

Course Outcome		Cognitive Skill
CO-01	Read and interpret electrical diagrams, wire control systems from electrical diagrams, set controls, design controls systems and diagnose and repair faults in electrical control systems	A, An, E
CO-02	Properly size HVAC systems, design HVAC systems, correctly install HVAC system components, install HVAC systems following the relevant codes and industry practice	A, An, E
CO-03	Articulate the purpose and operation of HVAC system components, the operation of HVAC systems, diagnose, repair faults and perform maintenance on HVAC systems	A, An, E
CO-04	Demonstrate positive work traits and good customer skills, and continue to upgrade their knowledge and skills	A, An, E
CO-05	Read and interpret electrical diagrams, wire control systems from electrical diagrams, set controls, design controls systems and diagnose and repair faults in electrical control systems	A, An, E

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J
CO-01	S	M	S	M	M	S	N	N	L	M
CO-02	S	M	S	M	M	S	N	N	L	M
CO-03	S	M	S	M	M	S	N	N	L	M
CO-04	S	M	S	M	M	S	N	N	L	M
CO-05	S	M	S	M	M	S	N	N	L	M

S-Strong, M- Medium, L-Low, N-Not relevant

Unit I: Electrical Controls for HVAC **6**

Installation of Heating - Cooling and Refrigeration Systems - Basic Electric Motors - Electronic Control Devices – Residential Air-Conditioning Control Systems

Unit II: Air Distribution Systems **7**

Diffuser Design and Selection - Diffuser Design and Selection – Diffuser - Operational Principles - Zone Location - Selection Criteria; Device Selection - Fan (Air Pump) Selection, System, Effects on Performance, Field Testing - Fan Output Controls and Energy Utilization; Pressure Loss in Ducts and Fittings - Duct System Design - Equal Friction Method; Comparison of Different Design Solutions - Energy Simulations

Unit III: Hydronic Systems **8**

Flow Regimes, HVAC Systems; Conservation of Energy Applied to Flows – System Characteristic Constants – Flow Measurements - Velocity Profiles – Total Flow – Centrifugal Pumps – Operating Characteristics – Selection – Pipe System Fundamentals –Fitting Coefficients & Equivalent Length Estimations of ΔP-system – Effects of Dissolved Gases on Hydronic System Performance – Temperature Induced Expansion Effects – 2-way & 3-way Valves – Common Pipe – Commercial Systems – Steam System Design

Unit IV: Introduction to Heating Fundamentals & Heat Loss and Heat Gain Calculations **12**

Types of automatic controls – Space temperature controls – Pressure controls – Introduction to motor control device – Portable electric heating devices – Sequencers – electric duct heater – Gun-type oil burners – Fuel oil pumps – Ventilation – Air Cleaning – Duct cleaning – Humidification – Heating Load – Wall Moisture –Introduction of Design Problem – Cooling Principles / Solar – Residential Cooling Loads.

Unit V: Advanced Refrigeration **12**

Compression Cycles – Environmental Chemistry of Refrigerants - Global Warming – Ozone Depletion – Potential Environmental Impacts of Refrigerants – Absorption Cooling – Principles of Operation – CO_2 systems – Cascade refrigeration system – Trans critical system – CO_2 – NH_3 System – CO_2 – HFC System – Gas cooler used in CO_2 system

TOTAL: 45 HOURS

TEXT BOOKS

1. F.C. McQuiston, J.D. Parker, and J.D. Spitler, 2005. Heating, Ventilating and Air-Conditioning – Analysis and Design, Sixth Edition, John Wiley & Sons, Inc.
2. Principles of Heating, Ventilating and Air Conditioning. Ronald Howell, Harry Sauer and William Coad. 1998. American Society of Heating, Refrigerating and Air-Conditioning Engineers. Atlanta. http://www.ashrae.org/
3. ASHRAE Handbook – Fundamentals. ASHRAE.

TE3506	FUELS AND COMBUSTION	L	T	P	C
		3	0	0	3

OBJECTIVES

To make the student understand

- Solid, liquid and gaseous fuel properties, analysis, process and handling
- A stoichiometry relation, the combustion process, features of different types of burners.
- About emissions

Course Outcome		Cognitive Skill
CO-01	Interpret and distinguish between the different types of conventional and non-conventional fuels.	R, U
CO-02	Demonstrate the utilization of synthetic and substitute fuels for practical applications.	An, R, U
CO-03	Describe various parameters that are utilized to characterize fuels and its combustion process.	An, R, U
CO-04	Analyze the kinetic mechanism involved in combustion and chemical reaction	An, R, U
CO-05	Differentiate between diffusion and premixed flame and their utilization in combustion devices	An, R, U

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J
CO-01	L	M	M	M	L	M	N	N	S	M
CO-02	L	M	M	M	L	M	N	N	S	M
CO-03	L	M	M	M	L	M	N	N	S	M
CO-04	L	M	M	M	L	M	N	N	S	M
CO-05	L	M	M	M	L	M	N	N	S	M

S-Strong, M- Medium, L-Low, N-Not relevant

Unit I: Characterization 9

Fuels - Types and Characteristics of Fuels - Determination of Properties of Fuels - Fuels Analysis - Proximate and Ultimate Analysis - Moisture Determination - Calorific Value - Gross & Net Calorific Values - Calorimetry - DuLong's Formula for CV Estimation - Flue gas Analysis - Orsat Apparatus - Fuel & Ash Storage & Handling - Spontaneous Ignition Temperatures.

Unit II: Solid Fuels & Liquid Fuels 9

(a) Solid Fuels

Types - Coal Family - Properties - Calorific Value - ROM, DMMF, DAF and Bone Dry Basis - Ranking - Bulk & Apparent Density - Storage - Washability - Coking & Caking Coals - Renewable Solid Fuels - Biomass - Wood Waste - Agro Fuels - Manufactured Solid Fuels.

(b) Liquid Fuels

Types - Sources - Petroleum Fractions - Classification - Refining - Properties of Liquid Fuels - Calorific Value, Specific Gravity, Flash & Fire Point, Octane Number, Cetane Number etc, - Alcohols - Tar Sand Oil - Liquefaction of Solid Fuels.

Unit III: Gaseous Fuels 9

Classification - Composition & Properties - Estimation of Calorific Value - Gas Calorimeter - Rich & Lean Gas - Wobbe Index - Natural Gas - Dry & Wet Natural Gas - Stripped NG - Foul & Sweet NG - LPG - LNG - CNG - Methane - Producer Gas - Gasifiers - Water Gas - Town Gas - Coal Gasification - Gasification Efficiency - Non - Thermal Route - Biogas - Digesters - Reactions - Viability - Economics.

Unit IV: Combustion, Stoichiometry & Kinetics 9

Stoichiometry - Mass Basis & Volume Basis - Excess Air Calculation - Fuel & Flue Gas Compositions - Calculations - Rapid Methods - Combustion Processes - Stationary Flame - Surface or Flameless Combustion - Submerged Combustion - Pulsating & Slow Combustion Explosive Combustion.

Mechanism of Combustion - Ignition & Ignition Energy - Spontaneous Combustion - Flame Propagation - Solid, Liquid & Gaseous Fuels Combustion - Flame Temperature - Theoretical, Adiabatic & Actual - Ignition Limits - Limits of Inflammability.

Unit V: Combustion Equipments 9

Coal Burning Equipments - Types - Pulverized Coal Firing - Fluidized Bed Firing - Fixed Bed & Recycled Bed - Cyclone Firing - Spreader Stokers - Vibrating Grate Stokers - Sprinkler Stokers, Traveling Grate Stokers

Oil Burners - Vaporizing Burners, Atomizing Burners - Design of Burners. Gas Burners - Atmospheric Gas Burners - Air Aspiration Gas Burners - Burners Classification according to Flame Structures - Factors Affecting Burners & Combustion.

TOTAL: 45 HOURS

REFERENCES:

1. Samir Sarkar, Fuels & Combustion, 2nd Edition, Orient Longman, 1990
2. Bhatt, Vora Stoichiometry, 2nd Edition, Tata Mcgraw Hill, 1984
3. Blokh AG,Heat Transfer in Steam Boiler Furnace, Hemisphere Publishing Corpn, 1988
4. Civil Davies, Calculations in Furnace Technology, Pergamon Press, Oxford, 1966
5. Sharma SP, Mohan Chander, Fuels & Combustion, Tata Mcgraw Hill, 1984.

TE3572	Thermal Engineering Laboratory – II	L	T	P	C
		0	0	3	1

OBJECTIVES

To make the student understand

Pressure Measurements, Flow Measurements and modes of Heat Transfer

Course Outcome		Cognitive Skill
CO-01	After the completion of the course, students should be able to: Identify the various fuel characterizations through experimental testing	An, R, U
CO-02	Analyze the performance characteristics of an internal combustion engines	An, R, U
CO-03	Evaluate the performance parameters of refrigeration systems	An, R, U
CO-04	Analyze the air compressor characteristics	An, R, U
CO-05	After the completion of the course, students should be able to: Identify the various fuel characterizations through experimental testing	An, R, U

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J
CO-01	S	S	S	S	S	S	N	N	M	M
CO-02	S	S	S	S	S	S	N	N	M	M
CO-03	S	S	S	S	S	S	N	N	M	M
CO-04	S	S	S	S	S	S	N	N	M	M
CO-05	S	S	S	S	S	S	N	N	M	M

S-Strong, M- Medium, L-Low, N-Not relevant

EXPERIMENTS:

1. Flow past an aero foil: Pressure measurements.
2. Numerical Simulation of Flow through a converging-diverging nozzle: subsonic and supersonic flows
3. Friction factor determination: incompressible flow through pipes/ducts
4. Visit report on (Any Two) (a) Cold Storage,(b) Ice Plant,(c) Dairy,(d) Pharmaceutical
5. Laminar/Turbulent boundary layer over a flat plate.
6. Steady State Conduction in Solid
7. Steady State Convection in Solid
8. Steady State Radiation in Solid
9. Steady state conduction in Fluids
10. Steady state convection in Fluids
11. Energy system simulations

TOTAL: 45 HOURS

LIST OF ELECTIVES

CORE ELECTIVES

Sl. No	Course Code	Course Title	L	T	P	C
1.	TE35A1	Renewable Energy Systems	3	0	0	3
2.	TE35A2	Cogeneration and Waste Heat Recovery Systems	3	0	0	3
3.	TE35A3	Instrumentation for Thermal system	3	0	0	3
4.	TE35A4	Computational Fluid Dynamics	3	0	0	3
5.	TE35A5	Cold Chain Technology	3	0	0	3
6.	TE35A6	Cryogenic Engineering	3	0	0	3
7.	TE35A7	Air Conditioning System Design	3	0	0	3
8.	TE35A8	Advanced Internal Combustion Engineering	3	0	0	3
9.	TE35A9	Transport phenomena	3	0	0	3
10.	TE35B1	Fluidized Bed System Design	3	0	0	3
11.	TE35B2	Advanced Finite Element Analysis	3	0	0	3
12.	TE35B3	Jet Propulsion And Rocketry	3	0	0	3
13.	TE35B4	Fans, Blowers and Compressors	3	0	0	3

TE35A1	Renewable Energy Systems	L	T	P	C
		3	0	0	3

OBJECTIVES

- Understand the various forms of conventional energy resources.
- Learn the present energy scenario and the need for energy conservation
- Explain the concept of various forms of renewable energy
- Outline division aspects and utilization of renewable energy sources for both domestics and industrial application
- Analyze the environmental aspects of renewable energy resources.

