Government College of Engineering, Salem – 636 011,
(An Autonomous Institution, Affiliated to Anna University, Chennai)

Regulations -2022
Autonomous Courses (For Students Admitted from 2022-2023)

M.E Thermal Engineering – Full Time

SI.No	Course code	Name of the Course	Hours/Week					Maximum Marks		
			Category	Lecture	Tutorial/ Demo*	Practical	Credits	CA	FE	Total
SEMESTER I										
THEORY										
1.	22THC11	Advanced Thermodynamics	PC	3	0	0	3	40	60	100
2.	22THC12	Advanced Fluid Dynamics	PC	3	0	0	3	40	60	100
3.	22THC13	Advanced Heat Transfer	PC	3	0	0	3	40	60	100
4.	22THE1X	Professional Elective-I	PE	3	0	0	3	40	60	100
5.	22THE2X	Professional Elective-II	PE	3	0	0	3	40	60	100
6.	22MLC01	Research Methodology and IPR	**MC**	3	0	0	3	40	60	100
PRACTICAL										
7.	22THC14	Thermal Engineering Laboratory	PC	0	0	4	2	60	40	100
8.	22THC15	Technical Seminar- I	EEC	0	0	2	1	100	0	100
9.	22AC**XX**	Audit Course – 1	AC	2	0	0	0	100	0	100
	TOTAL			**20**	**0**	**6**	**21**	**500**	**400**	**900**
SEMESTER II										
THEORY										
1.	22THC21	Hydrogen and Fuel cell Technologies	PC	3	0	0	3	40	60	100
2.	22THC22	Computational Fluid Dynamics for Thermal Systems	PC	3	0	0	3	40	60	100
3.	22THC23	Instrumentation for Thermal Systems	PC	3	0	0	3	40	60	100
4.	22THE3X	Professional Elective- III	PE	3	0	0	3	40	60	100
5.	22THE4X	Professional Elective-IV	PE	3	0	0	3	40	60	100
PRACTICAL										
6.	22THC24	Analysis & Simulation Laboratory	PC	0	0	4	2	60	40	100
7.	22THC25	Applied Thermal Engineering Laboratory	PC	0	0	4	2	60	40	100
8.	22THC26	Technical Seminar- II	EEC	0	0	2	1	100	0	100
9.	22AC**XX**	Audit Course-2	AC	2	0	0	0	100	0	100
	TOTAL			**17**	**0**	**10**	**20**	**520**	**380**	**900**

SI.No	Course code	Name of the Course	Category	Hours/Week Lecture	Tutorial/ Demo*	Practical	Credits	Maximum Marks CA	FE	Total
SEMESTER III										
THEORY										
1.	22THE5X	Professional Elective-V	PE	3	0	0	3	40	60	100
2.	22THE6X	Professional Elective-VI	PE	3	0	0	3	40	60	100
3.	22THE7X	Professional Elective-VII	PE	3	0	0	3	40	60	100
PRACTICAL										
4.	22THC31	Dissertation Phase – I	EEC	0	0	20	6	120	80	200
	TOTAL			**9**	**0**	**20**	**15**	**240**	**260**	**500**
SEMESTER IV										
PRACTICAL										
1.	22THC41	Dissertation Phase – II	EEC	0	0	32	14	240	160	400
	TOTAL			**0**	**0**	**32**	**14**	**240**	**160**	**400**

Total Credits for the Programme = 21 + 20 + 15 + 14 = 70

LIST OF ELECTIVES FOR M.E THERMAL ENGINEERING

Professional Electives (PE)

SI.No	Course code	Name of the Course	Hours/Week					Maximum Marks		
			Category	Lecture	Tutorial/ Demo*	Practical	Credits	CA	FE	Total
Elective - I										
1.	22CDE11	Advanced Mathematical Methods in Engineering	PE	3	0	0	3	40	60	100
2.	22THE11	Combustion in IC Engines	PE	3	0	0	3	40	60	100
3.	22THE12	Thermal management of Electric Vehicle Battery Systems	PE	3	0	0	3	40	60	100
4.	22THE13	Nuclear Engineering	PE	3	0	0	3	40	60	100
5.	22THE14	Boundary Layer Theory and Turbulence	PE	3	0	0	3	40	60	100
Elective - II										
6.	22THE21	Air Conditioning System Design	PE	3	0	0	3	40	60	100
7.	22THE22	Bio Energy Technologies	PE	3	0	0	3	40	60	100
8.	22THE23	Optimization Techniques in Engineering	PE	3	0	0	3	40	60	100
9.	22THE24	Electric and Hybrid Vehicle Technology	PE	3	0	0	3	40	60	100
10.	22THE25	Alternate Fuels for IC Engines	PE	3	0	0	3	40	60	100
Elective - III										
11.	22THE31	Advanced Energy Storage Technologies Refrigeration systems	PE	3	0	0	3	40	60	100
12.	22THE32	Refrigeration systems	PE	3	0	0	3	40	60	100
13.	22THE33	Advanced Power Plant Engineering	PE	3	0	0	3	40	60	100
14.	22THE34	Electronic Engine Management Systems	PE	3	0	0	3	40	60	100
15.	22THE35	Design of Heat Exchangers	PE	3	0	0	3	40	60	100
Elective - IV										
16.	22THE41	Solar Power Plants	PE	3	0	0	3	40	60	100
17.	22THE42	Cryogenic Engineering	PE	3	0	0	3	40	60	100
18.	22THE43	Renewable Energy Systems	PE	3	0	0	3	40	60	100
19.	22THE44	Materials For Solar Devices	PE	3	0	0	3	40	60	100
20.	22THE45	Energy Systems Modelling & Analysis	PE	3	0	0	3	40	60	100

Elective - V										
21.	22THE51	Design of Solar and Wind Systems	PE	3	0	0	3	40	60	100
22.	22THE52	Design and Analysis of Turbo machines	PE	3	0	0	3	40	60	100
23.	22THE53	Fire Engineering and Explosion control	PE	3	0	0	3	40	60	100
24.	22THE54	Waste to Energy	PE	3	0	0	3	40	60	100
25.	22THE55	Solar Refrigeration and Air-conditioning	PE	3	0	0	3	40	60	100
Elective - VI										
26.	22THE61	Environmental And Pollution control	PE	3	0	0	3	40	60	100
27.	22THE62	Nanotechnology	PE	3	0	0	3	40	60	100
28.	22THE63	Solar Energy for Industrial Process Heating	PE	3	0	0	3	40	60	100
29.	22THE64	Energy Efficient Buildings Design	PE	3	0	0	3	40	60	100
30.	22THE65	Analysis Of Thermal Power Cycles	PE	3	0	0	3	40	60	100
Elective - VII										
31.	22THE71	Energy Forecasting, Modeling and Project Management	PE	3	0	0	3	40	60	100
32.	22THE72	Energy Management and Environmental Benefits	PE	3	0	0	3	40	60	100
33.	22THE73	Solar Energy Appliances	PE	3	0	0	3	40	60	100
34.	22THE74	Cost Management of Engineering Projects	PE	3	0	0	3	40	60	100
35.	22THE75	Advanced Composite materials	PE	3	0	0	3	40	60	100

Audit Courses (AC)

Sl.No	Course code	Name of the Course	Hours/Week					Maximum Marks		
			Category	Lecture	Tutorial/ Demo*	Practical	Credits	CA	FE	Total
1.	22AC01	English for Research Paper Writing	PE	2	0	0	0	100	0	100
2.	22AC02	Disaster Management	PE	2	0	0	0	100	0	100
3.	22AC03	Sanskrit for Technical Knowledge	PE	2	0	0	0	100	0	100
4.	22AC04	Value Education	PE	2	0	0	0	100	0	100
5.	22AC05	Constitution of India	PE	2	0	0	0	100	0	100
6.	22AC06	Pedagogy Studies	PE	2	0	0	0	100	0	100
7.	22AC07	Stress Management by Yoga	PE	2	0	0	0	100	0	100
8.	22AC08	Personality Development through Life Enlightenment Skills	PE	2	0	0	0	100	0	100

22THC11	ADVANCED THERMODYNAMICS			Semester			I
PREREQUISITES		**Category**	**PC**	**Credit**			**3**
		Hours/Week	**L**	**T**	**P**		**TH**
			3	**0**	**0**		**3**

Course Learning Objectives

1	To develop the ability to use the thermodynamics concepts for various applications like availability analysis and thermodynamic relations
2	To impart the knowledge to analyze the real gas behavior and chemical thermodynamics
3	To impart the knowledge about chemistry behind the thermodynamics
4	To expose the basic concepts of Statistical and Irreversible thermodynamics
5	To disseminate the concepts of irreversible thermodynamics

UNIT I	**AVAILABILITY ANALYSIS AND THERMODYNAMIC PROPERTY RELATIONS**	**9**	**0**	**0**	**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	**REAL GAS BEHAVIOUR AND MULTI-COMPONENT SYSTEM**	**9**	**0**	**0**	**9**

Different equations of state – fugacity – compressibility - principle of corresponding states - Use of generalized charts for enthalpy and entropy departure - fugacity coefficient. 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**	**9**	**0**	**0**	**9**

Thermochemistry - 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**	**0**	**0**	**9**

Micro states and Macro states - thermodynamic probability - degeneracy of energy levels - Maxwell – Boltzman, Fermi – Diarc and Bose – Einstein statistics - microscopic interpretation of heat and work, evaluation of entropy, Partion function, calculation of the Macroscopic properties from partition functions.

UNIT V	**IRREVERSIBLE THERMODYNAMICS**	**9**	**0**	**0**	**9**

Conjugate fluxes and forces - entropy production Onsager's reciprocity relations – thermos-electric phenomena, formulations.

TOTAL (45L): 45 Periods

Reference Books:

1	Bejan, A., Advanced Engineering Thermodynamics, John Wiley and Cons, 1988.
2	DeHotf R.T., Thermodynamics in Materials Science, McGraw – Hill Inc., 1993

3	Holman J.P., Thermodynamics, Fourth Edition, McGraw – Hill Inc., 1988
4	Kenneth WarkJt.m., Advanced Thermodynamics for Engineers, McGrew – Hill Inc., 1995
5	Rao Y.V.C., Postulational and Statistical Thermodynamics, Allied Publisher Limited, New Delhi, 199
6	Sears F.W .and Salinger G.I.,Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Third Edition, Narosa Publishing House, New Delhi, 1993

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Explain availability, second law efficiency and derive thermodynamic relations	Evaluate
CO2	Describe fugacity, real gas behavior and Gibbs phase rule for non-reactive components.	Apply
CO3	Explain thermochemistry and characteristics of reacting system.	Understand
CO4	Demonstrate micro and macroscopic analysis of thermodynamics	Analyze
CO5	Describe the concepts of irreversible thermodynamics	Understand

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	2	0	1	0	2	0	0	0	0	0	3	3	1	
CO2	3	3	0	1	2	2	0	0	0	0	0	3	3	1	
CO3	3	3	0	1	0	2	0	0	0	0	0	3	3	1	
CO4	3	3	0	1	0	2	0	0	0	0	0	3	3	1	
CO5	3	3	0	1	0	2	0	0	0	0	0	3	3	1	
Avg	3	2.8	0	1	0.4	2	0	0	0	0	0	3	3	1	
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**															

22THC12	ADVANCED FLUID DYNAMICS				Semester		I
PREREQUISITES		**Category**	**PC**	**Credit**			**3**
		Hours/Week	**L**	**T**	**P**		**TH**
			3	**0**	**0**		**3**

Course Learning Objectives

1	To demonstrate different types of compressible flow processes
2	To develop the skill to derive the continuity and momentum equations using differential and integral approach
3	To develop the skill to derive the equations for transport theorem, stream function and velocity potential function
4	To communicate the analysis of the boundary layer concepts in fluid flow
5	To disseminate the characteristics of turbulent flow

UNIT I	**TYPES OF FLOW**	**9**	**0**	**0**	**9**
Compressible flow - Fully developed flows, parallel flow in straight channel, Couette flow, creeping flow					
UNIT II	**GOVERNING EQUATION IN FLUID DYNAMICS**	**9**	**0**	**0**	**9**
Derivation of continuity and momentum equations using integral and differential approach – Dimensionless form of governing equations - Special forms of governing equations – Integral quantities					
UNIT III	**POTENTIAL FLOW**	**9**	**0**	**0**	**9**
Reynolds - Transport theorem - Kelvin's theorem - Irrotational flow - Stream function- Velocity potential function					
UNIT IV	**BOUNDARY LAYERS**	**9**	**0**	**0**	**9**
Boundary layer equations, flow over flat plate, momentum - Integral equations for boundary layer -Approximate solution methodology for boundary layer equations.					
UNIT V	**TUTBULENT FLOW CHARACTERISTICS**	**9**	**0**	**0**	**9**
Characteristics of turbulent flow, Laminar - Turbulent transition - Mean motion and fluctuations - Derivation of governing equations for turbulent flow - Shear stress models - Universal velocity distribution.					
					TOTAL (45L): 45 Periods

Reference Books:

1	Muralidhar and Biswas, Advanced Engineering Fluid Mechanics, Alpha Science International, 2005
2	Irwin Shames, Mechanics of Fluids, McGraw Hill, 2003
3	Fox R.W., McDonald A.T, Introduction to Fluid Mechanics, John Wiley and Sons Inc,1985
4	Pijush K. Kundu, Ira M Kohen and David R. Dawaling, Fluid Mechanics, Fifth Edition,2005

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Demonstrate different types of fluid flow and derive mathematical formulations for their characteristic	Analyze
CO2	Derive the continuity and momentum equations using differential and integral approach	Evaluate
CO3	Derive the equations for transport theorem, stream function and velocity potential function.	Evaluate
CO4	Analyze the boundary layer concepts in fluid flow.	Analyze
CO5	Derive the governing equation for turbulent flow	Evaluate

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	2	0	2	0	2	0	0	0	0	0	3	3	1	
CO2	3	2	0	2	0	2	0	0	0	0	0	3	3	1	
CO3	3	2	0	2	0	2	0	0	0	0	0	3	3	1	
CO4	3	2	0	2	0	2	0	0	0	0	0	3	3	1	
CO5	3	2	0	2	0	2	0	0	0	0	0	3	3	1	
Avg	3	2	0	2	0	2	0	0	0	0	0	3	3	1	
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**															

22THC13	ADVANCED HEAT TRANSFER			Semester		I
PREREQUISITES		Category	PC	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives

1	To develop the ability to use the heat transfer concepts like one-dimensional, three-dimensional conduction heat transfer and adiation heat transfer
2	To develop the ability to solve problems in turbulent flow heat transfer
3	To impart the skill to design and analyze the heat exchangers including compact heat exchanges and phase change heat transfer
4	To introduce the different numerical techniques for solving heat transfer problems
5	To introduce mass transfer and engine heat transfer correlations

UNIT I	**CONDUCTION AND RADIATION HEAT TRANSFER**	**9**	**0**	**0**	**9**

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

UNIT II	**TURBULENT FORCED CONVECTIVE HEAT TRANSFER**	**9**	**0**	**0**	**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**	**0**	**0**	**9**

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

UNIT IV	**NUMERICAL METHODS IN HEAT TRANSFER**	**9**	**0**	**0**	**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 and diffusion problems - calculation of the flow field – SIMPLER Algorithm

UNIT V	**MASS TRANSFER AND ENGINE HEAT TRANSFER CORRELATION**	**9**	**0**	**0**	**9**

Mass transfer - vaporization of droplets - combined heat and mass transfers - heat transfer correlations in various applications like I.C. engines, compressors and turbines.