Course Outcome		Cognitive Skill
CO-01	To study the energy scenario like energy sources classification, needs	U, R
CO-02	To understand the solar energy like solar thermal systems, photovoltaic tech.	U, R
CO-03	To understand the wind energy like turbine, operation control	U, R
CO-04	To study other energy sources like biomass, tidal, geothermal	U, R
CO-05	To study energy storage and grid systems	U, R

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J
CO-01	L	M	M	M	L	M	N	N	S	M
CO-02	L	M	M	M	L	M	N	N	S	M
CO-03	L	M	M	M	L	M	N	N	S	M
CO-04	L	M	M	M	L	M	N	N	S	M
CO-05	L	M	M	M	L	M	N	N	S	M

S-Strong, M- Medium, L-Low, N-Not relevant

Unit I: Energy Scenario **9**

Energy Scenario - Classification of Energy Sources - Energy resources (Conventional and non-conventional) - Energy needs of India - energy consumption patterns - Worldwide Potentials of these sources - Energy efficiency and energy security - Energy and its environmental impacts - Global environmental concern - Kyoto Protocol - Concept of Clean Development Mechanism (CDM) and Prototype Carbon Funds (PCF) - Factors favoring and against renewable energy sources - IRP

Unit II: Solar Energy **9**

Solar thermal Systems - Types of collectors - Collection systems - efficiency calculations – applications - Photo voltaic (PV) technology - Present status - solar cells - cell technologies - characteristics of PV systems - equivalent circuit - array design - building integrated PV system - its components - sizing and economics - Peak power operation - Standalone and grid interactive systems.

Unit III: Wind Energy **9**

Wind Energy - wind speed and power relation - power extracted from wind - wind distribution - wind speed predictions - Wind power systems - system components - Types of Turbine - Turbine rating Choice of generators - turbine rating - electrical load matching - Variable speed operation - maximum power operation - control systems - system design features - stand alone and grid connected operation.

Unit IV: Other Energy Sources **9**

Biomass – various resources - energy contents - technological advancements - conversion of biomass in other form of energy – solid, liquid and gases – Gasifiers - Biomass fired boilers – Cofiring - Generation from municipal solid waste - Issues in harnessing these sources - Hydro energy – feasibility of small, mini and micro hydel plants - scheme layout economics - Tidal - wave energy - Geothermal - Ocean-thermal energy conversion (OTEC) systems – schemes, feasibility and viability

Unit V: Energy Storage and Grid Systems **9**

Energy storage: Battery – types, equivalent circuit - performance characteristics - battery design - charging and charge regulators - Battery management - Fly wheel energy relations – components - benefits over battery - Fuel Cell energy storage systems - Ultra Capacitors - Stand alone systems - Hybrid systems – hybrid with diesel - with fuel cell – solarwind - wind – hydro systems - mode controller - load sharing - system sizing - Hybrid system economics - Grid integration with the system - Interface requirements - Stable operation - Transient-safety - Operating limits of voltage – frequency - stability margin - energy storage - and load scheduling - Effect on power quality - harmonic distortion - voltage transients and sags - voltage flickers - Dynamic reactive power support -Systems stiffness.

TOTAL: 45 HOURS

REFERENCES:

1. Renewable energy technologies - R. Ramesh, Narosa Publication.
2. Energy Technology – S. Rao, Parulkar
3. Non-conventional Energy Systems – Mittal, Wheelers Publication.
4. Wind and solar systems by Mukund Patel, CRC Press.
5. Solar Photovoltaics for terrestrials, Tapan Bhattacharya.
6. Wind Energy Technology – Njenkins, John Wiley & Sons,
7. Solar & Wind energy Technologies – McNeils, Frenkel, Desai, Wiley Eastern.
8. Solar Energy – S.P. Sukhatme, Tata McGraw Hill.
9. Solar Energy – S. Bandopadhay, Universal Publishing.
10. Guide book for National Certification Examination for EM/EA – Book 1.

TE35A2	Cogeneration and Waste Heat Recovery Systems	L	T	P	C
		3	0	0	3

OBJECTIVES

Primary objective of the course is to introduce students the basis of the Exergy Analysis which is an emerging area in the field of energy science and engineering.

Course Outcome		Cognitive Skill
CO-01	Students will understand the cogeneration power plant.	U, R
CO-02	Students will study the application & techno economics of cogeneration.	U, R
CO-03	Students will identify the issues in cogeneration.	U, R
CO-04	Students will study the waste heat recovery system.	U, R
CO-05	Students will understand the environmental considerations in cogeneration.	U, R

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J
CO-01	L	M	M	M	L	M	N	N	S	M
CO-02	L	M	M	M	L	M	N	N	S	M
CO-03	L	M	M	M	L	M	N	N	S	M
CO-04	L	M	M	M	L	M	N	N	S	M
CO-05	L	M	M	M	L	M	N	N	S	M

S-Strong, M- Medium, L-Low, N-Not relevant

Unit I: Cogeneration **9**

Definition – need – application – advantages – classification - energy saving - performance terms - field testing procedure - diesel generating system-factors affecting selection - energy performance assessment of diesel conservation avenues - trends in different Cogeneration power plants.

Unit II: Application & Techno Economics of Cogeneration **9**

Cogeneration Application in various industries like Cement - Sugar Mill - Paper Mill etc - Sizing of waste heat boilers – Performance calculations - Part load characteristics selection of Cogeneration Technologies – Financial considerations – Operating and Investments – Costs of Cogeneration

Unit III: Issues in Cogeneration **9**

Cogeneration plants electrical interconnection issues – utility and plant interconnection issues – applications of Cogeneration in utility sector – industrial sector – building sector – rural sector – impacts of Cogeneration plants – fuel, electricity and environment.

Unit IV: Waste Heat Recovery **9**

Introduction - Principles of Thermodynamics and Second Law - sources of Waste Heat recovery - Diesel engines and Power Plant etc. Selection criteria for waste heat recovery technologies – recuperators – Regenerators – economizers – plate heat exchangers – thermic fluid heaters – Waste heat boilers – classification, location, service conditions, design Considerations – fluidized bed heat exchangers – heat pipe exchangers – heat pumps – sorption systems.

Unit V: Environmental Considerations **9**

Investment cost – economic concepts – measures of economic performance – procedure for economic analysis – examples – procedure for optimized system selection and design – load curves – sensitivity analysis – regulatory and financial frame work for Cogeneration.

TOTAL: 45 HOURS

REFERENCES:

1. Charles H.Butler, Cogeneration, McGraw Hill Book Co., 1984.
2. Horlock JH, Cogeneration - Heat and Power, Thermodynamics and Economics, Oxford, 1987.
3. Institute of Fuel, London, Waste Heat Recovery, Chapman & Hall Publishers, London, 1963.
4. Sengupta Subrata, Lee SS EDS, Waste Heat Utilization and Management, Hemisphere, Washington, 1983.
5. De Nevers, Noel, Air Pollution Control Engineering, McGrawHill, New York, 1995.

TE35A3	Instrumentation for Thermal Systems	L	T	P	C
		3	0	0	3

OBJECTIVES

- To provide knowledge on various measuring instruments.
- To provide knowledge on advance measurement techniques.
- To understand the various steps involved in error analysis and uncertainty.

Course Outcome		Cognitive Skill
CO-01	To provide the knowledge on various measuring instruments	U, R
CO-02	To provide the knowledge on advance measuring instruments	U, R
CO-03	To understand the various steps involved in error analysis and uncertainty	U, R
CO-04	To provide the knowledge on various control systems	U, R
CO-05	To understand the applications of instrumentation for thermal systems	U, R

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J
CO-01	S	M	S	M	M	S	N	N	L	M
CO-02	S	M	S	M	M	S	N	N	L	M
CO-03	S	M	S	M	M	S	N	N	L	M
CO-04	S	M	S	M	M	S	N	N	L	M
CO-05	S	M	S	M	M	S	N	N	L	M

S-Strong, M- Medium, L-Low, N-Not relevant

Unit I: Measurement System **9**

Concept of generalized measurement system – system configurations - Errors Problem analyses - Basic characteristics of measuring devices – Calibration – introduction to data acquisition and processing systems – compact data loggers

Unit II: Temperature & Pressure Measurement **9**

Temperature – thermo electric sensors – Thermocouple & electrical resistance- Radiation & optical thermometers – Quartz crystal Thermometers – High speed Temperature probe - Pressure: Variable reluctance & LVDT Type pressure sensors – Knudsen gauge – Thermal conductivity ionization gauge High pressure measurement – Piezo-electric and vibrating elements pressure sensors.

Unit III: Flow Visualisation **9**

Flow: Electromagnetic flow meter – Smoke tube and laser Doppler anemometer - ultrasonic flow meter – Rotor Torque mass flow meter – Flow visualization Techniques – shadow graph – Schilierene Apparatus - Measurement of speed – vibration – humidity - heat flux and time

Unit IV: Properties & Gas Composition Measurement **9**

Mass flow measurement - Density Measurement - Viscosity Measurement - Thermal Conductivity Measurement - Pressure drop Measurement across Heat Exchanger - Flow Measurement

Unit V: Control Systems **9**

Control Systems – Types - block diagrams - performance analysis - signal flow graphs – Hydraulic - Pneumatic and electronic controllers - Transient and steady state response - time domain and Laplace transform representation of P, P + D & P + I control action - frequency response analysis - stability of control systems – applications - Programmable Logical Controllers-programming - applications.