TOTAL(45L) : 45 PERIODS

Reference Books:

1	Ghoshdastidar. P.S., Heat Transfer, Oxford University Press, 2004
2	Holman.J.P., Heat Transfer, Tata Mc Graw Hill, 2002
3	Incropera F.P. and DeWitt. D.P., Fundamentals of Heat & Mass Transfer, John Wiley & Sons, 2002.

4	Nag.P.K., Heat Transfer, Tata McGraw-Hill, 2002.
5	Ozisik. M.N., Heat Transfer – A Basic Approach, McGraw-Hill Co.
6	Yadav, R., Heat and Mass Transfer, Central Publishing House, 1995
7	Yunus A.Cengal., Heat and Mass Transfer – A practical Approach, 3rd edition, Tata- McCraw-Hill,2007.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Demonstrate three-dimensional conduction heat transfer mechanism and radiation concepts for various conditions.	Remember
CO2	Explain the turbulent forced convective heat transfer concepts and analyze the heat and momentum transfer.	Analyze
CO3	Explain condensation concepts and analysis of heat exchangers	Analyze
CO4	Utilize the concepts numerical methods for the heat transfer applications	Apply
CO5	Knowledge in combined heat and mass transfer mechanisms in engine applications.	Remember

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	3	2	2	0	1	0	0	0	0	0	3	3	0
CO2	3	3	2	2	0	1	0	0	0	0	0	3	3	0
CO3	3	3	2	2	0	1	0	0	0	0	0	3	3	0
CO4	3	3	2	2	0	1	0	0	0	0	0	3	3	0
CO5	3	3	2	2	3	1	0	0	0	0	0	2	2	2
Avg	3	3	2	2	0.6	1	0	0	0	0	0	2.8	2.8	0.4
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**														

22MLC01	RESEARCH METHODOLOGY AND IPR			Semester		I
PREREQUISITES		**Category**	**PC**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To develop the subject of the research, encourage the formation of higher level of trained intellectual ability, critical analysis, rigor and independence of thought, foster individual judgement and skill in the application of research theory and methods and develop skills required in writing research proposals, reports and dissertations

UNIT I	INTRODUCTION TO RESEARCH	9	0	0	9

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of the research problem, Approaches to investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.

UNIT II	EFFECTIVE LITERATURE STUDIES, APPROACHES AND ANALYSIS	9	0	0	9

Developing the theoretical framework of research - Developing operational statements of the problem - Criteria for evaluating research approach - Hypotheses: Parametric and non-parametric testing- Establishing the reliability and validity of findings with literature review and experiments – documentation, Plagiarism, Research ethics.

UNIT III	EFFECTIVE TECHNICAL WRITING	9	0	0	9

Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

UNIT IV	NATURE OF INTELLECTUAL PROPERTY	9	0	0	9

Patents, Designs, Trade and Copyright, process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT V	PATENT RIGHTS AND IPR	9	0	0	9

Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical indications. Administration of Patents System. New developments in IPR; IPR of Biological Systems, Computer Software etc., Traditional knowledge Case Studies, IPR and IITs.

TOTAL(45L) : 45 PERIODS

Reference Books:

1	Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”
2	Ranjit Kumar, 2 nd Edition, “Research Methodology: A Step by Step Guide for beginners”
3	Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd, 2007
4	Mayall, “Industrial Design”, McGraw Hill, 1992
5	Niebel, “Product Design”, McGraw Hill, 1974
6	Asimov, “Introduction to Design”, Prentice Hall, 1962

7	Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age",2016.
8	T. Ramappa, "Intellectual Property Rights Under TO", S. Chand, 2008.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Understand research problem formulation	Understand
CO2	Analysis research related information	Analyse
CO3	Follow research ethics	Create
CO4	Understand that today's world is controlled by computer, Information technology, but tomorrow's world is ruled by ideas, concepts and creativity.	Apply
CO5	Understand that IPR production provides an incentive to inventors for further research work and investment in R& D, which leads to creation of new and better products, and in turn brings about economic growth and social benefits	Apply

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	0	2	0	2	3	0	0	0	2	0	3	2	2	2
CO2	0	2	0	3	3	2	0	0	2	0	2	2	2	2
CO3	2	2	0	3	2	0	0	0	3	0	0	2	2	2
CO4	2	2	0	3	3	0	0	2	3	0	0	1	0	2
CO5	1	2	0	3	3	0	0	2	3	0	0	0	0	2
Avg	1	2	0	2.8	2.8	0	0	0.8	2.6	0	1	1.4	1.2	2

3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**

22THC14	THERMAL ENGINEERING LABORATORY				Semester		I
PREREQUISITES		**Category**	**PC**	**Credit**			**2**
		Hours/Week	**L**	**T**	**P**		**TH**
			0	**0**	**4**		**4**

Course Learning Objectives

1	To conduct experiments on various Thermal Engineering devices to study the performance and its applications

LIST OF EXPERIMENTS:

1	Performance test on Spark Ignition engine and Compression Ignition using the alternate fuels
2	Emission measurement in Spark Ignition and Compression Ignition Engines
3	Performance test on variable compression ratio petrol and diesel engines
4	Performance study in a cooling tower
5	Performance study in a refrigeration and heat pump systems
6	Performance Study in a solar water heater
7	Properties of fuel oils, biomass, biogas
8	Direct and diffused solar radiation measurements
9	Performance study on Boiler
10	Performance study on parallel and counter flow Heat Exchangers
11	Performance and characteristics studies on fan
12	Study on Fuel Cell Systems

TOTAL(60P): 60 PERIODS

LIST OF EQUIPMENT

1	Single cylinder / multi cylinder Automotive Engine with data acquisition system
2	Flue gas analyzer
3	Smoke meter
4	Single cylinder variable Compression ratio petrol engine
5	Single cylinder variable Compression ratio Diesel engine
6	Cooling tower test rig
7	Refrigeration cum Heat Pump test rig
8	100 LPD Solar flat plate water heater test rig
9	Pyranometer
10	Redwood / Saybolt viscometer
11	Bomb calorimeter apparatus
12	Gas colorimeter

13	Cloud & Pour point apparatus
14	Non-IBR Boiler test rig
15	Parallel flow / Counter flow Heat exchanger test rig
16	Fan test rig

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Demonstrate the potential use of various alternate fuels available for IC engines and emission measurement of variable compression ratio SI engine	Analyze
CO2	Test the performance charact eristics of a cooling tower, water heater and refrigeration system.	Apply
CO3	Demonstrate the properties and measurement of various renewable energy sources	Evaluate
CO4	Conduct performance study of boiler and heat exchanger	Apply
CO5	Demonstrate performance and characteristics of fan, and fuel cell	Apply

COURSE ARTICULATION MATRIX

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	2	0	0	3	3	0	0	2	0	0	0	3	1	1
CO2	2	0	0	3	3	0	0	2	0	0	0	3	1	1
CO3	2	0	0	3	3	0	0	2	0	0	0	3	1	1
CO4	2	0	0	3	3	0	0	2	0	0	0	3	1	1
CO5	2	0	0	3	3	0	0	2	0	0	0	3	1	1
Avg	2	0	0	3	3	0	0	2	0	0	0	3	1	1
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**														

22THC15	TECHNICAL SEMINAR – I			Semester			I
PREREQUISITES		Category	EEC	Credit			1
		Hours/Week	L	T		P	TH
			0	0		2	2

Course Learning Objectives	
1	To Enhance the ability of self-study
2	To Improve presentation and communication skills
3	To Increase the breadth of knowledge

GUIDELINES	
1	The student is expected to present a seminar in one of the current topics in the field of Thermal Engineering related issues / technology
2	The seminar shall be of 30 minutes duration and give presentation to the Seminar Assessment Committee (SAC)
3	A faculty guide is to be allotted and he / she will guide and monitor the progress of the student and maintain attendance also
4	In a session of two periods per week, 4 students are expected to present the seminar
5	Students are encouraged to use various teaching aids such as power point presentation and demonstrative models
6	Students are required to prepare a seminar report in the prescribed format given by the Department
	TOTAL(30P): 30 PERIODS

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Identify and choose appropriate topic of relevance.	Create
CO2	Assimilate literature on technical articles of specified topic and develop comprehension.	Evaluate
CO3	Prepare technical report.	Create
CO4	Design, develop and deliver presentation on specified technical topic	Analyze
CO5	Communicate in a structured way	Evaluate

COURSE OUTCOMES:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	0	0	0	3	3	0	0	2	3	0	0	0	0	0
CO2	0	0	0	3	3	0	0	2	3	0	0	0	0	0
CO3	0	0	0	3	3	0	0	2	3	0	0	0	0	0
CO4	0	0	3	3	3	0	0	2	3	0	0	0	0	0
CO5	0	0	0	3	3	0	0	2	3	0	0	0	0	0
Avg	0	0	0	3	3	0	0	2	3	0	0	0	0	0

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low

22THC21	HYDROGEN AND FUEL CELL TECHNOLOGIES			Semester		II
PREREQUISITES		Category	PC	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives

1	To familiarize the hydrogen production techniques
2	To impart the knowledge about the possible applications and various storage options
3	To impart the knowledge about the basics of fuel cell, working and applications
4	To familiarize the types, their merits and demerits of fuel cells
5	To create enthusiasm to realize the cost effectiveness and eco-friendliness of fuel cells

UNIT I	HYDROGEN – BASICS AND PRODUCTION TECHNIQUES	9	0	0	9

Hydrogen – physical and chemical properties, salient characteristics. Production of hydrogen – steam reforming – water electrolysis – gasification and woody biomass conversion – biological hydrogen production – photo dissociation – direct thermal or catalytic splitting of water.

UNIT II	HYDROGEN STORAGE AND APPLICATIONS	9	0	0	9

Hydrogen storage options – compressed gas – liquid hydrogen – Hydride – chemical Storage – comparisons. Safety and management of hydrogen. Applications of Hydrogen

UNIT III	FUEL CELLS	9	0	0	9

History – principle - working - thermodynamics and kinetics of fuel cell process – performance evaluation of fuel cell– comparison on battery Vs fuel cell

UNIT IV	FUEL CELL – TYPES	9	0	0	9

Types of fuel cells – AFC, PAFC, SOFC, MCFC, DMFC, PEMFC – relative merits and demerit

UNIT V	APPLICATION OF FUEL CELL AND ECONOMICS	9	0	0	9

Fuel cell usage for domestic power systems, large scale power generation, Automobile, Space. Economic and environmental analysis on usage of Hydrogen and Fuel cell. Future trends in fuel cells.

TOTAL (45L): 45 PERIODS

Reference Books:

1	Viswanathan B. and Aulice Scibioh.M, Fuel Cells – Principles and Applications, Universities Press, 2006
2	Rebecca L. and Busby, Hydrogen and Fuel Cells: A Comprehensive Guide, Penn Well Corporation, Oklahoma, 2005
3	Bent Sorensen (Sørensen), Hydrogen and Fuel Cells: Emerging Technologies and Applications, Elsevier, UK 2005
4	Kordesch K. and G.Simader, Fuel Cell and Their Applications, Wiley-Vch, Germany 1996.
5	Hart A.B. and G.J.Womack, Fuel Cells: Theory and Application, Prentice Hall, New York Ltd., London 1989

6	Jeremy Rifkin, The Hydrogen Economy, Penguin Group, USA 2002
7	Barclay F.J., Fuel Cells, Engines and Hydrogen, Wiley, 2009

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Describe and analyze the techniques of Hydrogen generation.	Analyze
CO2	Describe and classify various options for Hydrogen storage.	Understand
CO3	Explain the principal operations of fuel cell, its thermodynamics and kinetics.	Understand
CO4	Comprehend the different types of fuel cells compare their merits and demerits.	Understand
CO5	Identify the potential application of a fuel cells for domestic, automotive, space craft power generations and evaluate the techno-economics of a fuel cells.	Evaluate

COURSE OUTCOMES:

COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	0	0	0	3	2	0	0	0	0	1	1	1	0
CO2	3	2	2	2	2	0	0	0	0	0	0	1	1	0
CO3	3	0	0	3	2	2	0	0	0	0	2	1	1	0
CO4	3	0	0	2	1	1	0	0	0	0	0	1	1	0
CO5	2	2	0	2	0	2	0	0	0	0	0	1	1	0
Avg	2.8	0.8	0.4	1.8	1.6	1.4	0.0	0.0	0.0	0.0	0.6	1.0	1.0	0.0

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22THC22	COMPUTATIONAL FLUID DYNAMICS FOR THERMAL SYSTEMS			Semester		II
PREREQUISITES		Category	PC	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives

1	To introduce numerical analysis for heat, fluid flow and combustion and to understand the various discretization methods
2	To enable to solve the steady and unsteady diffusion problems using finite volume method
3	To enable to solve one dimensional convection-diffusion problems using finite volume method
4	To enable to discretize and solve incompressible flow problems using SIMPLE and other algorithms
5	To enable to model and solve turbulence flow problems

UNIT I	**GOVERNING DIFFERENTIAL EQUATIONS AND DISCRETISATION TECHNIQUES**	**9**	**0**	**0**	**9**

Basics of Heat Transfer, Fluid flow – Mathematical description of fluid flow and heat transfer – Conservation of mass, momentum, energy and chemical species - Classification of partial differential equations – Initial and Boundary Conditions – Discretization techniques using finite difference methods – Taylor's Series - Uniform and non-uniform Grids, Numerical Errors, Grid Independence Test.

UNIT II	**DIFFUSION PROCESSES: FINITE VOLUME METHOD**	**9**	**0**	**0**	**9**

Steady one-dimensional diffusion, Two- and three-dimensional steady state diffusion problems, Discretization of unsteady diffusion problems – Explicit, Implicit and Crank-Nicholson's schemes, Stability of schemes.

UNIT III	**CONVECTION–DIFFUSION PROCESSES: FINITE VOLUME METHOD**	**9**	**0**	**0**	**9**

One dimensional convection – diffusion problem, Central difference scheme, upwind scheme – Hybrid and power law discretization techniques – QUICK scheme

UNIT IV	**FLOW PROCESSES: FINITE VOLUME METHOD**	**9**	**0**	**0**	**9**

Discretization of incompressible flow equations – Pressure based algorithms, SIMPLE, SIMPLER & PISO algorithms

UNIT V	**TURBULENCE AND ITS MODELING**	**9**	**0**	**0**	**9**

Description of turbulent flow, free turbulent flows, flat plate boundary layer and pipe flow. Algebraic Models, One equation model, $k – \varepsilon$ & $k – \omega$ models Standard and High and Low Reynolds number models.

TOTAL(45L) : 45 PERIODS

Reference Books:

1	Anderson, D.A., Tannehill, J.I., and Pletcher, R.H., "Computational fluid Mechanics and Heat Transfer " Hemisphere Publishing Corporation, New York, USA, 2012
2	Bose, T.K., "Numerical Fluid Dynamics" Narosa Publishing House, 1997
3	Fletcher, C.A.J. "Computational Techniques for Fluid Dynamics 1" Fundamental and General Techniques, Springer – Verlag, 1991

4	Fletcher, C.A.J. "Computational Techniques for fluid Dynamics 2" Specific Techniques for Different Flow Categories, Springer – Verlag, 1988
5	Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 2003.
6	Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 2003

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Explain and apply governing equations, boundary conditions various discretization techniques.	Apply
CO2	Solve solving diffusion heat transfer problems using finite volume based numerical method.	Evaluate
CO3	Solve convection-diffusion heat transfer problems using finite volume based numerical method.	Analyze
CO4	Write computer code for incompressible flow problems.	Create
CO5	Explain and formulate various turbulence modeling.	Understand

COURSE OUTCOMES:

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	2	3	3	3	0	2	0	0	0	0	1	2	3	0
CO2	2	2	3	3	0	2	0	0	0	0	0	2	3	0
CO3	2	3	3	3	0	3	0	0	0	0	0	2	2	3
CO4	2	3	3	3	0	3	0	0	0	0	0	2	2	3
CO5	3	2	2	3	0	0	0	0	0	0	0	2	3	0
Avg	2.2	2.6	2.8	3.0	0.0	2.0	0.0	0.0	0.0	0.0	0.2	2.0	2.6	1.2

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22THC23	INSTRUMENTATION FOR THERMAL SYSTEMS			Semester		II
PREREQUISITES		**Category**	**PC**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To provide knowledge on the characteristics of various measuring instruments for thermal engineering
2	To provide the roll of computers and microprocessors in the field of instrumentation systems
3	To provide insights about the instruments for measuring the physical properties
4	To provide knowledge on advance measurement techniques
5	To provide the insights of various gas analyzing techniques

UNIT I	**MEASUREMENT CHARACTERISTICS**	**9**	**0**	**0**	**9**
Instrument Classification, Characteristics of Instruments – Static and dynamic, experimental error analysis, Systematic and random errors, Statistical analysis, Uncertainty, Experimental planning and selection of measuring instruments, Reliability of instruments					
UNIT II	**MICROPROCESSORS AND COMPUTERS IN MEASUREMENT**	**9**	**0**	**0**	**9**
Data logging and acquisition – Sensors -types - use of sensors for error reduction, elements of micro- computer interfacing, intelligent instruments in use.					
UNIT III	**MEASUREMENT OF PHYSICAL QUANTITIES**	**9**	**0**	**0**	**9**
Measurement of thermo-physical properties, instruments for measuring temperature, pressure and flow –use of sensors for physical variables					
UNIT IV	**ADVANCED MEASUREMENT TECHNIQUES**	**9**	**0**	**0**	**9**
Shadowgraph, Schlieren, Interferometer, Laser Doppler Anemometer, Hot wire Anemometer, heat flux sensors, Telemetry in measurement.					
UNIT V	**MEASUREMENT ANALYSIS**	**9**	**0**	**0**	**9**
Chemical thermal, magnetic and optical gas analyzers, measurement of smoke, Dust and moisture, gas chromatography, spectrometry, measurement of pH.					
TOTAL(45L) : 45 PERIODS					

Reference Books:

1	Barnery, Intelligent Instrumentation, Prentice Hall of India, 1988.
2	Bolton.W, Industrial Control & Instrumentation, Universities Press, Second Edition, 2001
3	Doblin E.O, Measurement System Application and Design, Second Edition, McGraw Hill, 1978
4	Holman J.P., Experimental methods for engineers, McGraw-Hill, 2012
5	John G Webster, The measurement, Instrumentation and sensors Handbook, CRC and IEE Press, 1999
6	Morris A.S, Principles of Measurements and Instrumentation Prentice Hall of India, 1998

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Describe characteristics of measurement system and do errors encountered during measurements.	Create
CO2	Handle modern data acquisition system and interfacing of sensors with them.	Evaluate
CO3	Describe the measurement technique for the measurement of physical properties.	Create
CO4	Explain the advanced measurement technique for the measurement of physical properties.	Analyze
CO5	Describe the measurement analysis for the measurement of smoke, ph and magnetic properties.	Analyze

COURSE OUTCOMES:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	2	0	3	0	2	0	0	0	0	0	0	0	0
CO2	1	2	2	3	3	0	0	0	0	0	0	0	0	3
CO3	1	2	2	2	3	0	0	0	0	0	0	0	1	3
CO4	1	2	0	1	3	0	0	0	0	0	0	0	1	3
CO5	1	2	0	1	3	0	0	0	0	0	0	0	2	3
Avg	1.0	2.0	0.8	2.0	2.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.8	2.4
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)														

22THC24	ANALYSIS AND SIMULATION LABORATORY				Semester		II
PREREQUISITES		Category	PC		Credit		3
		Hours/Week	L	T	P		TH
			3	0	0		3

Course Learning Objectives	
1	To provide a platform to learn and get familiar with the modelling, analysis and simulation of thermal engineering systems
LIST OF EXERCISES	
1	Conduction heat transfer analysis
2	Convection heat transfer analysis – Velocity boundary layer
3	Convection heat transfer analysis – Internal flow
4	Radiation heat transfer analysis – Emissivity
5	Critical radius of insulation
6	Lumped heat transfer analysis
7	Heat exchanger analysis – NTU method
8	Heat exchanger analysis – LMTD method
9	Performance study on different types of solar flat plate collector
10	Performance study on stand-alone solar PV panel
11	Performance Study of solar PV panel including shading effects
SIMULATION LAB – REQUIREMENT:	
1	Software - Modeling software like ProE, Gambit, Ansys, etc
2	Analysis software like Ansys, fluent, CFX, etc
3	Equation solving software like Matlab, Engg equation solver
4	Hardware are compatible with the requirement of the above software
	TOTAL (60P): 60 PERIODS

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Develop a model, simulation and analysis for steady state heat conduction, Convection and radiation problems	Apply
CO2	Develop a model, simulation and analysis for critical radius of insulation and Lumped system analysis.	Analyze
CO3	Develop a model, simulation and analysis for a heat exchanger.	Evaluate
CO4	Develop a model develop a model, simulation and analysis for a solar collector	Analyze
CO5	Develop model, simulation and analysis for solar PV panel.	Analyze

COURSE OUTCOMES:

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	0	0	0	0	2	0	2	3	3
CO2	3	3	3	3	3	0	0	0	0	2	0	2	3	3
CO3	3	3	3	3	3	0	0	0	0	2	0	2	3	3
CO4	3	3	3	3	3	0	0	0	0	2	0	2	3	3
CO5	3	3	3	3	3	0	0	0	0	2	0	2	3	3
Avg	3.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0	0.0	2.0	0.0	2.0	3.0	3.0

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22THC25	APPLIED THERMAL ENGINEERING LABORATORY			Semester		II
PREREQUISITES		Category	PC	Credit		2
		Hours/Week	L	T	P	TH
			0	0	4	4

Course Learning Objectives	
1	To educate the realities and applications of thermal engineering
2	To educate about calibration and its essentiality in thermal systems

LIST OF EXPERIMENTS	
1	Calibration of Temperature Transducers (Thermocouple, RTD & Thermistors).
2	Calibration of Pressure Transducers
3	Experimental Analysis of Organic Rankine Cycle
4	Fluid and Thermal Transfer Properties of Liquid Fuels / Heat Transfer Fluids
5	Experimental Studies on Pool Boiling of Water using Flow Visualization Technique
6	Experimental Studies on Fluidization of Solid Fuels.
7	Studies on Absorption Refrigeration System
8	Performance testing of solar water heater
9	Performance evaluation of engine on biodiesel
10	Heat pipe solar collector
	TOTAL (60P): 60 PERIODS

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Calibrate temperature and pressure transducers.	Apply
CO2	Find thermal flow properties of liquid fuel.	Understand
CO3	Practically understand the pool boiling concept.	Apply
CO4	Conduct performance test on vapor absorption system and engine using biodiesel.	Apply
CO5	Conduct performance test on engine using biodiesel	Understand

COURSE OUTCOMES:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	1	3	3	0	0	0	0	2	0	2	3	2
CO2	3	3	1	3	3	0	0	0	0	2	0	2	3	2
CO3	3	3	1	3	3	0	0	0	0	2	0	2	3	2
CO4	3	3	1	3	3	0	0	0	0	2	0	2	3	2
CO5	3	3	1	3	3	0	0	0	0	2	0	2	3	2
Avg	3.0	3.0	1.0	3.0	3.0	0.0	0.0	0.0	0.0	2.0	0.0	2.0	3.0	2.0

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22THC26	TECHNICAL SEMINAR –II				Semester		II
PREREQUISITES		**Category**	**EEC**	**Credit**			**1**
		Hours/Week	**L**	**T**	**P**		**TH**
			0	**0**	**2**		**2**

Course Learning Objectives	
1	To enhance the reading ability required for identification of his/her field of interest
2	To develop skills regarding professional communication and technical report writing
3	To establish the fact that student is not mere recipient of ideas, but a participant in discovery and inquiry.
4	To learn how to prepare and publish technical papers
GUIDELINES	
1	The student is expected to present a seminar in one of the current topics in the field of Thermal Engineering related issues /technology
2	The seminars hall be of 30minutes duration and give presentation to the Seminar Assessment Committee (SAC).
3	The committee shall evaluate the seminar based on the style of presentation, technical context, and coverage of the topic, adequacy of references, depth of knowledge and the overall quality
4	A faculty guide is to be allotted and he/she will guide and monitor the progress of the student and maintain attendance also
5	Each student has to submit a seminar report in the prescribed format given by the Institution
6	In a session of two periods per week, 4 students are expected to present the seminar
7	Students are encouraged to use various teaching aids such as power point presentation and demonstrative models
8	It is recommended that the report for Technical Seminar II maybe in the form of a technical paper which is suitable for publishing in Conferences / Journals as a review paper
9	Students able to identify quality journal by quartile index which is the ranking of any journal that belongs to a specific field of discipline (Q index through Scimago), Scopus indexed journals, Web of Science (WOS) and paper title through cross ref
10	Cross reference is a reference to information located somewhere else in the same document.
11	Scholar ID creation through Google scholar, Scopus author and Web of Science Researcher ID

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Develop the capacity to observe intelligently and propose and defend opinions and ideas with tact and conviction	Evaluate
CO2	Develop skills regarding professional communication and technical report writing.	Apply
CO3	Learn the methodology of publishing technical papers.	Understand
CO4	Identification of good journal through various analyses for publication.	Analyze
CO5	Creation of scholar ID through various international forums for research identity	Understand

COURSE OUTCOMES:

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PSO1	PSO2	PSO3
CO1	0	1	2	2	2	1	0	0	3	0	0	1	1	1
CO2	0	1	2	2	2	1	0	0	3	0	0	1	1	1
CO3	0	1	2	2	2	1	0	0	3	0	0	1	1	1
CO4	0	1	2	2	2	1	0	0	3	0	0	1	1	1
CO5	0	1	2	2	2	1	0	0	3	0	0	1	1	1
Avg	0.0	1.0	2.0	2.0	2.0	1.0	0.0	0.0	3.0	0.0	0.0	1.0	1.0	1.0

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22THC31	DISSERTATION PHASE – I			Semester		III
PREREQUISITES		**Category**	**EEC**	**Credit**		**6**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**20**	**20**

Course Learning Objectives	
1	To develop the ability to solve a specific problem right from its identification and literature review until the successful solution of the same.
2	To train the students in preparing project reports and to face reviews and viva voce examination

CONTENTS:	
1	The Project Work will start in semester III and should preferably be a problem with research potential and should involve scientific research, design, generation/collection and analysis of data, determining solution and must preferably bring out the individual contribution
2	The seminar should be based on the area in which the candidate has undertaken the dissertation work as per the common instructions for all branches of M. E
3	The examination shall consist of the preparation of a report consisting of a detailed problem statement and a literature review
4	The preliminary results (if available) of the problem may also be discussed in the report. The work has to be presented in front of the examiner's panel set by Head and PG coordinator
5	The candidit has to be in regular contact with his guide and the topic of the dissertation must be mutually decided by the guide and student

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Students will learn to survey the relevant literature such as books, national/international refereed journals and contact resource persons for the selected topic of research.	Apply
CO2	Students will be able to use different experimental techniques.	Analyze
CO3	Students will be able to use different software/ computational/analytical tools.	Evaluate
CO4	Students will be able to design and develop an experimental set up/ equipment/test rig.	Analyze
CO5	Students will be able to conduct tests on existing setups/equipment and draw logical conclusions from the results after analyzing them.	Analyze