TOTAL: 45 HOURS

REFERENCES:

1. Holman, J.P., Experimental methods for engineers, McGraw-Hill, 1958.
2. Barney, Intelligent Instrumentation, Prentice Hall of India, 1988.
3. Prebrashensky. V., Measurement and Instrumentation in Heat Engineering, Vol.1 and 2 MIR Publishers, 1980.
4. Raman, C.S. Sharma, G.R., Mani, V.S.V., Instrumentation Devices and Systems, Tata McGraw-Hill, New Delhi, 1983.
5. Doeblin, Measurement System Application and Design, McGraw-Hill, 1978.
6. Morris. A.S, Principles of Measurements and Instrumentation Prentice Hall of India, 1998.
7. Nakra B.C. "Theory and Applications of Automatic Controls", New Age International (P) Ltd.,New Delhi.

TE35A4	Computational Fluid Dynamics	L	T	P	C
		3	0	0	3

OBJECTIVES

To understand the important issues and their abatement principles of Fluids

Course Outcome		Cognitive Skill
CO-01	Provide the student with a significant level of experience in the use of modern CFD software for the analysis of complex fluid-flow systems.	U, An, A
CO-02	Improve the student's understanding of the basic principles of fluid mechanics.	U, An, A
CO-03	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 in written form.	U, An, A
CO-04	The student will demonstrate the ability to simplify a real fluid-flow system into a simplified model problem, to select the proper governing equations for the physics involved in the system, to solve for the flow, to investigate the fluid-flow behavior, and to understand the results.	U, An, A
CO-05	The student will demonstrate the ability to communicate the results of this detailed fluid-flow study in a written format.	U, An, A

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J
CO-01	S	M	S	M	M	S	N	N	L	M
CO-02	S	M	S	M	M	S	N	N	L	M
CO-03	S	M	S	M	M	S	N	N	L	M
CO-04	S	M	S	M	M	S	N	N	L	M
CO-05	S	M	S	M	M	S	N	N	L	M

S-Strong, M- Medium, L-Low, N-Not relevant

Unit I: Introduction **9**

Finite difference method - finite volume method - finite element method - governing equations - boundary conditions - Derivation of finite difference equations - Solution methods - Solution methods of elliptical equations — finite difference formulations -interactive solution methods - direct method with Gaussian elimination - Parabolic equations-explicit schemes - Von Neumann stability analysis - implicit schemes - alternating direction implicit schemes - approximate factorization - fractional step methods - direct method with tridiagonal matrix algorithm

Unit II: Hyperbolic Equations **9**

Explicit schemes and Von Neumann stability analysis - implicit schemes - multi step methods - nonlinear problems - second order one-dimensional wave equations - Burgers equations - Explicit and implicit schemes - Runge-Kutta method.

Unit III: Formulations of Incompressible Viscous Flows **9**

Formulations of incompressible viscous flows by finite difference methods - pressure correction methods - vortex methods - Treatment of compressible flows - potential equation - Euler equations - Navier-stokes system of equations - flow field-dependent variation methods - boundary conditions - example problems.

Unit IV: Finite Volume Method **9**

Finite volume method via finite difference method - formulations for two and three-dimensional problems

Unit V: Standard Variational Methods **9**

Linear fluid flow problems - steady state problems -Transient problems

TOTAL: 45 HOURS

REFERENCES:

1. Versteeg, H. K. and Malalasekera, W., An Introduction to Computational Fluid Dynamics: The Finite Volume Method, 2nd Edition, Pearson, 2010.
2. Tannehill, J. C., Anderson, D. A. and Pletcher, R. H., Computational Fluid Mechanics and Heat Transfer,McGraw Hill, 2002.
3. Blazek, J., Computational Fluid Dynamics: Principles and Applications, 2nd Edition, Elsevier Science &Technology, 2006.
4. Chung, T. J., Computational Fluid Dynamics, Cambridge University Press, 2003
5. Text book of fluid dynamics/ Frank Choriton/ CBS Publishers & distributors, 1985
6. Numerical heat transfer and fluid flow / Suhas V. Patankar/ Hema shava Publishers corporation & Mc Graw Hill.
7. Computational Fluid Flow and Heat Transfer/ Muralidaran/ Narosa Publications
8. Fundamentals of Computational Fluid Dynamics/Tapan K. Sengupta / Universities Press.
9. Introduction to Theoretical and Computational Fluid Dynamics/C. Pozrikidis /Oxford University Press/2nd Edition.

TE35A5	Cold Chain Technology	L	T	P	C
		3	0	0	3

OBJECTIVES

- To understand the underlying principles of operation in different cold storage systems and its components.
- To provide knowledge on design aspects of cold storage systems.

Course Outcome		Cognitive Skill
CO-01	Students will understand the general principles of food preservation.	U, R
CO-02	Students will study the water activity and food preservation and preservation through temperature reduction.	U, R
CO-03	Students will identify the issues in dehydration of food.	U, R
CO-04	Students will study the preservation using high sugar and salts.	U, R
CO-05	Students will understand the fermentation process.	U, R

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J
CO-01	L	M	M	M	L	M	N	N	S	M
CO-02	L	M	M	M	L	M	N	N	S	M
CO-03	L	M	M	M	L	M	N	N	S	M
CO-04	L	M	M	M	L	M	N	N	S	M
CO-05	L	M	M	M	L	M	N	N	S	M

S-Strong, M- Medium, L-Low, N-Not relevant

Unit I: General Principles of Food Preservation **9**

Introduction to Process operations – principles - good manufacturing practices - Food Laws and Regulations - Principles of food preservation – Asepsis - removal of microorganisms - Maintenance of anaerobic conditions - Methods of food preservation

Unit II: Water Activity and Food Preservation and Preservation through Temperature Reduction **9**

Storage of food at chilling temperature – behavior, Refrigeration - Controlled Atmosphere Storage (CAS) - Modified Atmosphere Storage (MAS) - Chilling defects Freezing –principles - fundamental aspects of freezing - Freezing process – technological aspects, Freezing damage - osmotic damage - solute damage - Structural damage - Concentration of food – Evaporation - Freeze concentration - Membrane process for concentration

Unit III: Dehydration of Food **9**

Transport of water in foods - Different methods of dehydration - Cabinet drying - sun / solar drying - Osmo drying - Osmo - vac drying - microvac drying - vacuum drying – Nutritional - physico-chemical changes during drying - Quality aspects of dehydrated food - Recent advances in dehydration of food - Freeze drying – Introduction – principles - process and Preservation - Physico-chemical changes in food - Nutritional changes during freeze drying - Recent advances in freeze drying methods(industrial developments)

Unit IV: Preservation using High Sugar and Salts **9**

Jam - Jellies Squashes – syrups – marmalades – cordials - concentrate etc. - Intermediate moisture fruits (candies / murambas - tutti-frutti /glazed fruits) - Use of common salt – principle – process - Fish salting - Pickling - Pickle salting (sauerkraut, cucumber, Kimchi) - Vegetable salting - Acidified – brined pickles (vegetables-onion, garlic)

Unit V: Fermentation Process **9**

Pickle making technology - Wine making technology (grape and others) - Beer making - Traditional fermented food products- Dhokla, Idli, Curd, Tempe, Soya sauce - fish, meat and

vegetable fermented products - Various alcohol based products - Yeast fermented - Industrial Applications - Food Plant Sanitation - Environmental Aspects of Food Processing - Roles and scientific use of water in food processing - Food processing waste management

TOTAL: 45 HOURS

REFERENCES:

1. Mircea Enachescu Dauthy (1997) 'Fruit and vegetable processing', FAO Agricultural Services Bulletin 119, International Book Distributing Co.
2. Brain J.B. Wood (1985) Microbiology of Fermented Foods, Vol. I, Elsevier Applied Science Publishers.
3. Diane M Barrett, Laszlo Somogyi, Hoshahalli Ramaswamy Processing Fruits, II edition, Science and Technology, CRC Press.
4. Marcus Karel, Owen R Fernnema Physicalprinciples Food Science, Part I and II Marcel Dekker inc.
5. IGNOU-2006 Food Processing and Engineering –II, Practical Mannual, www.ignou.ac.in.
6. Giridhari Lal, G.S. Siddappa and G. L. Tondon Preservation of Fruits and Vegetables, CFTRI, ICAR , New Delhi -12.

TE35A6	Cryogenic Engineering	L	T	P	C
		3	0	0	3

OBJECTIVES

- To provide the knowledge of evolution of low temperature science.
- To provide knowledge on the properties of materials at low temperature.
- To familiarize with various gas liquefaction and refrigeration systems and to provide design aspects of cryogenic storage and transfer lines.

Course Outcome		Cognitive Skill
CO-01	Students will understand the principles of cryogenic system.	R, U
CO-02	Students will study the gas liquefaction systems & cryogenic insulation.	R, U
CO-03	Students will identify the issues in storage of cryogenic liquids.	R, U
CO-04	Students will study the cryogenic instrumentation & cryogenic equipment.	R, U
CO-05	Students will understand the applications of space technology.	R, U

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J
CO-01	L	M	M	M	L	M	N	N	S	M
CO-02	L	M	M	M	L	M	N	N	S	M
CO-03	L	M	M	M	L	M	N	N	S	M
CO-04	L	M	M	M	L	M	N	N	S	M
CO-05	L	M	M	M	L	M	N	N	S	M

S-Strong, M- Medium, L-Low, N-Not relevant

Unit I: Introduction to Cryogenic Systems **9**

Mechanical Properties at low temperatures - Properties of Cryogenic Fluids - Gas Liquefaction - Minimum work for liquefaction - Methods to protect low temperature - Liquefaction systems for gages other than Neon - Hydrogen and Helium

Unit II: Gas Liquefaction Systems & Cryogenic Insulation **9**

Recuperative – Linde – Hampson, Claude, Cascade, Heylandt, Kapitza, Collins, Simon - Regenerative – Stirling cycle and refrigerator - Slovay refrigerator - Gifford-McMahon refrigerator - Vuilleumier refrigerator - Pulse Tube refrigerator - Liquefaction of natural gas -

Vacuum insulation - Evacuated porous insulation - Gas filled Powders and fibrous materials - Solid foams - Multilayer insulation - Liquid and vapour Shields - Composite insulations.