22THC41	DISSERTATION PHASE – II				Semester		I
PREREQUISITES			**Category**	**EEC**	**Credit**		**14**
			Hours/Week	**L**	**T**	**P**	**TH**
				0	**0**	**32**	**32**

Course Learning Objectives

1	To develop the ability to solve a specific problem right from its identification and literature review till the successful solution of the same.
2	To train the students in preparing project reports and to face reviews and viva voce examination

CONTENTS:

1	The Project Work will start in semester III and should preferably be a problem with research potential and should involve scientific research, design, generation/collection and analysis of data, determining solution and must preferably bring out the individual contribution
2	The seminar should be based on the area in which the candidate has undertaken the dissertation work as per the common instructions for all branches of M.E
3	The examination shall consist of the preparation of a report consisting of a detailed problem statement and a literature review
4	The preliminary results (if available) of the problem may also be discussed in the report. The work has to be presented in front of the examiner's panel set by Head and PG coordinator
5	The candidate has to be in regular contact with his guide and the topic of the dissertation must be mutually decided by the guide and student

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Students will learn to survey the relevant literature such as books, national/international refereed journals and contact resource persons for the selected topic of research.	Understand
CO2	Students will be able to use different experimental techniques.	Apply
CO3	Students will be able to use different software/ computational/analytical tools.	Analyze
CO4	Students will be able to design and develop an experimental set up/ equipment/test rig.	Evaluate
CO5	Students will be able to conduct tests on existing set ups/equipment and draw logical conclusions from the results after analyzing them.	Understand

PROFESSIONAL ELECTIVES - I

22CDE11	ADVANCED MATHEMATICAL METHODS IN ENGINEERING		Semester			I
PREREQUISITES		**Category**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To implement the knowledge about the vector spaces, inverse of a linear transformation and composition of linear maps
2	To analyze the solution of wave equation by method of Eigenfunction
3	To illustrate the solutions of diffusion and wave equations by using techniques of Laplace and Fourier transforms
4	To examine the significance of the central limit theorem and testing of hypotheses
5	To analyze the variance of factors by one way and two-way classification and some standard design of experiments.

UNIT I	**LINEAR ALGEBRA**	**9**	**0**	**9**	**0**

Vector space - linear dependence of vectors, basis and dimension- Linear transformations (maps) - range and kernel of linear transformation- rank and nullity- Inverse of linear transformation- rank-nullity theorem – Composition of linear maps- Matrix associated with linear map.

UNIT II	**PARTIAL DIFFERENTIAL EQUATIONS**	**9**	**0**	**0**	**9**

Classification of second order PDE- Solution of PDE by separation of variables- Solution of Parabolic, elliptic and hyperbolic equation in cylindrical and spherical co-ordinates- Initial and boundary value problems for Two-dimensional wave equation by the method of Eigen function - D Alembert’s solution for the wave equation.

UNIT III	**FOURIER AND LAPLACE TRANSFORMS**	**9**	**0**	**0**	**9**

Maximum-Minimum principle for Elliptic equations- Solution of diffusion equation and wave equation by Laplace transform technique – Solution of Diffusion equation, wave equation and Laplace equation by Fourier transform technique.

UNIT IV	**STANDARD DISTRIBUTIONS AND TESTING OF HYPOTHESIS**	**9**	**0**	**0**	**9**

Random variables - Standard discrete and continuous distributions (Binomial, poisson, normal, uniform and exponential) – Central limit theorem and its significance - Testing a statistical hypothesis sampling distribution (t-test, F-test and Chi-square test).

UNIT V	**ANALYSIS OF VARIANCE AND DESIGN OF EXPERIMENTS**	**9**	**0**	**0**	**9**

Analysis of variance - One way and two way classifications- Principles of design of experiments- Some standard designs (completely randomized design, randomized block design and latin square design).

TOTAL(45L) : 45 PERIODS

Reference Books:

1	Gilbert Strang, “Linear Algebra and its applications”, Cengage Learning, New Delhi, 4th edition, 2006

2	K. Sankara Rao, “Introduction to Partial Differential Equations”, Prentice Hall of India Pvt. Ltd., New Delhi, 2003
3	Veerarajan.T, “Probability, Statistics and Random process”, Tata McGraw- Hill publications, second edition New Delhi, 2002
4	V.Krishnamoorthy, V.P.Maintra and J L Arora “ An Introduction to Linear Algebra” East West Press Reprint 2005
5	Grewal, B.S., “Higher Engineering Mathematics”, 43rd edition, Khanna Publishers, New Delhi 2014
6	J.B.Joshi, “Differential equations for Scientists and Engineers”, Narosa Publications, 2010.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom’s Taxonomy Level**
CO1	Demonstrate the vector spaces and linear transformations.	Apply
CO2	Analyze the solution of wave equation by method of Eigenfunction.	Analyze
CO3	Implement the Laplace and Fourier transform techniques for the solutions of diffusion and wave equation involved in engineering problems.	Evaluate
CO4	Experiment various tests of statistics for the samples.	Apply
CO5	Analyze the variance of factors by one way and two-way classification and some standard design of experiments.	Analyze

COURSE OUTCOMES:

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	0	2	0	0	0	0	0	0	0	2	0	0
CO2	3	2	0	2	0	0	0	0	0	0	0	2	0	0
CO3	3	2	0	2	0	0	0	0	0	0	0	2	0	0
CO4	3	2	0	2	0	0	0	0	0	0	0	2	0	0
CO5	3	2	0	2	0	0	0	0	0	0	0	2	0	0
Avg	3	2	0	2	0	0	0	0	0	0	0	2	0	0

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22THE11	COMBUSTION IN IC ENGINES			Semester			I
PREREQUISITES			**Category**	**PE**	**Credit**		**3**
			Hours/Week	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Learning Objectives

1	To make familiar with the design and operating characteristics of engines
2	To understand the basic principles of combustion
3	To gain knowledge in the principles of SI engine combustion
4	To understand the concepts of CI engine system.
5	To understand the basic concepts of gas turbine combustion and the latest technological advances in low temperature combustion

UNIT I	**ENGINE BASICS**	**9**	**0**	**0**	**9**

Principles of Engine operation – Torque and Power Characteristics – Intake and Exhaust Flows – Fuel Characteristics – ISO standards (Qualitative treatment only) Balancing, valve trains

UNIT II	**COMBUSTION PRINCIPLES**	**9**	**0**	**0**	**9**

Combustion – Combustion equations, chemical equilibrium and Dissociation -Theories of Combustion - Flammability Limits - Reaction rates - Laminar and Turbulent Flame Propagation in Engines, Flame structure and speed - Chemical kinetics.

UNIT III	**COMBUSTION IN S.I. ENGINES**	**9**	**0**	**0**	**9**

Stages of combustion, Cylinder pressure measurement and heat release analysis normal and abnormal combustion, knocking, Variables affecting Knock, Features and design consideration of combustion chambers, Types of combustion chambers., Cyclic variations, Lean burn combustion, Stratified charge combustion systems. Heat release correlations

UNIT IV	**COMBUSTION IN C.I. ENGINES**	**9**	**0**	**0**	**9**

Stages of combustion, and spray formation and characterization, air motion, swirl measurement, knock and engine variables, Features and design considerations of combustion chambers, delay period correlations, heat release correlations, Influence of the injection system on combustion, Direct and indirect injection systems.

UNIT V	**COMBUSTION CONCEPTS IN LOW TEMPERATURE I.C. ENGINE**	**9**	**0**	**0**	**9**

Homogeneous charge compression ignition (HCCI) engine – Premixed charge compression ignition (PCCI) engine, Gasoline Direct Injection Compression Ignition (GDCI) engine, Reactivity controlled compression ignition (RCCI) engine – An introduction.

TOTAL(45L) : 45 PERIODS

Reference Books:

1	Cohen, H, Rogers, G, E.C, and Saravanamuttoo, H.I.H., Gas Turbine Theory, Longman Group Ltd., 1980
2	Ganesan, V, Internal Combustion Engines, Tata McGraw Hill Book Co., 2003
3	John B. Heywood, Internal Combustion Engine Fundamentals, McGraw Hill Book, 1998

4	Pundir B P, I.C. Engines Combustion and Emission, 2010, Narosa Publishing House
5	Rajput R.K. Internal Combustion Engines, Laxmi Publications (P) Ltd, 2006

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Analyze fuel and engine characteristics.	Analyze
CO2	Describe combustion fundamental, theories and flame propagation in engineering.	Evaluate
CO3	Discuss combustion characteristics and combustion chamber types for SI engine.	Apply
CO4	Discuss combustion characteristics and combustion chamber types for CI engine.	Analyze
CO5	Describe combustion concepts of low temp IC engine.	Understand

COURSE OUTCOMES:

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO8	PO 9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	0	2	2	0	1	0	0	0	0	0	2	2	0
CO2	3	0	0	0	0	2	0	0	0	0	2	2	2	0
CO3	3	3	2	2	0	0	0	0	0	0	0	3	3	0
CO4	3	3	2	2	0	0	0	0	0	0	0	3	3	0
CO5	2	0	2	0	0	0	0	0	0	0	2	2	2	0
Avg	2.8	1.2	1.6	1.2	0	0.6	0	0	0	0	0.8	2.4	2.4	0

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22THE12	THERMAL MANAGEMENT OF ELECTRIC VEHICLE BATTERY SYSTEMS		Semester			I
PREREQUISITES		**Category**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**
Course Learning Objectives						
1	To study the insights of Thermal Management of Electric Vehicle Battery Systems					
2	To recognize the applications of PCM in Thermal Management					
3	To investigate the Thermal behaviors in Electric Vehicle Battery Systems through Simulation and Experiments.					
4	To calculate the Energy and Exergy Analyses of Battery TMSs					
5	To obtain solutions for case Studies on Thermal Management Solutions of Electric batteries					
UNIT I	**VEHICLE BATTERY TECHNOLOGIES**		**9**	**0**	**0**	**9**
Introduction, Current Battery Technologies: Lead Acid Batteries, Nickel Cadmium Batteries, Nickel Metal Hydride Batteries, Lithium-Ion Batteries, Battery Technologies under Development, Zinc-Air Batteries, Sodium-Air Batteries, Lithium-Sulfur Batteries, Aluminum-Air Batteries, Lithium-Air Batteries, Battery Environmental Impact, Impact of Various Loads and Environmental Conditions, Battery Management Systems, Safety Management/Fault Diagnosis/ Thermal Management.						
UNIT II	**PHASE CHANGE MATERIALS FOR PASSIVE TMS's**		**9**	**0**	**0**	**9**
Basic Properties and Types of PCMs, Organic PCMs, Inorganic PCMs, Measurement of Thermal Properties of PCMs, Heat Transfer Enhancements, Cost and Environmental Impact of Phase Change Materials, Applications of PCMs. Case Study 1: Heat Exchanger Design and Optimization Model for EV Batteries using PCMs Case Study 2: Melting and Solidification of Paraffin in a Spherical Shell from Forced External Convection						
UNIT III	**SIMULATION AND EXPERIMENTAL INVESTIGATION OF BATTERY TMS's**		**9**	**0**	**0**	**9**
Numerical Model Development for Cell and Submodules, Cell and Module Level Experimentation Set Up and Procedure, Vehicle Level Experimentation Set Up and Procedure, Illustrative Example: Simulations and Experimentations on the Liquid Battery Thermal Management System Using PCMs, Simulation and Experimentations Between the Cells in the Submodule, Thermal Conductivity Enhancement by Nanoparticles						
UNIT IV	**ENERGY AND EXERGY ANALYSES OF BATTERY TMSs**		**9**	**0**	**0**	**9**
TMS Comparison, Modeling of Major TMS Components, Energy and Exergy Analyses, Illustrative Example: Liquid Battery Thermal Management Systems, Case Study: Trans critical CO_2-Based Electric Vehicle BTMS.						
UNIT V	**CASE STUDIES ON THERMAL MANAGEMENT SOLUTIONS OF ELECTRIC BATTERIES**		**9**	**0**	**0**	**9**
Case Study 1: Experimental and Theoretical Investigation of Temperature Distributions in a Prismatic Lithium-Ion Battery Case Study 2: Thermal Management Solutions for Electric Vehicle Lithium-Ion Batteries based on Vehicle Charge and Discharge Cycles Case Study 3: Heat Transfer and Thermal Management of Electric Vehicle Batteries with Phase Change Materials Case Study 4: Experimental and Theoretical Investigation of Novel Phase Change Materials for Thermal Applications.						
						TOTAL(45L) : 45 PERIODS

Reference Books:	
1	Ibrahim Dinçer, Halil S. Hamut, Nader Javani, Thermal Management of Electric Vehicle Battery Systems, C, 2017.
2	Halil S. Hamut, Nader Javani, Ibrahim Dinçer, Thermal Management of Electric Vehicle Battery Systems, Wiley, 2016.
3	Weixiang Shen, Rui Xiong, Advanced Battery Management Technologies for Electric Vehicles, John Wiley and sons, First edition 2019
4	Chitra A., Sanjeevikumar Padmanaban, Jens Bo Holm-Nielsen, Artificial Intelligent Techniques for Electric and Hybrid Electric Vehicles, John Wiley and sons, First edition 2020
5	Bruno Scrosati, Jurgen Garche, Werner Tillmetz, Advances in Battery Technologies for Electric Vehicles, Woodhead Publishing, 2015.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Describe and analyze the techniques of Thermal Management of Electric Vehicle Battery Systems.	Analyze
CO2	Describe and classify various applications of PCM in Thermal Management.	Evaluate
CO3	Investigate the Thermal behaviors in Electric Vehicle Battery Systems through Simulation and experiments.	Evaluate
CO4	Calculate the Energy and Exergy Analyses of Battery tmss.	Apply
CO5	Identify the solutions for case Studies on Thermal Management Solutions of Electric batteries.	Analyze

COURSE OUTCOMES:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	0	2	0	1	0	0	0	0	0	1	1	1
CO2	3	2	0	2	0	1	0	0	0	0	1	2	2	0
CO3	3	2	0	2	0	2	0	0	0	0	1	2	2	0
CO4	3	2	0	2	0	2	0	0	0	0	1	2	2	0
CO5	3	3	0	2	0	2	0	0	0	0	1	2	2	0
Avg	**2.8**	**2.2**	**0**	**2**	**0**	**1.6**	**0**	**0**	**0**	**0**	**0.8**	**1.8**	**1.8**	**0**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)														

22THE13	**NUCLEAR ENGINEERING**		**Semester**			**I**
PREREQUISITES		**Category**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To impart the fundamentals of nuclear reactions, design of reactors and heat transfer techniques
2	To demonstrate the characteristics of nuclear fuels
3	To discuss the need and principle of reprocessing of nuclear fuels
4	To discuss the separation of reactor products
5	To impar the knowledge about the waste disposal and radiation protection

UNIT I	**NUCLEAR REACTIONS**	**9**	**0**	**0**	**9**

Mechanism of nuclear fission - nuclides - radioactivity – decay chains - neutron reactions - the fission process - reactors - types of fast breeding reactor - design and construction of nuclear reactors - heat transfer techniques in nuclear reactors - reactor shielding

UNIT II	**REACTOR MATERIALS**	**9**	**0**	**0**	**9**

Nuclear Fuel Cycles - characteristics of nuclear fuels - Uranium - production and purification of Uranium - conversion to UF4 and UF6 - other fuels like Zirconium, Thorium – Beryllium

UNIT III	**REPROCESSING**	**9**	**0**	**0**	**9**

Nuclear fuel cycles - spent fuel characteristics - role of solvent extraction in reprocessing - solvent extraction equipment

UNIT IV	**SEPARATION OF REACTOR PRODUCTS**	**9**	**0**	**0**	**9**

Processes to be considered - 'Fuel Element' dissolution - precipitation process – ion exchange – redox - purex - TTA - chelation -U235 - Hexone - TBP and thorax Processes - oxidative slagging and electro - refining - Isotopes - principles of Isotope separation

UNIT V	**WASTE DISPOSAL AND RADIATION PROTECTION**	**9**	**0**	**0**	**9**

Types of nuclear wastes - safety control and pollution control and abatement - international convention on safety aspects - radiation hazards prevention

TOTAL(45L) : 45 PERIODS

Reference Books:

1	Cacuci, Dan Gabriel, Nuclear Engineering Fundamentals, Springer, 2010
2	Kenneth Shultis J., Richard E. Faw, Fundamentals of Nuclear Science and Engineering, CRC Press; 3 edition, 2016
3	Kenneth D. Kok, Nuclear Engineering, CRC Press, 2009
4	Lamarsh, J.R., Introduction to Nuclear Reactor Theory, Wesley, 2002

5	Tatjana Tevremovic, Nuclear Principles in Engineering, Springer, 2008

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Describe fundamentals of nuclear reactions and describe the construction and heat transfer techniques in nuclear reactor.	Understand
CO2	Describe production, purification and characterization of nuclear fuels.	Analyze
CO3	Describe fuel cycle and spent fuel reprocessing.	Understand
CO4	Describe the separation of reactor products.	Analyze
CO5	Describe waste disposal techniques and protection from radiation hazards	Apply

COURSE OUTCOMES:														
CO/PO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO8**	**PO 9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	1	1	2	2	0	0	0	0	0	1	2	0
CO2	2	2	1	1	2	2	0	0	0	0	0	1	2	0
CO3	2	2	0	2	2	1	0	0	0	0	0	1	2	0
CO4	2	2	0	2	2	1	0	0	0	0	0	1	2	0
CO5	2	2	0	2	2	1	2	0	0	0	0	1	2	0
Avg	2	2	0.4	1.6	2	1.4	0.4	0	0	0	0	1	2	0
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)														

22THE14	BOUNDARY LAYER THEORY AND TURBULENCE			Semester		I
PREREQUISITES		**Category**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To introduce the fundamental concepts of boundary layer in real flows
2	To distinguish between turbulent and laminar boundary layers
3	To model turbulent flows using various approaches
4	To discuss the various flow parameters using statistical principles
5	To introduce the types, characteristics of wall shear flows from free shear flows

UNIT I	**FUNDAMENTALS OF BOUNDARY LAYER THEORY**	**9**	**0**	**0**	**9**

Boundary Layer Concept, Laminar Boundary Layer on a Flat Plate at zero incidence, Turbulent Boundary Layer on a Flat plate at zero incidence, Fully Developed Turbulent Flow in a pipe, Boundary Layer on an airfoil, Boundary Layer separation.

UNIT II	**TURBULENT BOUNDARY LAYERS**	**9**	**0**	**0**	**9**

Internal Flows – Couette flow – Two-Layer Structure of the velocity Field – Universal Laws of the wall– Friction law – Fully developed Internal flows – Channel Flow, Couette – Poiseuille flows, Pipe Flow

UNIT III	**TURBULENCE AND TURBULENCE MODELS**	**9**	**0**	**0**	**9**

Nature of turbulence – Averaging Procedures – Characteristics of Turbulent Flows – Types of Turbulent Flows – Scales of Turbulence, Prandtl’s Mixing length, Two-Equation Models, Low – Reynolds Number Models, Large Eddy Simulation

UNIT IV	**STATISTICAL THEORY OF TURBULENCE**	**9**	**0**	**0**	**9**

Ensemble Average – Isotropic Turbulence and Homogeneous Turbulence – Kinematics of Isotropic Turbulence – Taylor’s Hypothesis – Dynamics of Isotropic Turbulence – Grid Turbulence and decay – Turbulence in Stirred Tanks.

UNIT V	**TURBULENT FLOWS**	**9**	**0**	**0**	**9**

Wall Turbulent shear flows – Structure of wall flow – Turbulence characteristics of Boundary layer – Free Turbulence shear flows – Jets and wakes – Plane and axi-symmetric flows.

TOTAL(45L) : 45 PERIODS

Reference Books:

1	Philip G. Hill and Carl R. Peterson, Mechanics and Thermodynamics of Propulsion, Second Edition, Addition – Wesley Publishing Company, New York, 2009
2	Cohen, H. Rogers, G.F.C. and Saravanamuttoo, H.I.H, Gas Turbine Theory, Longman,1989
3	G.C. Oates, “Aerothermodynamics of Aircraft Engine Components”, AIAA Education Series,1985
4	S. M. Yahya, Fundamentals of Compressible Flow. Third edition, New Age International Pvt Ltd,2003
5	George P. Sutton, Oscar Biblarz. Rocket Propulsion Elements, John Wiley & Sons, 8th Edition, 2010

6	Ramamurthy, Rocket Propulsion, Pan Macmillan (India) Ltd, 2010
7	W.P.Gill, H.J.Smith & J.E. Ziurys, "Fundamentals of Internal Combustion Engines as applied to Reciprocating, Gas turbine & Jet Propulsion Power Plants", Oxford & IBH Publishing Co., 1980

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Analyze flow with the principles of boundary layer theory.	Analyze
CO2	Distinguish turbulent boundary layer for various types of flows.	Understand
CO3	Select and use various turbulence models for the appropriate applications.	Analyze
CO4	Apply the statistical theory for averaging various flow parameters.	Apply
CO5	Differentiate the characteristics of wall shear and free shear flows.	Understand

COURSE OUTCOMES:

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	2	0	0	0	2	0	0	1	0	0	2	3	0	0
CO2	2	2	3	0	0	2	0	0	0	1	2	3	0	0
CO3	2	2	3	2	0	0	0	0	0	2	2	3	2	0
CO4	2	2	3	2	0	0	0	0	0	2	2	3	1	0
CO5	2	2	3	2	0	0	0	0	0	2	2	3	1	0
Avg	2	1.6	2.4	1.2	0.4	0.4	0	0.2	0	1.4	2	3	0.8	0

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22THE21	AIR CONDITIONING SYSTEM DESIGN				Semester		I
PREREQUISITES		**Category**	**PE**	**Credit**			**3**
		Hours/Week	**L**	**T**		**P**	**TH**
			3	**0**		**0**	**3**

Course Learning Objectives

1	To teach the insights of the psychometric concepts underlying Air conditioning process
2	To conversant with the design features and load estimation principles of specific Air conditioning system.
3	To introduce the different air conditioning system design
4	To introduce the components and control in the air distribution system in air conditioning system
5	To introduce the components, controls of air conditioning systems in automobile

UNIT I	**PSYCHROMETRY AND AIR CONDITIONING PROCESSES**	**9**	**0**	**0**	**9**

Moist Air properties, use of Psychrometric Chart, Various Psychrometric processes, Air Washer, Adiabatic Saturation. Summer and winter Air conditioning, Enthalpy potential and its insights.

UNIT II	**LOAD ESTIMATION**	**9**	**0**	**0**	**9**

Thermal comfort – Design conditions – Solar Radiation-Heat Gain through envelopes – Infiltration and ventilation loads – Internal loads – Procedure for heating and cooling load estimation.

UNIT III	**AIR CONDITIONING SYSTEMS**	**9**	**0**	**0**	**9**

Thermal distribution systems – Single, multi zone systems, terminal reheat systems, Dual duct systems, variable air volume systems, water systems and Unitary type systems.

UNIT IV	**AIR DISTRIBUTION AND CONTROL**	**9**	**0**	**0**	**9**

Flow through Ducts, Static & Dynamic Losses, Diffusers, Duct Design–Equal Friction Method, System Balancing, Fans & Duct System Characteristics, Fan Arrangement Variable Air Volume systems, Air Handling Units and Fan Coil units – Control of temperature, humidity, air flow and quality.

UNIT V	**HVAC SYSTEM IN AUTOMOBILES**	**9**	**0**	**0**	**9**

Automotive System layout and Components- Commonly used Refrigerants- Safety devices – Climate control – Fuel efficiency aspects.

TOTAL(45L) : 45 PERIODS

Reference Books:

1	Ali Vedavarz, Sunil Kumar, Mohammed Iqbal, Hussain Handbook of Heating, Ventilation and Air conditioning for Design Implementation, Industrial press Inc, 2007
2	Arora C.P., Refrigeration and Air Conditioning, Tata McGraw Hill Pub. Company, 2010
3	ASHRAE , Fundamentals and equipment , 4 volumes-ASHRAE Inc. 2005
4	Carrier Air Conditioning Co., Handbook of Air Conditioning Systems design, McGraw Hill, 1985
5	Jones, Air Conditioning Engineering, Edward Amold pub. 2001

6	Kuehn T.H., Ramsey, J.W. and Threlkeld, J.L., Thermal Environmental Engineering, 3rd Edition, Prentice Hall, 1998

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Describe the moist air properties and psychrometric process.	Apply
CO2	Analyze and estimate the heat loads.	Analyze
CO3	Explain the construction and working of air conditioning systems.	Understand
CO4	Analyze and design ducting system for optimum air distribution and control.	Analyze
CO5	Explain layout, components HAVC system used in automobile	Apply

COURSE OUTCOMES:

COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	1	1	0	0	0	0	0	0	0	0	2	0	0
CO2	3	3	3	0	0	2	0	0	0	0	0	2	2	0
CO3	2	1	1	1	0	0	0	0	0	0	0	2	1	0
CO4	2	3	3	1	0	0	0	0	0	0	0	2	1	0
CO5	2	2	2	0	0	0	0	0	0	0	0	1	1	0
Avg	2.4	2	2	0.4	0	0.4	0	0	0	0	0	1.8	1	0

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22THE22	BIO ENERGY TECHNOLOGIES				Semester		I
PREREQUISITES			**Category**	**PE**	**Credit**		**3**
			Hours/Week	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Learning Objectives

1	To detail on the types of biomasses, its surplus availability and characteristics
2	To create awareness on the technologies available for conversion of biomass to energy in terms of its technical competence and economic implications
3	To impart knowledge on stoichiometry and combustion of bio fuels
4	To elucidate on the influence of equivalence ratio on thermochemical conversion of biomass.
5	To provide insight to the possibilities of producing liquid fuels form biomass

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**
Biomass: types – advantages and drawbacks – Indian scenario – characteristics – carbon neutrality – conversion mechanisms – fuel assessment studies – densification technologies Comparison with coal – Proximate & Ultimate Analysis - Thermo Gravimetric Analysis –Differential Thermal Analysis – Differential Scanning Calorimetry					
UNIT II	**BIO-METHANATION**	**9**	**0**	**0**	**9**
Microbial systems – phases in biogas production – parameters affecting gas production – effect of additives on biogas yield – possible feed stocks. Biogas plants – types – design –constructional details and comparison – biogas appliances – burner, luminaries and power generation.					
UNIT III	**COMBUSTION**	**9**	**0**	**0**	**9**
Perfect, complete and incomplete combustion - stoichiometric air requirement - Biofuels equivalence ratio – fixed Bed and fluid Bed combustion – fuel and ash handling systems –steam cost comparison with conventional fuels					
UNIT IV	**GASIFICATION, PYROLYSIS AND CARBONISATION**	**9**	**0**	**0**	**9**
Chemistry of gasification – Types - Pyrolysis - Classification - process governing parameters – Typical yield rates. Carbonization Techniques – merits of carbonized fuels – application – performance evaluation –economics – dual fueling in IC engines – 100 % Gas Engines – engine characteristics on gas mode – gas cooling and cleaning systems					
UNIT V	**LIQUIFIED BIOFUELS**	**9**	**0**	**0**	**9**
History of usage of Straight Vegetable Oil (SVO) as fuel - Biodiesel production from oil seeds, waste oils and algae - Process and chemistry - Biodiesel health effects / emissions /performance. Production of alcoholic fuels (methanol and ethanol) from biomass – engine modifications					
					TOTAL(45L) : 45 PERIODS

Reference Books:

1	David Boyles, Bio Energy Technology Thermodynamics and costs, Ellis Hoknood Chichester,1984
2	Iyer PVR et al, Thermochemical Characterization of Biomass, M N E S
3	Khandelwal KC, Mahdi SS, Biogas Technology – A Practical Handbook, Tata McGraw Hill, 1986

4	Mahaeswari, R.C. Bio Energy for Rural Energisation, Concepts Publication,1997
5	Tom B Reed, Biomass Gasification – Principles and Technology, Noyce Data Corporation, 1981

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Describe and characterize various bio fuels, densifying technologies and estimate the elements present in the bio fuels.	Understand
CO2	Explain the biogas production, methodologies to enhance the bio gas production and working of the production system.	Analyze
CO3	Describe and estimate the combustion requirements of biofuels and its compare with conventional fuels.	Analyze
CO4	Explain and compare the gasification techniques and estimate its performance while using in IC engine.	Understand
CO5	Describe the production techniques of liquid bio fuels and estimate the performance and emission characteristics.	Apply

COURSE OUTCOMES:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	0	0	0	3	0	0	0	0	0	1	0	0
CO2	2	3	3	2	0	3	2	0	0	0	0	2	2	0
CO3	3	3	3	0	0	0	1	0	0	0	0	2	2	0
CO4	2	2	2	2	0	0	0	0	0	0	2	0	0	0
CO5	2	2	0	2	0	0	0	0	0	0	0	2	2	0
Avg	2.2	2.4	1.6	1.2	0	1.2	0.6	0	0	0	0.4	1.4	1.2	0

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22THE23	OPTIMIZATION TECHNIQUES IN ENGINEERING			Semester		I
PREREQUISITES		**Category**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To introduce the concepts and formulations of a optimization problems
2	To impart the knowledge about the decision analysis
3	To details the insights of linear programming and methods of solving the LPP
4	To familiarize with the non-linear optimization techniques
5	To study the various non-traditional optimization techniques used in engineering applications

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Classification of optimization problems, concepts of design vector, design constraints, constrains surface, objective function, surface and multi-level optimization, parametric linear programming.