Unit III: Storage of Cryogenic Liquids **9**

Design considerations of storage vessel - Dewar vessels - Industrial storage vessels - Storage of cryogenic fluids in space - Transfer systems and Lines for cryogenic liquids - Cryogenic valves in transfer lines - Two phase flow in Transfer system - Cool-down of storage and transfer systems.

Unit IV: Cryogenic Instrumentation & Cryogenic Equipment **9**

Measurement of: strain, pressure, flow, liquid level and Temperature in cryogenic environment – Cryostats - Cryogenic heat exchangers – recuperative and regenerative - Variables affecting heat exchanger and system performance - Cryogenic compressors –Pumps – expanders - Turbo alternators - Effect of component inefficiencies - System Optimization - 3He-4He Dilution refrigerator -Cryopumping;

Unit V: Applications **9**

APPLICATIONS: Space technology - In-Flight air separation and collection of LOX - Gas industry – Biology – Medicine - Electronics.

TOTAL: 45 HOURS

REFERENCES

1. Cryogenics: Applications and Progress, A. Bose and P. Sengupta, Tata McGraw Hill.
2. Cryogenic Engineering, T.M. Flynn, Marcel Dekker
3. Handbook of Cryogenic Engineering, Editor – J.G. Weisend II, Taylor and Francis
4. Cryogenic Systems, R. Barron, Oxford University Press.
5. Cryogenic Process Engineering, K.D. Timmerhaus and T.M. Flynn, Plenum Press.
6. Cryogenic Fundamentals, G.G. Haselden, Academic Press.
7. Advanced Cryogenics, Editor – C.A. Bailey, Plenum Press.
8. Applied Cryogenic Engineering, Editors – R.W. Vance and W.M. Duke, John Wiley & sons.

TE35A7	Air Conditioning System Design	L	T	P	C
		3	0	0	3

OBJECTIVES

- Learning the fundamental principles and different methods of refrigeration and air conditioning.
- Study of various refrigeration cycles and evaluate performance using Mollier charts and/ or refrigerant property tables.
- Comparative study of different refrigerants with respect to properties, applications and environmental issues.
- Understand the basic air conditioning processes on psychometric charts, calculate cooling load for its applications in comfort and industrial air conditioning.
- Study of the various equipment-operating principles, operating and safety controls employed in refrigeration air conditioning systems.

Course Outcome		Cognitive Skill
CO-01	Students will understand the principles of air conditioning systems.	R, U
CO-02	Students will study the heat transfer in building structures and load calculation.	R, U
CO-03	Students will identify the psychometric analysis of the air conditioning system.	R, U
CO-04	Students will study the fluid flow in piping and ducts.	R, U
CO-05	Students will understand the fans, air distribution devices and planning and designing.	R, U

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J
CO-01	S	M	S	M	M	S	N	N	L	M
CO-02	S	M	S	M	M	S	N	N	L	M
CO-03	S	M	S	M	M	S	N	N	L	M
CO-04	S	M	S	M	M	S	N	N	L	M
CO-05	S	M	S	M	M	S	N	N	L	M

S-Strong, M- Medium, L-Low, N-Not relevant

Unit I: Air Conditioning Systems **9**

Hydronic Piping Systems and Terminal Units: Scope of air conditioning - All-water (Hydronic) air- conditioning systems - All-air air- conditioning systems - Human comfort - Comfort standards - Hydronic piping systems - Piping arrangements - Series loop - One-pipe main - Two-pipe direct and revere returns - Three-pipe and four pipe systems - Terminal units- Radiators – Convectors – Baseboard - Fin-tube - Radiant panels - Unit heaters - Fan-coil and induction units - Selection of terminal units - System design procedure.

Unit II: Heat Transfer in Building Structures and Load Calculation **9**

Fabric heat gain - Overall heat transfer coefficient - Periodic heat transfer through walls and roofs - Empirical methods to evaluate heat transfer through wall and roofs – Infiltration - Passive heating and cooling of buildings - Internal heat gains - System heat gains - Break-up of ventilation load and effective sensible heat factor - cooling-load estimate - Heating-load estimate - Psychometric calculations for cooling.

Unit III: Psychometric Analysis of the Air Conditioning System **9**

Determining moist air properties - The psychrometric chart - Air conditioning processes - Determining supply air conditions - Sensible heat ratio - The RSHR or condition line - Coil process line - contact factor - bypass factor - effective surface temperature – Reheat - Part load operation and control - Fan heat gains - Comfort chart.

Unit IV: Fluid Flow in Piping and Ducts **9**

The continuity equation - The flow energy equation - Pressure loss in closed and open systems - Total, static and velocity pressures in piping - Pressure loss in pipe fitting - System pipe sizing - Friction loss from air flow in ducts - duct fittings at fan inlet and outlet - Duct system pressure loss - Duct design methods.

Unit V: Fans, Air Distribution Devices and Planning and Designing **9**

Fan: Types, Performance characteristics, Selection, Ratings - Selection of optimum conditions – Laws - Arrangement and installation - Air distribution devices: Air patterns – Location -Types,

Selection, Accessories, Return air devices, Sound and its control – Pumps: Types, Characteristics - Similarity laws - Net positive suction head - The expansion and compression tanks - Air control and venting - Classification of A/C systems- Single zone – Reheat - Multi zone - Dual duct - Variable air volume - All-water systems - Air water systems - Unitary air conditioners - Rooftop units - Air handling units - Procedures for designing a hydronic system.

TOTAL: 45 HOURS

REFERENCES:

1. Air Conditioning Principles and Systems by Edward G. Pita, Published by PHI, New Delhi
2. Refrigeration and Air Conditioning by C.P. Arora, Published by TMH, New Delhi.
3. Refrigeration and Air Conditioning by W.F. Stocker and J.W. Jones, Published by TMH, New Delhi.
4. Refrigeration and Air Conditioning by Manohar Prasad, Published by Wiley Eastern Limited, New Delhi.

TE35A8	Advanced Internal Combustion Engineering	L	T	P	C
		3	0	0	3

OBJECTIVES

- To study the IC engines types and their cycles.
- To learn supercharging, turbocharging and volumetric efficiency.

Course Outcome		Cognitive Skill
CO-01	Students will learn the outline of engine types, design and operating parameters, cycle analysis.	R, An, A
CO-02	Students will learn flow through ports and charge motion.	R, An, A
CO-03	Students will understand combustion in SI engines and CI engines.	R, An, A
CO-04	Students will understand pollution formation and control.	R, An, A
CO-05	Students will know the heat transfer of SI engines and CI engines.	R, An, A

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J
CO-01	S	M	S	M	M	S	N	N	L	M
CO-02	S	M	S	M	M	S	N	N	L	M
CO-03	S	M	S	M	M	S	N	N	L	M
CO-04	S	M	S	M	M	S	N	N	L	M
CO-05	S	M	S	M	M	S	N	N	L	M

S-Strong, M- Medium, L-Low, N-Not relevant

Unit I: Introduction **9**

Historical Review – Engine Types – Design and operating Parameters - Cycle Analysis: Thermo-chemistry of Fuel – Air mixtures, properties – Ideal Models of Engine cycles – Real Engine cycles - differences and Factors responsible for – Computer Modeling.

Unit II: Gas Exchange Processes **9**

Volumetric Efficiency – Flow through ports – Supercharging and Turbo charging Charge Motion: Mean velocity and Turbulent characteristics – Swirl, Squish – Pre-chamber Engine flows.

Unit III: Engine Combustion in S.I Engines **9**

Combustion and Speed – Cyclic Variations – Ignition – Abnormal combustion Fuel factors, MPFI, SI engine testing.

Combustion in CI engines: Essential Features – Types off Cycle. Pr. Data – Fuel Spray Behavior – Ignition Delay – Mixing Formation and control, Common rail fuel injection system

Unit IV: Pollutant Formation and Control **9**

Nature and extent of problems – Nitrogen Oxides - Carbon monoxide - unburnt hydrocarbon and particulate – Emissions – Measurement – Exhaust Gas Treatment - Catalytic converter – SCR - Particulate Traps - Lean, NOx, Catalysts

Unit V: Engine Heat Transfer **9**

Importance of heat transfer - heat transfer and engine energy balance - Convective heat transfer - radiation heat transfer - Engine operating characteristics - Fuel supply systems for S.I and C.I engines to use gaseous fuels like LPG, CNG and Hydrogen - Modern Trends in IC Engines: Lean Burning - Adiabatic concepts - Rotary Engines - Modification in I.C engines to suit Bio – fuels - HCCI and GDI concepts.

TOTAL: 45 HOURS

REFERENCES:

1. E.F. Obert, "Internal Combustion Engines and Air Pollution", Intext Educational Publishers, 1973.
2. Yadav, R., I. C. Engines and Air Pollution, Central Publishing House, 2002
3. Maleev, V. L., Internal Combustion Engines, McGraw Hill Book Company, New York, 1987.
4. C.F. Taylor and E.S. Taylor, "Internal Combustion Engine", Stanton, 1961.
5. P.G. Burman and B. Luca, "Fuel Injection and Controls of I.C. Engines", Technical Press, 1962.
6. V. Ganeshan, "Internal Combustion Engines", Tata McGraw Hill, New Delhi, 1996.
7. C.R. Fergusson & A.R. Kirkpatrick, "Internal Combustion Engines", Delhi, 2001.
8. Internal Combustion Engines, C.R. Ferguson & A.R. Kirkpatrick, Delhi, 2001.

TE35A9	Transport Phenomena	L	T	P	C
		3	0	0	3

OBJECTIVES

- Explain the physical properties of a fluid and their consequences on fluid flow and heat transfer, expressed in terms of the Reynolds number, Nusselt number, and other dimensionless quantities.
- Use conservation principles of mass, momentum, and energy to develop models of fluid flow and heat transfer systems that can be used to predict the behavior of real world systems.