UNIT II	**DECISION ANALYSIS**	**9**	**0**	**0**	**9**

Decision Trees, utility theory, game theory, multi-objective Optimization, MCDM- Goal Programming, analytic hierarchy process and ANP.

UNIT III	**LINEAR PROGRAMMING**	**9**	**0**	**0**	**9**

Standard form of linear programming problem; Canonical form of LP problem; Assumptions in LP Models; Elementary operations Graphical method for two variable optimization problem; Examples Motivation of simplex method, Simplex algorithm and construction of simplex tableau; Simplex criterion; Minimization versus maximization problems

UNIT IV	**NON-LINEAR OPTIMIZATION**	**9**	**0**	**0**	**9**

Unconstrained single variable and multi variable optimization, KKT Conditions, constrained optimization, quadratic programming, convex programming, Separable programming, Geometric programming, non-convex programming

UNIT V	**NON-TRADITIONAL OPTIMIZATION**	**9**	**0**	**0**	**9**

Genetic algorithms, simulated annealing, neural network-based optimization, particle swarm optimization, ant Colony Optimization, Optimization of Fuzzy Systems

TOTAL(45L) : 45 PERIODS

Reference Books:

1	Singiresu S. Rao, “Engineering optimization – Theory and practices”, John Wiley and Sons, 1996
2	Ravindran – Phillips –Solberg, “Operations Research – Principles and Practice”, John Wiley India, 2006
3	Kalymanoy Deb, “Optimization for Engineering Design”, PHI, 2003
4	Fredrick S.Hillier and G.J.Liberman, “Introduction to Operations Research”, McGraw Hill Inc. 1995
5	G. Hadley, "Linear programming", Narosa Publishing House, New Delhi, 1990

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Classify the optimization problems and formulate suitable optimization problem.	Apply
CO2	Choose suitable optimization method for a problem.	Apply
CO3	Explain the forms and use the LPP and solve a problem using LPP technique.	Analyze
CO4	Describe non-linear optimization techniques and apply for a problem.	Analyze
CO5	Describe non-traditional optimization techniques and apply for a problem.	Understand

COURSE OUTCOMES:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	3	2	2	3	1	0	0	0	0	1	2	2	1
CO2	2	3	2	2	3	1	2	0	0	0	1	2	2	1
CO3	2	3	2	2	2	1	1	0	0	0	1	1	1	2
CO4	2	3	3	2	2	1	0	0	0	0	1	2	1	2
CO5	2	2	0	2	0	0	0	0	0	0	0	2	2	2
Avg	2	2.8	1.8	2	2	0.8	0.6	0	0	0	0.8	1.8	1.6	1.6

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22THE24	ELECTRIC AND HYBRID VEHICLE TECHNOLOGY		Semester			I
PREREQUISITES		Category	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives	
1	To introduce the concept of hybrid and electric drive trains
2	To elaborate on the types and utilization of hybrid and electric drive trains
3	To expose on different types of AC and DC drives for electric vehicles
4	To understand and utilize different types of energy storage systems.
5	To introduce the concept of energy management strategies and drive sizing

UNIT I	INTRODUCTION	9	0	0	9

Basics of vehicle performance, vehicle power source characterization, transmission characteristics, History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies.

UNIT II	HYBRID ELECTRIC DRIVE TRAINS	9	0	0	9

Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive train topologies, fuel efficiency analysis. Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.

UNIT III	CONTROL OF AC & DC DRIVES	9	0	0	9

Introduction to electric components used in hybrid and electric vehicles, Configuration and control - DC Motor drives, Induction Motor drives, Permanent Magnet Motor drive, and Switch Reluctance Motor drives, drive system efficiency.

UNIT IV	ENERGY STORAGE	9	0	0	9

Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Energy storage and its analysis - Battery based, Fuel Cell based, and Super Capacitor based, Hybridization of different energy storage devices

UNIT V	DRIVE SIZING AND ENERGY MANAGEMENT STRATEGIES	9	0	0	9

Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selection of appropriate energy storage technology, Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification and comparison of energy management strategies, implementation issues.

TOTAL(45L) : 45 PERIODS

Reference Books:	
1	Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003
2	James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003
3	Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004

4	Rand D.A.J, Woods, R & Dell RM Batteries for Electric vehicles, John Wiley & Sons, 1998

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Characterize and configure hybrid drivetrains requirement for a vehicle.	Understand
CO2	Design and apply appropriate hybrid and electric drive trains in a vehicle.	Analyze
CO3	Design and install suitable AC and DC drives for electric vehicles.	Analyze
CO4	Arrive at a suitable energy storage system for a hybrid / electric vehicle.	Understand
CO5	Apply energy management strategies to ensure better economy and efficiency.	Apply

COURSE OUTCOMES:														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	0	0	0	0	0	0	0	0	0	1	0	0	1
CO2	3	2	2	2	1	1	0	0	0	2	2	0	0	2
CO3	1	1	1	1	2	0	1	2	0	3	0	0	0	2
CO4	1	1	0	1	1	0	1	1	0	3	2	0	1	1
CO5	1	0	0	0	0	2	1	0	0	2	1	0	1	1
Avg	1.8	0.8	0.6	0.8	0.8	0.6	0.6	0.6	0	2	1.2	0	0.4	1.4
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)														

22THE25	ALTERNATE FUELS FOR IC ENGINES			Semester		I
PREREQUISITES		**Category**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives					
1	To expose potential alternate fuels and their characteristics				
2	To introduce the characteristics, merit and effects of using synthetic fuels.				
3	To introduce the concepts utilizing alcohol as a fuel and study its effects on combustion and emission				
4	To elaborate the need Bio-Diesel, its properties and its effects on combustion and emission				
5	To discuss about various gaseous fuels and predict their performance and combustion characteristics				
UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**
Availability, suitability, properties, merits and demerits of potential alternative fuels – alcohols, Bio-Diesel, hydrogen, liquefied petroleum gas, natural gas, biogas, fuel standards – ASTM & EN.					
UNIT II	**SPECIAL AND SYNTHETIC FUELS**	**9**	**0**	**0**	**9**
Different synthetic fuels, Merits and demerits, Dual, Bi-fuel and Pilot injected fuel systems, Fuel additives – types and their effect on performance and emission characteristics of engines, flexi-fuel systems, Ethers - as fuel and fuel additives, properties and characteristics.					
UNIT III	**ALCOHOL FUELS**	**9**	**0**	**0**	**9**
Alcohols – Properties, Production methods and usage in engines. Blending, dual fuel operation, surface ignition, spark ignition and oxygenated additives. Performance, combustion and emission Characteristics in engines. Issues & limitation in alcohols					
UNIT IV	**BIO-DIESEL FUELS**	**9**	**0**	**0**	**9**
Vegetable oils and their important properties. Fuel properties characterization. Methods of using vegetable oils – Blending, preheating, Transesterification and emulsification – Performance, combustion and emission Characteristics in diesel engines. Third generation biofuels, Ternary and Quaternary fuels, Issues & limitation of using vegetable oils in IC engines					
UNIT V	**GASEOUS FUELS**	**9**	**0**	**0**	**9**
Biogas, Natural gas, LPG, Hydrogen – Properties, problems, storage and safety aspects. Methods of utilization in engines. Performance, combustion and emission Characteristics in engines. Issues & limitation in Gaseous fuels					
TOTAL(45L) : 45 PERIODS					

Reference Books:	
1	Keith Owen and Trevor Eoley, Automotive Fuels Handbook, SAE Publications,1990
2	Pundir B.P , I.C. Engines Combustion and Emission, 2010, Narosa Publishing House
3	Pundir B.P , Engine Combustion and Emission, 2011, Narosa Publishing House Keith
4	Richard L. Bechtold, Automotive Fuels Guide Book, SAE Publications, 1997

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Analyze potential alternate fuels and their characteristics.	Analyze
CO2	Use appropriate synthetic fuels and fuel additives for better combustion characteristics.	Analyze
CO3	Describe the properties of alcohol fuel and estimate the performance of alcohol fuels and its emissions.	Understand
CO4	Explain the properties and combustion and emission characteristics of bio-diesel.	Apply
CO5	Explain different gaseous fuels and predict their performance and combustion characteristics	Apply

COURSE OUTCOMES:

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	0	0	0	0	0	0	0	0	0	1	3	2	1
CO2	3	2	2	2	1	1	0	0	0	2	2	2	2	0
CO3	1	1	1	1	2	0	1	2	0	3	0	2	2	1
CO4	1	1	0	1	1	0	1	1	0	3	2	0	2	0
CO5	1	0	0	0	0	2	1	0	0	2	1	3	0	0
Avg	1.8	0.8	0.6	0.8	0.8	0.6	0.6	0.6	0	2	1.2	2	1.6	0.4

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22THE31	ADVANCED ENERGY STORAGE TECHNOLOGIES				Semester		II
PREREQUISITES			**Category**	**PE**	**Credit**		**3**
			Hours/Week	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Learning Objectives

1	To understand the various types of energy storage technologies and its applications.
2	To study the various modelling techniques of energy storage systems using TRNSYS.
3	To learn the concepts and types of batteries
4	To make to get understand the concepts of Hydrogen and Biogas storage
5	To provide the insights on Flywheel and compressed energy storage systems

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**
Necessity of energy storage – types of energy storage – comparison of energy storage technologies – Applications.					
UNIT II	**THERMAL STORAGE SYSTEM**	**9**	**0**	**0**	**9**
Thermal storage – Types – Modelling of thermal storage units – Simple water and rock bed storage system – pressurized water storage system – Modelling of phase change storage system – Simple units, packed bed storage units - Modelling using porous medium approach, Use of TRNSYS.					
UNIT III	**ELECTRICAL ENERGY STORAGE**	**9**	**0**	**0**	**9**
Fundamental concept of batteries – measuring of battery performance, charging and discharging of a battery, storage density, energy density, and safety issues. Types of batteries – Lead Acid, Nickel – Cadmium, Zinc Manganese dioxide and modern batteries for example (i) zinc-Air (ii) Nickel Hydride, (iii) Lithium Battery.					
UNIT IV	**HYDROGEN AND BIOGAS STORAGE**	**9**	**0**	**0**	**9**
Hydrogen storage options – compressed gas – liquid hydrogen – Metal Hydrides, chemical Storage, Biogas storage - comparisons. Safety and management of hydrogen and Biogas storage - Applications.					
UNIT V	**ALTERNATE ENERGY STORAGE TECHNOLOGIES**	**9**	**0**	**0**	**9**
Flywheel, Super capacitors, Principles & Methods – Applications, Compressed air Energy storage, Concept of Hybrid Storage – Applications					
					TOTAL(45L) : 45 PERIODS

Reference Books:

1	Ibrahim Dincer and Mark A. Rosen, Thermal Energy Storage Systems and Applications, John Wiley & Sons 2002
2	James Larminie and Andrew Dicks, Fuel cell systems Explained, Wiley publications, 2003
3	Luisa F. Cabeza, Advances in Thermal Energy Storage Systems: Methods and Applications, Elsevier Woodhead Publishing, 2015
4	Robert Huggins, Energy Storage: Fundamentals, Materials and Applications, 2nd edition, Springer, 2015
5	Ru-shiliu, Leizhang, Xueliang sun, electrochemical technologies for energy storage and conversion, Wiley publications, 2012

Course Outcomes: Upon completion of this course, the students will be able to:		Bloom's Taxonomy Level
CO1	Identify the energy storage technologies for suitable applications.	Analyze
CO2	Analyze the energy storage systems using TRNSYS.	Analyze
CO3	Recognize the concepts and types of batteries.	Evaluate
CO4	Diagnose the principle of operations of Hydrogen and Biogas storage.	Apply
CO5	Analyze the concepts of Flywheel and compressed energy storage systems.	Analyze

COURSE OUTCOMES:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	3	1	1	0	0	1	0	0	0	3	0	0
CO2	3	1	3	1	1	0	0	1	0	0	0	0	0	3
CO3	3	1	3	1	1	0	0	1	0	0	0	3	0	0
CO4	3	1	3	1	1	0	0	1	0	0	0	1	1	0
CO5	3	1	3	1	1	0	0	1	0	0	0	2	2	0
Avg	3	1	3	1	1	0	0	1	0	0	0	1.8	0.6	0.6

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22THE32	REFRIGERATION SYSTEMS			Semester		II
PREREQUISITES		Category	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives

1	To provide a complete insights of Refrigeration systems
2	To analyze the performance of refrigeration cycles
3	To study the various components and their roles in the refrigeration systems
4	To analyze, balance and simulate the refrigeration systems
5	To acquire the knowledge about the electrical and electronic components provided in the refrigeration systems

UNIT I	**INTRODUCTION AND REFRIGERANTS**	**9**	**0**	**0**	**9**

Applications, Unit of refrigeration – Ideal cycles - Classification of Refrigerants, Refrigerant properties, Oil Compatibility, Environmental Impact-Montreal / Kyoto protocols-Eco Friendly Refrigerants, alternatives to HCFCS, Secondary Refrigerants.

UNIT II	**REFRIGERATION CYCLES**	**9**	**0**	**0**	**9**

Development of Vapor Compression Refrigeration Cycle from Reverse Carnot Cycle- conditions for high COP-deviations from ideal vapor compression cycle, multi-pressure System, Cascade Systems-Analysis. Vapor Absorption Systems-Aqua Ammonia & Li-Br Systems, Steam Jet Refrigeration.

UNIT III	**REFRIGERATION SYSTEM COMPONENTS**	**9**	**0**	**0**	**9**

Compressor- Types, performance, Characteristics, Types of Evaporators & Condensers and their functional aspects, Expansion Devices and their Behavior with fluctuating load, cycling controls, other components such as Accumulators, Receivers, Oil Separators, Strainers, Driers, Check Valves, Solenoid Valves Defrost Controllers, etc.

UNIT IV	**SYSTEM BALANCING**	**9**	**0**	**0**	**9**

Balance points and system simulation - compressor, condenser, evaporator and expansion devices performance – Complete system performance; graphical and mathematical analysis – sensitivity analysis.

UNIT V	**ELECTRICAL DRIVES & CONTROLS**	**9**	**0**	**0**	**9**

Electric circuits in Refrigeration systems, Refrigerant control devices, Types of Motors, Starters, Relays, Thermostats, Microprocessor based control systems, Pressure controls and other controls, Acoustics and noise controls.

TOTAL(45L) : 45 PERIODS

Reference Books:

1	Arora C.P., Refrigeration and Air conditioning, McGraw Hill, 3rd Ed., 2010
2	Dossat R.J., Principles of refrigeration, John Wiley, S.I. Version, 2001
3	Jordan and Priester, Refrigeration and Air conditioning 1985
4	Kuehn T.H., Ramsey J.W. and Threlkeld J.L., Thermal Environmental Engineering, 3rd Edition, Prentice Hall, 1998
5	Langley Billy C., ‘Solid state electronic controls for HVACR, Prentice-Hall 1986
6	Rex Milter, Mark R.Miller., Air conditioning and Refrigeration, McGraw Hill, 2006

7	Stoecker W.F., Refrigeration and Air conditioning, McGraw-Hill Book Company, 1989

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Classify the refrigerants and suggest alternative refrigerants.	Apply
CO2	Analyze refrigeration cycles and calculate COP and explain the construction and working vapour absorption system.	Analyze
CO3	Describe the components and characteristics, classification and performance of refrigeration system.	Analyze
CO4	Simulate the refrigeration components and asses the performance.	Understand
CO5	Describe various electrical and electronic devices to drive and control of refrigeration system	Apply

COURSE OUTCOMES:														
COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO8**	**PO 9**	**PO1 0**	**PO1 1**	**PSO1**	**PSO2**	**PSO3**
CO1	3	0	0	0	0	2	3	0	0	0	2	2	0	0
CO2	3	3	0	3	0	2	0	2	0	0	0	2	3	0
CO3	3	0	0	0	0	2	0	2	0	0	0	2	0	0
CO4	0	0	3	3	2	0	0	2	0	0	2	0	3	3
CO5	1	0	0	0	2	2	0	0	0	0	2	0	0	0
Avg	**2.0**	**0.6**	**0.6**	**1.2**	**0.8**	**1.6**	**0.6**	**1.2**	**0.0**	**0.0**	**1.2**	**1.2**	**1.2**	**0.6**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)														

22THE33	ADVANCED POWER PLANT ENGINEERING			Semester		II
PREREQUISITES		**Category**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To provide the broad overview about the power, generation and costing
2	To provide a very clear understanding about the steam power plant, components and their functions
3	To provide a very clear understanding about the diesel and gas power plant, components and their functions
4	To analyze the advanced power cycles for power generation
5	To provide a very clear understanding about the hydro and nuclear power plant, components and their functions

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Overview of Indian power sector – load curves for various applications – types of power plants – merits and demerits – criteria for comparison and selection - Economics of power plants.

UNIT II	**STEAM POWER PLANTS**	**9**	**0**	**0**	**9**

Basics of typical power plant utilities - Boilers, Nozzles, Turbines, Condensers, Cooling Towers, Water Treatment and Piping system - Rankine Cycle – thermodynamic analysis. Cycle improvements – Superheat, Reheat, Regeneration.

UNIT III	**DIESEL AND GAS TURBINE POWER PLANTS**	**9**	**0**	**0**	**9**

I.C Engine Cycles - Otto, Diesel & Dual –Theoretical vis-à-vis actual – Typical diesel power plant – Types – Components - Layout - Performance analysis and improvement - E.C cycles – Gas turbine & Stirling - Gas turbine cycles –thermodynamic analysis – cycle improvements - Intercoolers, Re heaters, regenerators.

UNIT IV	**ADVANCED POWER CYCLES**	**9**	**0**	**0**	**9**

Cogeneration systems – topping & bottoming cycles - Performance indices of cogeneration systems– Heat to power ratio - Thermodynamic performance of steam turbine cogeneration systems – gas turbine cogeneration systems – reciprocating IC engines cogeneration systems- Binary Cycle -Combined cycle – IGCC – AFBC / PFBC cycles – Thermionic steam power plant. MHD – Open cycle and closed cycle- Hybrid MHD & steam power plants.

UNIT V	**HYDRO ELECTRIC & NUCLEAR POWER PLANTS**	**9**	**0**	**0**	**9**

Hydroelectric Power plants – classifications - essential elements – pumped storage systems – micro and mini hydel power plants. General aspects of Nuclear Engineering – Components of nuclear power plants - nuclear reactors & types – PWR, BWR, CANDU, Gas Cooled, Liquid Metal Cooled and Breeder reactor - nuclear safety – Environmental issues.

TOTAL(45L) : 45 PERIODS

Reference Books:

1	Arora and Domkundwar, A course in power Plant Engineering, Dhanpat Rai and CO, 2004
2	Gill A.B., Power Plant Performance, Butterworths, 1984
3	Haywood R.W., Analysis of Engineering Cycles, 4th Edition, Pergamon Press, Oxford, 1991
4	Horlock J.H., Cogeneration - Heat and Power, Thermodynamics and Economics, Oxford,1987
5	Lamarsh J.R., Introduction to Nuclear Engineering - 2nd edition, Addison-Wesley, 1983

6	Nag P.K., Power Plant Engineering, Tata Mcgraw Hill Publishing Co Ltd, New Delhi, 1998
7	Wood A.J., Wollenberg B.F., Power Generation, operation and control, John Wiley, New York,1984

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Describe the characteristics of power generation and economics of power generation.	Analyze
CO2	Describe the components of steam power plant and analyze steam power cycle.	Evaluate
CO3	Calculate the cycle efficiency and analyze performance improvement of diesel and gas power cycles**.**	Analyze
CO4	Describe the fundamentals of cogeneration, classification and their working principles.	Analyze
CO5	Describe the components and classification working of hydroelectric nuclear power plants.	Understand

COURSE OUTCOMES:

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	0	0	0	2	2	2	0	0	0	2	2	1	0	0
CO2	2	2	2	2	0	0	0	0	0	0	0	0	0	0
CO3	3	3	2	0	0	0	0	0	0	0	0	2	2	0
CO4	3	3	2	0	0	0	0	0	0	0	0	2	2	0
CO5	2	0	0	0	2	0	2	0	0	0	2	2	0	0
Avg	2	1.6	1.2	0.8	0.8	0.4	0.4	0	0	0.4	0.8	1.4	0.8	0

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

22THE34	ELECTRONIC ENGINE MANAGEMENT SYSTEMS			Semester		II
PREREQUISITES		**Category**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To provide fundamental knowledge on electrical and electronics and basic components
2	To provide details of construction and functions of various sensors and actuators used in engine management systems
3	To provide an overview of different types of ignition systems
4	To provide significant features of gasoline injection systems
5	To provide the latest advancements in Diesel injection systems

UNIT I	ELECTRICAL AND ELECTRONICS PRINCIPLES	9	0	0	9

Voltage, current and resistance – Electrical components in series and parallel – Electrical Energy and Power – Direct Current and Alternating Current – Inductance and Capacitance – Diodes and Bipolar Junction and Field Effect Transistors – Analog and Digital Integrated circuits. Comparator- Logic gates – Microcontroller – Basics of Analog to Digital and Digital to Analog Converters, Potentiometer – Wheatstone bridge.

UNIT II	SENSORS AND ACTUATORS	9	0	0	9

Sensors - Camshaft Position, Crank Position, Throttle Position, Air flow, Pressure, Temperature, Speed, Exhaust gas Oxygen, Knock and Oxides of nitrogen, Principle of operation, construction and characteristics. Actuators – Intake throttle valves Pneumatic, EGR Valve, Waste Gate, Brushless DC motor and stepper motor, calibration of electronic sensors and actuators.

UNIT III	IGNITION SYSTEMS	9	0	0	9

Ignition fundamentals, Solid state ignition systems, High energy ignition systems, electronic spark timing and control. Combined ignition and fuel management systems. Dwell angle calculation, ignition timing calculation, Engine mapping, Lookup tables and maps.

UNIT IV	GASOLINE INJECTION SYSTEMS	9	0	0	9

Open loop and closed loop systems, Single-point, Multi-point, Direct injection systems and Air assisted systems – Principles and Features, Types of injection systems, Idle speed, lambda, knock and spark timing control, simple fuel injection calculation, Fuel injection volume control for different engine operation.

UNIT V	DIESEL INJECTION SYSTEMS	9	0	0	9

Heat release, control of fuel injection, Inline injection pump, Rotary Pump and Injector – Construction and principle of operation, electronic control, Common rail, unit injector and Piezoelectric fuel injector- Principle – Construction and principle of operation.

TOTAL(45L) : 45 PERIODS

Reference Books:

1	Eric Chowanietz, Automobile Electronics, SAE Publications 1995
2	Robert Bosch, Gasoline Engine Management, Third Edition, Bentley Publications, 2004
3	Robert Bosch, Diesel Engine Management, Fourth Edition,Newness Publications, 2005

4	Tom Denton, Automotive Electrical and Electronic Systems, 4th Edition, Taylor and Francis Group,2004
5	William B. Ribbens, Understanding Automotive Electronics, Sxith Edition, Elsevier Inc, 2002

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Identify and describe the application of electrical and electronics components used in engine management systems.	Understand
CO2	Describe various sensors and actuators used in electronic engine management system.	Analyze
CO3	Describe the fundamentals of ignition system and calculate the ignition characteristics.	Evaluate
CO4	Describe the concepts, components, working and control of gasoline injection system.	Analyze
CO5	Various injector, injection system, control of fuel injection in CI engine.	Evaluate

COURSE ARTICULATION MATRIX

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	3	0	0	0	0	0	0	0	0	0	1	0	0	2
CO2	3	2	2	2	1	1	0	0	0	2	2	0	0	2
CO3	1	1	1	1	1	0	1	2	0	3	0	1	1	1
CO4	1	1	0	1	1	0	1	1	0	3	2	2	1	1
CO5	1	0	0	0	0	2	1	0	0	2	1	2	1	1
Avg	1.8	0.8	0.6	0.8	0.6	0.6	0.6	0.6	0	2	1.2	1	0.6	1.4
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)														

22THE35	DESIGN OF HEAT EXCHANGERS				Semester		II
PREREQUISITES			**Category**	**PE**	**Credit**		**3**
			Hours/Week	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Learning Objectives

1	To study the fundamentals of heat transfer analysis in heat exchangers
2	To study the effects of flow parameters and do stress analysis
3	To study the effects various design factors on the performance of a heat exchanger.
4	To study the classification and design aspects of a compact heat exchangers
5	To analyze the sizing and rating of the heat exchangers for various applications

UNIT I	**FUNDAMENTALS OF HEAT EXCHANGER**	**9**	**0**	**0**	**9**
Temperature distribution and its implications types – shell and tube heat exchangers – regenerators and recuperators – analysis of heat exchangers – LMTD and effectiveness method.					
UNIT II	**FLOW AND STRESS ANALYSIS**	**9**	**0**	**0**	**9**
Effect of turbulence – friction factor – pressure loss – stress in tubes – header sheets and pressure vessels – thermal stresses, shear stresses - types of failures.					
UNIT III	**DESIGN ASPECTS**	**9**	**0**	**0**	**9**
Heat transfer and pressure loss – flow configuration – effect of baffles – effect of deviations from ideality – design of double pipe - finned tube - shell and tube heat exchangers - simulation of heat exchangers.					
UNIT IV	**COMPACT AND PLATE HEAT EXCHANGERS**	**9**	**0**	**0**	**9**
Types – merits and demerits – design of compact heat exchangers, plate heat exchangers – performance influencing parameters - limitations.					
UNIT V	**CONDENSERS AND COOLING TOWERS**	**9**	**0**	**0**	**9**
Design of surface and evaporative condensers – cooling tower – performance characteristics.					
					TOTAL(45L) : 45 PERIODS

Reference Books:

1	Arthur P. Frass, Heat Exchanger Design, John Wiley & Sons, 1988
2	Hewitt G.F., Shires G.L. and Bott T.R., Process Heat Transfer, CRC Press, 1994
3	Nicholas Cheremisioff, Cooling Tower, Ann Arbor Science Pub 1981
4	SadikKakac and Hongtan Liu, Heat Exchangers Selection, Rating and Thermal Design, CRC Press, 2002
5	Sekulic D.P., Fundamentals of Heat Exchanger Design, John Wiley, 2003
6	TaborekT., Hewitt.G.F. and Afgan N., Heat Exchangers, Theory and Practice, McGraw-Hill Book Co. 1980

7	Walker, Industrial Heat Exchangers - A Basic Guide, McGraw Hill Book Co., 1980

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Design and analyze heat exchanger using LMTD and effectiveness method.	Analyze
CO2	Conduct stress analysis in heat exchanger components and identify failure types.	Analyze
CO3	Describer the effects of various parameters in performance of heat exchanger.	Evaluate
CO4	Classify, design of compact and plate heat exchanger.	Analyze
CO5	Design condenser and cooling tower and analyze its performance	Analyze

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	1	3	2	0	2	0	0	0	0	0	3	2	0
CO2	3	2	3	3	0	1	0	0	0	0	0	3	2	0
CO3	3	2	3	3	3	1	0	0	0	0	0	3	3	3
CO4	3	3	2	3	0	0	0	0	0	0	0	3	2	0
CO5	3	3	2	3	0	0	0	0	0	0	0	3	2	0
Avg	3	2.2	2.6	2.8	0.6	0.8	0	0	0	0	0	3	2.2	0.6
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)														

22THE41	SOLAR POWER PLANTS				Semester		II
PREREQUISITES			**Category**	**PE**	**Credit**		**3**
			Hours/Week	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Learning Objectives

1	To discuss the fundamental classification, working and comparisons of solar power plants
2	To study the various power cycles involved in the solar power plants
3	To study the components and their functions fof solar thermal power plants
4	To study the components and their functions of solar of PV power plants
5	To study the fundamentals of economics involved in the solar power plants

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Power Plant Scenario - Classification, Basic Principles and Features - Comparison and selection Criteria.