Course Outcome		Cognitive Skill
CO-01	At the end of the course the students should know: Generalized equations for mass, momentum and heat.	U, A
CO-02	Reynolds and Gauss theorems.	U, A
CO-03	Combined diffusive and convective transport.	U, A
CO-04	Film- and penetration models for mass and heat transfer.	U, A
CO-05	Stefan-Maxwells equations for multi-component diffusion.	U, A

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J
CO-01	L	M	M	M	L	M	N	N	S	M
CO-02	L	M	M	M	L	M	N	N	S	M
CO-03	L	M	M	M	L	M	N	N	S	M
CO-04	L	M	M	M	L	M	N	N	S	M
CO-05	L	M	M	M	L	M	N	N	S	M

S-Strong, M- Medium, L-Low, N-Not relevant

Unit I: Basic Equations of Flow **9**

Pressure - Kinetic & Datum Energy - Bernoulli's Theorem - Deduction of Bernoulli's Theorem – Eulers Equations for motion - Limitations of Bernoulli's Theorem - Practical Applications of Bernoulli's Theorem - Liquid jet & syphon - Momentum Equation - Forced and Free Vortex

Unit II: Reynold's Analysis & Boundary Layer Concept **9**

Reynold's Experiment - Laminar and Turbulent Flow -Reynold's Number - Navier Stoke's Equation of Motion -Laminar Flow between Parallel Plates - Waojuen - Poiseuille's Equation for Flow through Circular Pipes -Turbulence - Darcy Weisbach Equation for Flow Through Circular Pipe - Friction Factor - Smooth and Rough Pipes - Moody Diagram - Uses due to Contraction / Expansion etc., Pipes in Series & Parallel – Economical Diameter of Pipe Transmission of Power. Boundary Layer - Displacement & Momentum Thickness - Laminar & Turbulent Boundary Layers in Flat Plates- Velocity Distribution in Turbulent Flows in Smooth and Rough Boundaries - Laminar Sub Layer

Unit III: Transportation of Fluids, Interphase and Multiphase Momentum Transfer 9

Types of Centrifugal and Reciprocating Pumps - Comparision of Centrifugal and Reciprocating Pumps - Industrial Pipe Systems - Selection of Fans, Blowers, Pumps and Compressors - Efficiency Prediction - Pressure Drop Characteristics - Friction Factor, Fluid - Fluid System Flow Patterns in Vertical and Horizontal Pipes - Formation of Bubbles and Drops and their Size Distribution, Solid - Fluid Systems - Forces acting on Stagnant and Moving Solids - Flow through Porous Medium - Capillary Tube Model and its Applications for Packed Bed and Filters - Fluidised Bed - Solid Fluid Conveying Settling and Sedimentation

Unit IV: Interphase Transport in Non-Isothermal Systems and Radiation Heat Transfer **9**

Heat Transfer Co-efficient - Forced Convection in Tubes - around Submerged Objects - through Packed Beds - Heat Transfer by Free Convection - Film Type and Drop wise Condensation - Equations for Heat Transfer Coefficients for both, Heat Transfer in Boiling Liquids.

Unit V: Interphase Mass Transport and Macroscopic Balances for Multicomponent System **9**

Mass transfer coefficient in one and two phases at low and high mass transfer rates - film theory penetration theory - boundary layer theory - fixed bed catalytic – reactor - macroscopic balances to solve steady and unsteady state problems

TOTAL: 45 HOURS

REFERENCES:

1. Bansal, Fluid Mechanics, Saurabh & Co., New Delhi, 1985.
2. Arora KR, Fluid Mechanics, Hydraulics & Hydraulic Machines, Standard Publishers, New Delhi, 1976.
3. Jagadish Lal, Hydraulics & Fluid Mechanics, 2nd Edition Revised & Enlarged, Metropolitan Book Co, New Delhi.
4. P.N. Modi & SM Seth, Hydraulics & Fluid Mechanics, 8th Edition, Standard Book House, 1987.
5. Natarajan MK, Principles of Fluid Mechanics, Oxford & IBH Publishers, 1984.

TE35B1	Fluidized Bed System Design	L	T	P	C
		3	0	0	3

OBJECTIVES

Learning the fundamental principles of fluidized bed system design

Course Outcome		Cognitive Skill
CO-01	Students will understand the fluidized bed behaviour.	R, U
CO-02	Students will study the heat transfer.	R, U
CO-03	Students will identify the combustion and gasification.	R, U
CO-04	Students will study the system design.	R, U
CO-05	Students will understand the industrial applications.	R, U

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J
CO-01	S	M	S	M	M	S	N	N	L	M
CO-02	S	M	S	M	M	S	N	N	L	M
CO-03	S	M	S	M	M	S	N	N	L	M
CO-04	S	M	S	M	M	S	N	N	L	M
CO-05	S	M	S	M	M	S	N	N	L	M

S-Strong, M- Medium, L-Low, N-Not relevant

Unit I: Fluidized Bed Behaviour **9**

Fluidization Phenomena - Regimes of Fluidized Bed Behaviour - Characterization of Fluidized Particles - Two Phase and Well Mixed Theory of Fluidization - Solids Mixing - Particle Entrainment and Carryover.

Unit II: Heat Transfer **9**

Different Modes of Heat Transfer in Fluidized Bed - Use of Immersed Tubes - Finned Tubes - Heat Recovery Systems.

Unit III: Combustion and Gasification **9**

Fluidized Bed Combustion - Gasification Pressurized Systems - Sizing of Combustion and Gasification Systems - Start-up Methods - Fast Fluidized Beds - Different Modes of Heat Transfer in Fluidized Beds.

Unit IV: System Design **9**

Design of Distributors - Fluidized Bed Furnaces for Fossil and Agricultural Fuels - Fluidized Bed Heat Recovery Systems - Fluid Bed Dryers.

Unit V: Industrial Applications **9**

Sulphur Retention - Nitrogen Emission Control – Furnaces, Dryers Heat Treatment, etc. - Pollution Control - Environmental Effects - Cost Analysis

TOTAL: 45 HOURS

REFERENCES:

1. Howard, J.R., Fluidized Bed Technology: Principles and Applications, Adam Hilger, New York, 1983.
2. Geldart, D, Gas Fluidization Technology, John Wiley & Sons, New York, 1986.
3. Howard, J.R. (Ed), Fluidized Beds: Combustion and Applications, Applied Science Publishers, New York 1983.
4. Yates, J.G. Fundamentals of Fluidized bed Chemical Processes, Butter worths, 1983.
5. Reed, T.B., Biomass Gasification: Principles and Technology, Noyes Data Corporation, New Jersey, 1981.

TE35B2	Advanced Finite Element Analysis	L	T	P	C
		3	0	0	3

OBJECTIVES

- To learn basic principles of finite element analysis procedure.
- To learn the theory and characteristics of finite elements that represent engineering structures.
- To learn and apply finite element solutions to structural, thermal, dynamic problem to develop the knowledge and skills needed to effectively evaluate finite element analyses.

Course Outcome		Cognitive Skill
CO-01	Understand the concepts behind formulation methods in FEM.	R, An ,E
CO-02	Identify the application and characteristics of FEA elements such as bars, beams, plane and iso-parametric elements.	R, An ,E
CO-03	Develop element characteristic equation and generation of global equation.	R, An ,E
CO-04	Able to apply suitable boundary conditions to a global equation for bars, trusses, beams, circular shafts, heat transfer, fluid flow, axisymmetric and dynamic problems and solve them displacements, stress and strains induced.	R, An ,E
CO-05	To understand the structural problems.	R, An ,E

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J
CO-01	S	M	S	M	M	S	N	N	L	M
CO-02	S	M	S	M	M	S	N	N	L	M
CO-03	S	M	S	M	M	S	N	N	L	M
CO-04	S	M	S	M	M	S	N	N	L	M
CO-05	S	M	S	M	M	S	N	N	L	M

S-Strong, M- Medium, L-Low, N-Not relevant

Unit I: Introduction to FEM **9**

Basic concepts - historical back ground - applications of FEM - general description - comparison of FEM with other methods - variational approach - Glerkin's Methods - Co-ordinates - basic element shapes - interpolation function - Virtual energy principle - Rayleigh – Ritz method - properties of stiffness matrix - treatment of boundary conditions - solution of system of equations - shape functions and characteristics - Basic equations of elasticity -strain- displacement relations.

Unit II: 1-D Structural Problems **9**

Axial bar element – stiffness matrix - load vector - temperature effects - Quadratic shape functions and problems - ANALYSIS OF TRUSSES: Plane Trusses and Space Truss elements and problems - ANALYSIS OF BEAMS: Hermite shape functions – stiffness matrix – Load vector – Problems.

Unit III: 2-D Problems **9**

CST, LST, force terms, Stiffness matrix - load vectors - boundary conditions - Isoparametric elements – quadrilateral element - shape functions – Numerical Integration - Finite element modeling of Axi-symmetric solids subjected to Axi-symmetric loading with triangular elements - 3-D PROBLEMS: Tetrahedron element – Jacobian matrix – Stiffness matrix.

Unit IV: Scalar Field Problems **9**

1-D Heat conduction-Slabs – fins - 2-D heat conduction problems – Introduction to Torsional problems.

Unit V: Dynamic Considerations **9**

Dynamic equations – consistent mass matrix – Eigen Values - Eigen vector - natural frequencies – mode shapes – modal analysis.

TOTAL: 45 HOURS

REFERENCES:

1. Rao, S. S., The Finite Element Method in Engineering, 5th Edition, Elsevier 2011.
2. Nithiarasu, P., Seetharamu, K. N. and Lewis, R. W., The Finite Element Method for Heat Transfer Analysis, John Wiley and Sons, 2004.
3. Reddy, J. N. and Gartling D. K., The Finite Element Method in Heat Transfer and Fluid Dynamics, 3rd Edition, CRC Press, 2010.
4. Introduction to Finite Elements in Engineering, Chandrupatla, Ashok and Belegundu, Prentice – Hall.
5. Finite Element Method – Zincowitz / Mc Graw Hill
6. A First Course in the Finite Element Method/Daryl L Logan/Cengage Learning/5th Edition.
7. Finite Element Method – Krishna Murthy / TMH.
8. Finite Element Analysis – Bathe / PH.

TE35B3	Jet Propulsion and Rocketry	L	T	P	C
		3	0	0	3

OBJECTIVES

- Define basic concept and importance of gas dynamics.
- Interpret the flow pattern in flow and non-flow systems.

- Identify the thrust equation and its usage in jet aircraft and rocket propulsion in an efficient way.

Course Outcome		Cognitive Skill
CO-01	Explain basic concepts of gas dynamics and describe the basic fundamental equations of one dimensional flow of compressible fluid and isentropic flow of an ideal gas.	An, A
CO-02	Analyze the steady one-dimensional is entropic flow, frictional flow and isothermal flow and express the concepts of steady one dimensional flow with heat transfer.	An, A
CO-03	Discuss the effect of heat transfer on flow parameters.	An, A
CO-04	Describe the jet propulsion engines.	An, A
CO-05	Describe the basic concepts of rocket propulsion.	An, A

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J
CO-01	L	M	M	M	L	M	N	N	S	M
CO-02	L	M	M	M	L	M	N	N	S	M
CO-03	L	M	M	M	L	M	N	N	S	M
CO-04	L	M	M	M	L	M	N	N	S	M
CO-05	L	M	M	M	L	M	N	N	S	M

S-Strong, M- Medium, L-Low, N-Not relevant

Unit I: Turbo Jet Propulsion System **9**

Gas turbine cycle analysis – layout of turbo jet engine - Turbo machinery- compressors and turbines, combustor - blade aerodynamics - engine off design performance analysis - Flight Performance - Forces acting on vehicle – Basic relations of motion – multi stage vehicles.

Unit II: Principles of Jet Propulsion and Rocketry **9**

Fundamentals of jet propulsion - Rockets and air breathing jet engines – Classification – turbo jet - turbo fan - turbo prop - rocket (Solid and Liquid propellant rockets) and Ramjet engines - Nozzle Theory and Characteristics Parameters: Theory of one dimensional convergent – divergent nozzles – aerodynamic choking of nozzles and mass flow through a nozzle – nozzle exhaust velocity – thrust - thrust coefficient - Ac / At of a nozzle - Supersonic nozzle shape - non-adapted nozzles - summer field criteria - departure from simple analysis – characteristic parameters – 1)

characteristic velocity, 2) specific impulse 3) total impulse 4) relationship between the characteristic parameters 5) nozzle efficiency - combustion efficiency and overall efficiency.

Unit III: Aero Thermo Chemistry of the Combustion Products 9

Review of properties of mixture of gases – Gibbs – Dalton laws – Equivalent ratio - enthalpy changes in reactions - heat of reaction and heat of formation – calculation of adiabatic flame temperature and specific impulse – frozen and equilibrium flows.

Solid Propulsion System: Solid propellants – classification - homogeneous and heterogeneous propellants - double base propellant compositions and manufacturing methods - Composite propellant oxidizers and binders - Effect of binder on propellant properties - Burning rate and burning rate laws - factors influencing the burning rate - methods of determining burning rates.

Unit IV: Solid & Liquid Propellant 9

Solid propellant rocket engine – internal ballistics, equilibrium motor operation and equilibrium pressure to various parameters - Transient and pseudo equilibrium operation - end burning and burning grains - grain design. - Rocket motor hard ware design - Heat transfer considerations in solid rocket motor design - Ignition system - simple pyro devices - Liquid Rocket Propulsion System: Liquid propellants – classification - Mono and Bi propellants - Cryogenic and storage propellants - ignition delay of hypergolic propellants - physical and chemical characteristics of liquid propellant - Liquid propellant rocket engine – system layout - pump and pressure feed systems - feed system components - Design of combustion chamber - characteristic length - constructional features - and chamber wall stresses - Heat transfer and cooling aspects – Un-cooled engines - injectors – various types - injection patterns - injector characteristics - and atomization and drop size distribution - propellant tank design

Unit V: Ramjet & Integral Rocket Ramjet Propulsion System **9**

Fuel rich solid propellants - gross thrust - gross thrust coefficient - combustion efficiency of ramjet engine - air intakes and their classification – critical, super critical and sub-critical operation of air intakes - engine intake matching - classification and comparison of IIRR propulsion systems

TOTAL: 45 HOURS

REFERENCES:

1. Mechanics and Dynamics of Propulsion/ Hill and Peterson/John Wiley & Sons
2. Rocket propulsion elements/Sutton/John Wiley & Sons/8th Edition
3. Gas Turbines/Ganesan /TMH
4. Gas Turbines & Propulsive Systems/Khajuria & Dubey/Dhanpat Rai & Sons
5. Rocket propulsion/Bevere/
6. Jet propulsion /Nicholas Cumpsty/ Tansfer and cooling aspects.
7. Uncooled engines, injectors – various types, injection pat.

TE35B4	Fans, Blowers and Compressors	L	T	P	C
		3	0	0	3

OBJECTIVES

Primary objective of the course is to introduce students the basis of the fans, blowers and compressors, which is an emerging area in the field of energy science and engineering.

Course Outcome		Cognitive Skill
CO-01	Students will understand the principles of turbomachinery.	R, U
CO-02	Students will study the application of steam and gas turbines.	R, U
CO-03	Students will identify the issues in fans and blowers.	R, U
CO-04	Students will study the fans and blowers.	R, U
CO-05	Students will understand the centrifugal compressors.	R, U

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J
CO-01	L	M	M	M	L	M	N	N	S	M
CO-02	L	M	M	M	L	M	N	N	S	M
CO-03	L	M	M	M	L	M	N	N	S	M
CO-04	L	M	M	M	L	M	N	N	S	M
CO-05	L	M	M	M	L	M	N	N	S	M

S-Strong, M- Medium, L-Low, N-Not relevant

Unit I: Principles of Turbo machinery **9**

The turbo machine - Positive displacement machines and turbo machines - Static and stagnation states - Application of first and second laws to turbo machines - Efficiency of turbo machines - The Euler turbine equation - Fluid energy changes - Impulse and reaction –Turbines - utilization factor - Compressors and pumps

Unit II: Steam & Gas Turbines **9**

Back pressure - pass-out and mixed-pressure turbines - topping turbine - steam accumulator - special considerations in design of nuclear steam turbines - Impulse staging - Velocity and pressure compounding - Effects of blade and nozzle losses - Reaction staging - Reheat factor in

turbines - Problem of radial equilibrium - Performance characteristics of steam turbines - Governing of turbines - part load operation - pressure distribution at part load - mechanisms of governing - integrated control of thermal power plant.

Unit III: Fans & Blowers **9**

Introduction - Centrifugal blower - Types of vane shape - Size and speed of machine - Vane shape and efficiency - Vane shape and stresses - Vane shape and characteristics - Actual performance characteristics - The slip coefficient - Fan laws ,characteristics and Types -performance evaluation - efficient system operation - flow control strategies and energy conservation opportunities

Unit IV: Reciprocating Compressors **9**

Constructional details – open , hermetic and semi-sealed compressors - Performance of the ideal compressor - Clearance volumetric efficiency - Effects of evaporator and condenser pressures - Actual volumetric efficiency - Effects of cylinder cooling - heating and friction - Empirical equations for actual volumetric efficiency - Power requirements of ideal and actual compressors - optimum work for given condenser and evaporator pressures - mean effective pressure - pull down characteristics - Compressor discharge temperatures and need for cooling and Capacity control

Unit V: Centrifugal Compressors **9**

Low-speed steam engine driven compressors - High-speed electric motor driven compressors - Rotary- single vane and multi-vane compressor - Centrifugal compressors - Velocity diagrams - Efficiency considerations - Construction details - applications and performance characteristics - Screw compressors - Basic principles - single screw and double screw compressors - Working principle - work requirement and performance characteristics - Comparison with reciprocating and centrifugal compressors - Scroll compressors.

TOTAL: 45 HOURS

REFERENCES:

1. The Design of High Efficiency Turbo machinery and Gas Turbines, Wilson and Korakianitis, Prentice Hall, 1998.
2. Turbo machinery: Basic Theory and Applications, E. Logan, Marcel Dekker, 1993.
3. Principles of Turbo machinery, Shepherd, MacMillian, 1989.
4. Gas Turbine Theory, Cohen, et al., John Wiley & Sons, 1991.
5. Handbook of Turbo machinery, Edited by E. Logan and R. Roy, Marcel Dekker, 2003.
6. Pump Characteristics and Applications, M.W. Volk, Marcel Dekker, 1996.
7. Principles of Turbo machinery in Air-Breathing Engines, Baskharone, Cambridge, 2006.

OPEN ELECTIVES

Sl. No	Course Code	Course Title	L	T	P	C
1.	TE35B5	Environmental Pollution and Abatement	3	0	0	3
2.	TE35B6	Technology Management	3	0	0	3
3.	TE35B7	Performance Assessment of Mechanical Equipments	3	0	0	3
4.	TE35B8	Energy Systems Modeling and Analysis	3	0	0	3
5.	GE35A1	Business Analytics	3	0	0	3
6.	GE35A2	Industrial Safety	3	0	0	3
7.	GE35A3	Operations Research	3	0	0	3
8.	GE35A4	Cost Management of Engineering Projects	3	0	0	3
9.	GE35A5	Composite Materials	3	0	0	3
10.	GE35A6	Waste to Energy	3	0	0	3

TE35B5	Environmental Pollution and Abatement	L	T	P	C
		3	0	0	3

OBJECTIVES

To understand the important issues and their abatement principles of industrial pollution

Course Outcome		Cognitive Skill
CO-01	Students will understand the greenhouse effect, ozone depletion and natural cycles.	R, U
CO-02	Students will understand sources of air pollution and measurement methods.	R, U
CO-03	Students will study the sources of water pollution and water treatment.	R, U
CO-04	Students will study the waste management systems.	R, U
CO-05	Students will study the various waste control principles.	R, U

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J
CO-01	L	M	M	M	L	M	N	N	S	M
CO-02	L	M	M	M	L	M	N	N	S	M
CO-03	L	M	M	M	L	M	N	N	S	M
CO-04	L	M	M	M	L	M	N	N	S	M
CO-05	L	M	M	M	L	M	N	N	S	M

S-Strong, M- Medium, L-Low, N-Not relevant

Unit I: Introduction **9**

Global atmospheric change – Greenhouse effect –Ozone Depletion - Natural Cycles - Mass and Energy Transfer – Material balance – Environmental chemistry and biology – Impacts – Environmental legislations - Classification and sources of pollutants-CO, CO2, O2, N2 cycles – sources and sink

Unit II: Air Pollution & Pollutant Measurement Methods **9**

Pollutants - Sources and Effect – Air Pollution meteorology – Atmospheric dispersion –Indoor air quality - Control Methods and Equipment - Issues in Air Pollution control – Air sampling and measurement and emission standards

Unit III: Water Pollution **9**

Water resources - Water Pollutants - Characteristics – Quality - Water Treatment systems – Wastewater treatment - Treatment, Utilization and Disposal of Sludge - Monitoring compliance with Standards

Unit IV: Waste Management & Reactions of Pollutants in the Atmosphere Waste Management **9**

Sources and Classification – Solid waste – Hazardous waste - Characteristics – Collection and Transportation - Disposal – Processing and Energy Recovery – Waste minimization

Smoke – smog – fog - acid rain and ozone layer - Global warming and its effects - Regulatory laws and standards - Atmospheric diffusion of pollutants – transport - transformation and deposition -Atmospheric lapse rate - inversions and heat balance.

Unit V: Control Principles **9**

Removal of gaseous pollutants by absorption – adsorption - chemical reaction and other methods - Selective catalytic reduction of NOX - Particulate emission control - settling chambers - cyclone separation - wet collectors - fabric filters and electrostatic precipitators - Clean coal technology and shifted emphasis on non-carbon sources of energy

TOTAL: 45 HOURS

TEXT BOOKS

1. G.Masters (2003): Introduction to Environmental Engineering and Science, Prentice Hall of India Pvt Ltd, New Delhi.
2. H.S.Peavy, D.R..Rowe, G.Tchobanoglous (1985): Environmental Engineering - McGraw-Hill Book Company, New York.

REFERENCES:

1. H.Ludwig, W.Evans (1991): Manual of Environmental Technology in Developing Countries, International Book Company, Absecon Highlands, N.J.
2. Arcadio P Sincero and G. A. Sincero, (2002): Environmental Engineering – A Design Approach, Prentice Hall of India Pvt. Ltd, New Delhi.

TE35B6	Technologies Management	L	T	P	C
		3	0	0	3

OBJECTIVES

Learning the fundamental principles and different types of technology management

Course Outcome		Cognitive Skill
CO-01	Students will understand the technology management.	U
CO-02	Students will study the technology forecasting.	U
CO-03	Students will identify the technology choice and evaluation. .	U
CO-04	Students will study the technology transfer and acquisition.	U
CO-05	Students will understand the technology absorption and innovation.	U

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J
CO-01	L	L	L	L	N	L	S	S	L	L
CO-02	L	L	L	L	N	L	S	S	L	L
CO-03	L	L	L	L	N	L	S	S	L	L
CO-04	L	L	L	L	N	L	S	S	L	L
CO-05	L	L	L	L	N	L	S	S	L	L

S-Strong, M- Medium, L-Low, N-Not relevant

Unit I: Introduction **9**

Technology management – Scope - components - overview - Technology and environment - Technology and society - Technology Impact analysis - environmental, social, legal, political aspects - techniques for analysis - steps involved - Technology policy strategy: Science and technology Policy of India - implications to industry - dynamics of technology change

Unit II: Technology Forecasting **9**

Need - methodology and methods - trend Analysis – Analogy – Delphi - Soft System Methodology - Mathematical Models - Simulation and System Dynamics.

Unit III: Technology Choice and Evaluation **9**

Issues in the development new high tech products - Methods of analyzing alternate technologies - Techno-economic feasibility studies - Need for multi-criteria considerations: social, environmental, and political - Analytic hierarchy method - Fuzzy multi-criteria decision making - other methods.

Unit IV: Technology Transfer and Acquisition **9**

Import regulations, Implications of agreements like Uruguay Round-WTO - Bargaining process, Transfer option, MOU- Technology Adoption and Productivity - Adopting technology-human interactions - Organizational redesign and re-engineering - Technology productivity.

Unit V: Technology Absorption and Innovation **9**

Present status in India - Need for new outlook - Absorption strategies for acquired technology - creating new/improved technologies – Innovations - Technology Measurement- Technology Audit - Risk and exposure - R&D portfolio management

TOTAL: 45 HOURS

REFERENCES:

1. Joseph M. Putti, Management – A Functional Approach, McGraw Hill, 1997
2. Kenneth C. Lauden, MIS: Organization and Technology, Prentice Hall, 1995
3. James A.Senn, Information technology in Business, Prentice Hall, 1995
4. Ronald J. Jordan, Security analysis and Portfolio Management, Prentice Hall, 1995
5. Irvin M. Rubin, Organizational behavior an experimental approach, Prentice Hall, 1995
6. Gerard H. Gaynor, Handbook of Technology Management, McGraw-Hill Professional, 1996.

TE35B7	Performance Assessment of Mechanical Equipment	L	T	P	C
		3	0	0	3

OBJECTIVES

- To provide knowledge on various measuring instruments.
- To provide knowledge on advance measurement techniques.
- To understand the various steps involved in error analysis and uncertainty.

Course Outcome		Cognitive Skill
CO-01	Students should evaluate the performance of the boiler and understand the affecting factors.	A,E
CO-02	Students should apply the trends in different cogeneration power plants.	A,E
CO-03	Students should evaluate the performance of fans and blowers.	A,E
CO-04	Students should evaluate the performance of pumping system and compressor.	A,E
CO-05	Students will understand the energy conservation in boiler, furnace, pumps and other equipments.	U, A, E

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J
CO-01	L	L	L	L	N	L	S	S	L	L
CO-02	L	L	L	L	N	L	S	S	L	L
CO-03	L	L	L	L	N	L	S	S	L	L
CO-04	L	L	L	L	N	L	S	S	L	L
CO-05	L	L	L	L	N	L	S	S	L	L

S-Strong, M- Medium, L-Low, N-Not relevant

Unit I: Boilers **9**

Introduction – types - combustion in boilers - performances evaluation - analysis of losses - feed water treatment - blow down - energy conservation opportunities - Performance terms and definitions - reference standards - direct and indirect method testing - boiler efficiency calculation - factors affecting boiler performance - modern trends.

Unit II: Furnaces and Cogeneration **9**

Furnaces

Classification - types of fuels - general fuel economy measures in furnaces - excess air - heat distribution - temperature control - draft control - waste heat recovery - performance terms and definitions - furnace efficiency - testing method.

Cogeneration
Definition - need - application - advantages - classification - energy saving - performance terms and definitions - field testing procedure - diesel generating system-factors affecting selection - energy performance assessment of diesel conservation avenues - trends in different cogeneration **power** plants.

Unit III: Fans and Blowers **9**
Types - performance evaluation - efficient system operation - flow control strategies and energy conservation opportunities - performance terms and definitions - field testing

Unit IV: Pumping System and Compressed Air System **9**
Types - pumping system components - performance evaluation - efficient system operation - flow control strategies and energy conservation opportunities - performance terms and definitions - field testing - Types of air compressors - compressor efficiency - efficient compressor operation - Compressed air system components - capacity assessment - and leakage test - factors affecting the performance and savings opportunities.

Unit V: Energy Conservation **9**
Energy conservation in - boilers - furnaces - pumps - fans - pumping systems - compressed air systems - Waste heat recovery: recuperators - heat wheels - heat pipes - heat pumps.

TOTAL: 45 HOURS

REFERENCES:

1. Handbook on Energy Audit and Environment Management - Abbi Y.A, Jain, Shashank TERI Press New Delhi, 2006.
2. Energy Management Handbook, Wayne C Turner, the Fairmont Press Inc.
3. Boiler Operator's Guide Fourth Edition, Anthony L Kohan, McGraw Hill.
4. Boiler Test Calculations – J. Senior, Edward Arnold Publisher.
5. Gas Turbine Engineering Handbook, Meherwan P Boyce, Gulf Publishing Company.
6. Modeling of Gas Fired Furnaces & Boilers, Rhine J M.
7. Pumps, Principles and Practice, Jaico Publishing House, Mumbai.
8. Reciprocating Compressors Operation and Maintenance, Heinz P Bloch & John J
9. Principles and Performance in Diesel Engineering, Sam Haddad and Neil Watson.

TE35B8	Energy Systems Modeling and Analysis	L	T	P	C
		3	0	0	3

OBJECTIVES
- Develop models and modeling approaches.
- Develop input/output analysis and utilize knowledge from various disciplines (mathematical programming, economy, physics and energy resources, energy technologies, etc.) in order to perform techno-economic analyses of sustainable energy systems.

Course Outcome		Cognitive Skill
CO-01	To study the capabilities and limitations of various modeling methods.	U , A , An
CO-02	To analyze the energy and environmental input/output.	U , A , An
CO-03	To know the energy demand analysis and forecasting.	U , A , An
CO-04	To learn solar, biomass, wind energy and other renewable sources, waste heat recovery and cogeneration.	U , A , An
CO-05	To study cost analysis, financial management and project evaluation techniques.	U , A , An

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J
CO-01	S	M	S	M	M	S	N	N	L	M
CO-02	S	M	S	M	M	S	N	N	L	M
CO-03	S	M	S	M	M	S	N	N	L	M
CO-04	S	M	S	M	M	S	N	N	L	M
CO-05	S	M	S	M	M	S	N	N	L	M

S-Strong, M- Medium, L-Low , N-Not relevant

Unit I: Models and Modeling Approaches **9**

Macroeconomic Concepts - Measurement of National Output - Investment Planning and Pricing - Economics of Energy Sources - Reserves and Cost Estimation

Unit II: Input Output Analysis **9**

Multiplier Analysis - Energy and Environmental Input / Output Analysis - Energy Aggregation – Econometric Energy Demand Modeling - Overview of Econometric Methods

Unit III: Energy Demand Analysis and Forecasting **9**

Methodology of Energy Demand Analysis - Methodology for Energy Technology Forecasting - Methodology for Energy Forecasting - Sectoral Energy Demand Forecasting

Unit IV: Economics of Standalone Power Supply System **9**

Solar Energy - Biomass Energy - Wind Energy and other Renewable Sources of Energy - Economics of Waste Heat Recovery and Cogeneration - Energy Conservation Economics

Unit V: Project Management-Financial Accounting **9**

Cost Analysis - Budgetary Control - Financial Management - Techniques for Project Evaluation.

TOTAL: 45 HOURS

REFERENCES

1. M.Munasinghe and P.Meier (1993): Energy Policy Analysis and Modeling, Cambridge University Press.
2. W.A.Donnelly (1987): The Econometrics of Energy Demand: A Survey of Applications, New York.
3. S.Pindyck and Daniel L.Rubinfeld (1990): Econometrics Models and Economic Forecasts, 3rd edition MC Graw -Hill , New York.
4. UN-ESCAP (1991): Sectoral Energy Demand Studies: Application of the END-USE Approach to Asian Countries, New York.
5. UN-ESCAP (1996): Guide Book on Energy -Environment Planning in Developing Countries: Methodological Guide on Economic Sustainability and Environmental Betterment Through Energy Savings and Fuel Switching in Developing Countries, New York.
6. S. Makridakis Wiley (1983): Forecasting Methods and Applications.

GE35A1	Business Analytics	L	T	P	C
		3	0	0	3

OBJECTIVES

To make students understandable about the Regression Analysis , Business analytics , forecasting and decision analysis.

Course Outcome		Cognitive Skill
CO-01	Ability to understand the concepts of Business Analytics.	U ,An
CO-02	Can understand the factors of Trendiness and Regression analysis.	U , An
CO-03	Students can understand about organization structures of business analytics.	U , An
CO-04	One can understand the concepts of Forecasting Techniques.	U , An
CO-05	Can understand the Decision analysis.	U , An

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J
CO-01	L	L	L	L	N	L	S	S	L	L
CO-02	L	L	L	L	N	L	S	S	L	L
CO-03	L	L	L	L	N	L	S	S	L	L
CO-04	L	L	L	L	N	L	S	S	L	L
CO-05	L	L	L	L	N	L	S	S	L	L

S-Strong, M- Medium, L-Low, N-Not relevant

Unit I: Business Analytics **9**

Overview of Business analytics - Scope of Business analytics - Business Analytics Process - Relationship of Business Analytics Process and organization - competitive advantages of Business Analytics - Statistical Tools: Statistical Notation - Descriptive Statistical methods - Review of probability distribution and data modeling - sampling and estimation methods overview.

Unit II: Trendiness and Regression Analysis **9**

Modeling Relationships and Trends in Data - Simple Linear Regression - Important Resources - Business Analytics Personnel - Data and models for Business analytics - problem solving - Visualizing and Exploring Data - Business Analytics Technology

Unit III: Organization Structures of Business Analytics **9**

Team management -Management issues - Designing information policy - Outsourcing - Ensuring Data Quality - Measuring contribution of Business analytics - Managing Changes.

Descriptive Analytics - predictive analytics - predicative Modeling - Predictive analytics analysis - Data Mining - Data Mining Methodologies - Prescriptive analytics and its step in the business analytics Process - Prescriptive Modeling - nonlinear Optimization.

Unit IV: Forecasting Techniques **9**

Qualitative and Judgmental Forecasting - Statistical Forecasting Models - Forecasting Models for Stationary Time Series - Forecasting Models for Time Series with a Linear Trend - Forecasting Time Series with Seasonality - Regression Forecasting with Casual Variables - Selecting Appropriate Forecasting Models - Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform - New-Product Development Model - Newsvendor Model - Overbooking Model - Cash Budget Model.

Unit V: Decision Analysis **9**

Formulating Decision Problems - Decision Strategies with the without Outcome Probabilities - Decision Trees - the Value of Information - Utility and Decision Making. Recent Trends in: Embedded and collaborative business intelligence - Visual data
Recovery - Data Storytelling and Data journalism.

TOTAL: 45 HOURS

REFERENCES:

1. Business analytics principles, Concepts, and Applications by Marc J. Schniederjans, Dara G.Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.

GE35A2	Industrial Safety	L	T	P	C
		3	0	0	3

OBJECTIVES

To make students understandable about the Industrial safety , Maintenance and fault tracing.

Course Outcome		Cognitive Skill
CO-01	Ability to understand the concepts of Industrial Safety.	R , U
CO-02	Can understand the fundamentals of Maintenance Engineering.	R , U
CO-03	Students can understand the ways to prevent from wear and corrosion.	R , U
CO-04	One can understand the concepts of fault tracing.	R , U
CO-05	Can understand the functions of periodic and preventive maintenance.	R , U

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J
CO-01	L	M	M	M	L	M	N	N	S	M
CO-02	L	M	M	M	L	M	N	N	S	M
CO-03	L	M	M	M	L	M	N	N	S	M
CO-04	L	M	M	M	L	M	N	N	S	M
CO-05	L	M	M	M	L	M	N	N	S	M

S-Strong , M- Medium , L-Low , N-Not relevant

Unit I: Industrial Safety **9**

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

Unit II: Fundamentals of Maintenance Engineering: **9**

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.

Unit III: Wear and Corrosion and their Prevention **9**

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.

Unit IV: Fault Tracing **9**

Fault tracing-concept and importance - decision tree concept - 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. Pump ii. Air compressor iii. Internal combustion engine - iv. Boiler - v. Electrical motors - Types of faults in machine tools and their general causes.

Unit V: Periodic and Preventive Maintenance **9**

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.

TOTAL: 45 HOURS

REFERENCES:

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.

GE35A3	Operations Research	L	T	P	C
		3	0	0	3

OBJECTIVES

To make students understandable about the optimization techniques

Course Outcome		Cognitive Skill
CO-01	Ability to understand the concepts of Optimization Techniques.	U , A
CO-02	Can understand the fundamentals of LPP formulation.	U , A
CO-03	Students can understand the Non-Linear Programming.	U , A
CO-04	One can understand the concepts Scheduling and Sequencing.	U , A
CO-05	Can understand the functions of Competitive models.	U , A

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J
CO-01	L	L	L	L	N	L	S	S	L	L
CO-02	L	L	L	L	N	L	S	S	L	L
CO-03	L	L	L	L	N	L	S	S	L	L
CO-04	L	L	L	L	N	L	S	S	L	L
CO-05	L	L	L	L	N	L	S	S	L	L

S-Strong, M- Medium, L-Low, N-Not relevant

Unit I: Optimization Techniques **9**

Model Formulation - models - General L.R Formulation - Simplex Techniques - Sensitivity Analysis - Inventory Control Models.

Unit II: LPP Formulation **9**

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

Unit III: Nonlinear Programming **9**

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

Unit IV: Scheduling and Sequencing **9**

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

Unit V: Competitive Models **9**

Competitive models - Single and multi-channel problems - Sequencing models - Dynamic programming - Flow in networks - Elementary graph theory - Game theory simulation.

TOTAL: 45 HOURS

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.

GE35A4	Cost Management of Engineering Projects	L	T	P	C
		3	0	0	3

OBJECTIVES

To make students understandable about the cost concepts in decision making and profit planning.

Course Outcome		Cognitive Skill
CO-01	Ability to understand the strategic cost management.	U , A
CO-02	Can understand the fundamentals of cost concepts in decision making.	U , A
CO-03	Students can understand the process involved in project execution.	U , A
CO-04	One can understand the concepts of cost behavior and profit planning.	U , A
CO-05	Can understand the functions of quantitative techniques.	U , A

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J
CO-01	S	S	S	L	N	L	S	S	L	L
CO-02	S	S	S	L	N	L	S	S	L	L
CO-03	S	S	S	L	N	L	S	S	L	L
CO-04	S	S	S	L	N	L	S	S	L	L
CO-05	S	S	S	L	N	L	S	S	L	L

S-Strong , M- Medium , L-Low , N-Not relevant

Unit I: Strategic Cost Management **9**

Introduction - Overview of the Strategic Cost Management Process.

Unit II: Cost Concepts in Decision Making **9**

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 **9**

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 **9**

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 **9**

Quantitative techniques for cost management - Linear Programming - PERT/CPM - Transportation problems - Assignment problems - Simulation - Learning Curve Theory.

TOTAL: 45 HOURS

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.

GE35A5	Composite Materials	L	T	P	C
		3	0	0	3

OBJECTIVES

To make students understandable about the material characteristics , processing and classifications of composite materials.

Course Outcome		Cognitive Skill
CO-01	Ability to understand the functional requirements of composite materials.	R ,U , A
CO-02	Can understand the properties and applications of reinforcements.	R ,U , A
CO-03	Students can understand the process involved in metal matrix composite fabrication.	R ,U , A
CO-04	One can understand the concepts of polymer matrix composites fabrication.	R ,U , A
CO-05	Can understand the physical characteristics of composite materials.	R ,U , A

R-Remember , U-Understand , A-Apply , An-Analyze , E-Evaluate , S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J
CO-01	L	M	M	M	L	M	N	N	S	M
CO-02	L	M	M	M	L	M	N	N	S	M
CO-03	L	M	M	M	L	M	N	N	S	M
CO-04	L	M	M	M	L	M	N	N	S	M
CO-05	L	M	M	M	L	M	N	N	S	M

S-Strong, M- Medium, L-Low, N-Not relevant

Unit I: Introduction **9**

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 **9**

Preparation- layup - curing – properties- 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 **9**

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 **9**

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

Unit V: Strength **9**

Laminar failure criteria - strength ratio - maximum stress criteria - maximum strain criteria - interacting failure criteria - hydrothermal failure - Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

TOTAL: 45 HOURS

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.

GE35A6	Waste to Energy	L	T	P	C
		3	0	0	3

OBJECTIVES

To make students understandable about the gasification process , bio materials and its design considerations.

Course Outcome		Cognitive Skill
CO-01	Ability to understand the process of obtaining Energy from waste substances.	R , U
CO-02	Can understand manufacturing of pyrolytic oils and gases , yields and applications.	R , U
CO-03	Students can understand kinetic consideration in gasifier operation.	R , U
CO-04	One can understand the Design , construction and operation of Bio Mass chamber.	R , U
CO-05	Can understand the basic Properties of biogas	R , U

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J
CO-01	L	M	M	M	L	M	N	N	S	M
CO-02	L	M	M	M	L	M	N	N	S	M
CO-03	L	M	M	M	L	M	N	N	S	M
CO-04	L	M	M	M	L	M	N	N	S	M
CO-05	L	M	M	M	L	M	N	N	S	M

S-Strong, M- Medium, L-Low, N-Not relevant

Unit I: Introduction to Energy from Waste **9**

Classification of waste as fuel – Agro based, Forest residue - Industrial waste - MSW – Conversion devices – Incinerators - gasifiers - digestors.

Unit II: Biomass Pyrolysis **9**

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

Unit III: Biomass Gasification **9**

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 **9**

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 **9**

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.

TOTAL: 45 HOURS

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.