UNIT II	**SOLAR POWER CYCLES**	**9**	**0**	**0**	**9**

“Vapour cycles – Organic cycles – Combined Cycles – Binary Cycles – Stirling Cycle – Brayton Cycle – Ericsson Cycle – Kalina Cycle.”

UNIT III	**SOLAR THERMAL POWER PLANTS**	**9**	**0**	**0**	**9**

Collector, Receiver, Energy Transfer Power cycles - Tower, Trough and Dish Systems - Concentrating Dish Systems - Concentrating Linear Fresnel Reflectors - Combined and Binary Cycles - Solar Chimneys - Hybrid Systems.

UNIT IV	**SOLAR PV POWER PLANTS**	**9**	**0**	**0**	**9**

International PV Power programs - Photovoltaic Power Systems - System Integration - Energy Storage - Power Electronics - Stand-Alone Systems - Grid-Connected Systems - Concentrating Photovoltaics (CPV) - Electrical Performance.

UNIT V	**ECONOMICS OF POWER PLANTS**	**9**	**0**	**0**	**9**

Methods of fixing power tariff - Simple Methods to Calculate the Plant Economy - Life Cycle Cost - Payback Period - Economic Analysis for the Selection of Alternative Decisions and the future of the Power Plants.

TOTAL(45L) : 45 PERIODS

Reference Books:

1	Duffie, J.A., and Beckman, W.A. Solar Energy Thermal Process, John Wiley and Sons, New York, 2006
2	Kosuke Kurokawa (Ed.), Eergy from the Desert – Feasibility of very large-scale photovoltaic power generation systems, James and James 2003
3	Sukhatme S.P., Solar Energy, Tata McGraw Hills P Co., 3rd Edition, 2008
4	C.J. Winter, R.L. Sizmann, L.L. Vant-Hull, Solar Power Plants, Springer- Verlag Berlin and Heidelberg GmbH & Co. K, 2001

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Describe the fundamental classification, working and comparisons of solar power plants.	Understand
CO2	Analyze different cycle for solar power generation.	Analyze
CO3	Describe the various power cycles involved in the solar power plants.	Evaluate
CO4	Describe the components and their functions fof solar thermal power plants.	Analyze
CO5	Explain the fundamentals of economics involved in the solar power plants	Understand

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	0	0	3	0	2	0	0	0	0	0	2	2	0
CO2	3	3	3	2	0	0	0	0	0	0	0	2	2	0
CO3	3	0	3	2	0	0	0	0	0	0	0	0	0	2
CO4	2	2	2	2	2	2	0	0	0	0	0	0	0	2
CO5	0	2	0	2	0	2	0	0	0	0	0	0	0	2
Avg	2.2	1.4	1.6	2.2	0.4	1.2	0	0	0	0	0	0.8	0.8	1.2
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)														

22THE42	CRYOGENIC ENGINEERING			Semester		II
PREREQUISITES		**Category**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives	
1	To give introductory knowledge about cryogenic Engineering
2	To impart knowledge in various liquefaction cycles and important components in the liquefaction system
3	To impart knowledge on separation and purification of cryogenics gases
4	To provide the insights of cryo-coolers and cycles using which the cryo-refrigerators are working
5	To explain the instruments for the cryogenic measurement and techniques to handle them

UNIT I	**INTRODUCTION**	**8**	**0**	**0**	**8**

Insight on Cryogenics, Properties of Cryogenic fluids, Material properties at Cryogenic Temperatures. Applications of Cryogenics in Space Programs, Superconductivity, Cryo-metallurgy, medical applications.

UNIT II	**LIQUEFACTION CYCLES**	**10**	**0**	**0**	**10**

Carnot Liquefaction Cycle, F.O.M. and Yield of Liquefaction Cycles. Inversion Curve - Joule Thomson Effect. Linde Hampson Cycle, Precooled Linde Hampson Cycle, Claudes Cycle Dual Cycle, Ortho-Para hydrogen conversion, Eollins cycle, Simpson cycle, Critical Components in Liquefaction Systems.

UNIT III	**SEPARATION OF CRYOGENEIC GASES**	**9**	**0**	**0**	**9**

Binary Mixtures, T-C and H-C Diagrams, Principle of Rectification, Rectification Column Analysis - McCabe Thiele Method. Adsorption Systems for purification.

UNIT IV	**CRYOGENIC REFRIGERATORS**	**8**	**0**	**0**	**8**

J. T. Cryocoolers, Stirling Cycle Refrigerators, G.M. Cryocoolers, Pulse Tube Refrigerators Regenerators used in Cryogenic Refrigerators, Dilution refrigerators, Magnetic Refrigerators.

UNIT V	**HANDLING OF CRYOGENS**	**10**	**0**	**0**	**10**

Cryogenic Dewar, Cryogenic Transfer Lines. Insulations used in Cryogenic Systems, Instrumentation to measure Flow, Level and Temperature.

TOTAL(45L) : 45 PERIODS

Reference Books:

1	Klaus D. Timmerhaus and Thomas M. Flynn, Cryogenic Process Engineering,PlenumPress,New York, 1989
2	Randall F. Barron, Cryogenic Systems, McGraw-Hill, 1985
3	Scott R.B., Cryogenic Engineering, Van Nostrand and Co., 1962
4	Herald Weinstock, Cryogenic Technology, Boston Technical Publishers, inc., 1969
5	Robert W. Vance, Cryogenic Technology, John wiley & Sons, Inc., New York, London
6	G.Venkatarathnam, Cryogenic Mixed Refrigerant Processes, Springer Publication, 2010

7	J.G.Weisend,Hand Book of Cryogenic Engineering —II, Taylor and Francis, 1998

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Describe the properties and applications of cryogenic fluids, materials.	Apply
CO2	Analyze various liquification cycles.	Analyze
CO3	Describe and analyze the rectification process and absorption system.	Evaluate
CO4	Explain components, construction and working of cryogenic refrigerator.	Analyze
CO5	Explain insulation and instrumentations used in cryogenic system.	Understand

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	2	0	0	0	0	2	0	0	0	0	2	2	0	0
CO2	3	3	0	2	0	2	0	0	0	0	2	2	3	0
CO3	3	3	0	2	0	2	0	0	0	0	2	2	3	0
CO4	3	3	0	2	0	2	0	0	0	0	2	2	0	0
CO5	2	0	0	0	0	2	0	0	0	0	2	2	0	0
Avg	2.6	1.8	0.0	1.2	0.0	2.0	0.0	0.0	0.0	0.0	2.0	2.0	1.2	0.0
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)														

<table>
<tr><td>22THE43</td><td colspan="3">RENEWABLE ENERGY SYSTEMS</td><td colspan="3">Semester</td><td>II</td></tr>
<tr><td colspan="3">PREREQUISITES</td><td>Category</td><td>PE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="3" rowspan="2"></td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="8">Course Learning Objectives</td></tr>
<tr><td>1</td><td colspan="7">To give a broad overview of the Indian and global energy scenario</td></tr>
<tr><td>2</td><td colspan="7">To explain the various solar energy and their conversion technologies</td></tr>
<tr><td>3</td><td colspan="7">To educate the insights of wind energy, wind turbine and environmental effects</td></tr>
<tr><td>4</td><td colspan="7">To explore the various bio-energy resources, conversion techniques and applications</td></tr>
<tr><td>5</td><td colspan="7">To discuss the techniques to convert the ocean and geothermal energies</td></tr>
<tr><td>UNIT I</td><td colspan="3">ENERGY SCENARIO</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Indian energy scenario in various sectors – domestic, industrial, commercial, agriculture, transportation and others – Present conventional energy status – Present renewable energy status- Potential of various renewable energy sources-Global energy status-Per capita energy consumption - Future energy plans</td></tr>
<tr><td>UNIT II</td><td colspan="3">SOLAR ENERGY</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Solar radiation – Measurements of solar radiation and sunshine – Solar spectrum - Solar thermal collectors – Flat plate and concentrating collectors – Solar thermal applications – Solar thermal Energy storage – Fundamentals of solar photo voltaic conversion – Solar cells – Solar PV Systems –Solar PV applications.</td></tr>
<tr><td>UNIT III</td><td colspan="3">WIND ENERGY</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Wind data and energy estimation – Betz limit - Site selection for windfarms – characteristics - Wind resource assessment - Horizontal axis wind turbine – components - Vertical axis wind turbine – Wind turbine generators and its performance – Hybrid systems – Environmental issues - Applications.</td></tr>
<tr><td>UNIT IV</td><td colspan="3">BIO-ENERGY</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Bio resources – Biomass direct combustion – thermochemical conversion - biochemical conversion- mechanical conversion - Biomass gasifier - Types of biomass gasifiers - Cogeneration –- Carbonization – Pyrolysis - Biogas plants – Digesters – Biodiesel production – Ethanol production - Applications.</td></tr>
<tr><td>UNIT V</td><td colspan="3">OCEAN AND GEOTHERMAL ENERGY</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Small hydro - Tidal energy – Wave energy – Open and closed OTEC Cycles – Limitations –Geothermal energy – Geothermal energy sources - Types of geothermal power plants – Applications- Environmental impact.</td></tr>
<tr><td colspan="8" align="right">TOTAL(45L) : 45 PERIODS</td></tr>
</table>

<table>
<tr><td colspan="2">Reference Books:</td></tr>
<tr><td>1</td><td>Godfrey Boyle, “Renewable Energy, Power for a Sustainable Future”, Oxford University Press, U.K., 2012</td></tr>
<tr><td>2</td><td>Rai.G.D., “Non-Conventional Energy Sources”, Khanna Publishers, New Delhi, 2014</td></tr>
<tr><td>3</td><td>Sukhatme.S.P., “Solar Energy: Principles of Thermal Collection and Storage”, Tata Mc Graw Hill Publishing Company Ltd., New Delhi, 2009</td></tr>
<tr><td>4</td><td>Tiwari G.N., “Solar Energy – Fundamentals Design, Modelling and applications”, Alpha Science Intl Ltd, 2015</td></tr>
<tr><td>5</td><td>Twidell, J.W. & Weir A., “Renewable Energy Resources”, EFNSpon Ltd., UK, 2015</td></tr>
</table>

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Describe the Indian and global energy scenario	Apply
CO2	Describe the various solar energy technologies and its applications.	Analyze
CO3	Describe knowledge in the various wind energy technologies.	Evaluate
CO4	Describe the various bio-energy technologies.	Analyze
CO5	Describe the ocean and geothermal technologies.	Analyze

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	1	1	1	1	1	2	0	0	0	0	0	2	0	1
CO2	3	2	2	1	1	1	0	0	0	0	0	2	0	1
CO3	3	2	3	2	2	1	0	0	0	0	0	2	0	1
CO4	3	2	2	1	2	1	0	0	0	0	0	2	0	1
CO5	2	1	2	1	2	1	0	0	0	0	0	2	0	1
Avg	2.4	1.6	2	1.2	1.6	1.2	0	0	0	0	0	2	0	1
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)														

22THE44	MATERIALS FOR SOLAR DEVICES			Semester		II
PREREQUISITES		**Category**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To comprehend the materials for various parts of solar collectors
2	To discuss the fundamentals of solar cell structure and classification
3	To educate novel materials for solar cell manufacturing
4	To identify the materials for thermal energy storage and electrical energy storage
5	To study the system balance and cost analysis

UNIT I	**MATERIALS FOR SOLAR COLLECTORS**	**12**	**0**	**0**	**12**

Collector Materials for Low, Medium and High Temperature Applications - Glazing Materials, Optical Materials - Absorber Coatings, Insulations, Desiccants, Use of Plastics – Reliability and Durability of Solar Collectors - Environmental Degradation of Low Cost Solar Collectors.

UNIT II	**FUNDAMENTALS OF SOLAR CELLS**	**12**	**0**	**0**	**12**

Crystalline Structure - Fundamental Principles of Energy Bands – Band Gap – Types of Semiconductors – Doping and influence of impurities on energy levels – Element and Compound Semiconductors – Structure of Silicon solar cell – Fabrication and Optimization of solar cells – Amorphous silicon solar cells.

UNIT III	**THIN FILM AND NOVEL SOLAR CELL MATERIALS**	**12**	**0**	**0**	**12**

Cadmium Telluride, Galium-Arsenic, GaInP / GaAs / Ge - Thin Film, Single Crystalline, Polycrystalline Materials - Multi Junction and Tandem Junction Solar Cells - Low Cost and High Efficiency Materials - Conversion Efficiency of Solar Cells. – Perovskite solar cells –Dye-sensitized Organic solar cells.

UNIT IV	**ENERGY STOARAGE MATERIALS**	**12**	**0**	**0**	**12**

Thermal Storage Concepts - Materials for Sensible and Latent Heat Energy Storage. Organic, Inorganic Eutectic Materials, Materials for Low and High Temperature Storage Applications. Chemical storage Concepts - Rechargeable Batteries – Types, Operating range, Comparison and suitability for various applications - Super Capacitors.

UNIT V	**BALANCE OF SYSTEM MATERIALS AND COST ANALYSIS**	**12**	**0**	**0**	**12**

Functional requirements of other materials for components like Invertors, Charge Controllers, Wires, Pipes, Valves, etc. and identification of suitable materials - Simple Cost Analysis for alternative selection of materials - Case studies.

TOTAL(45L) : 45 PERIODS

Reference Books:

1	Ibrahim Dincer and Marc A Rosan, Thermal Energy Storage: Systems and Applications, John Wiley, 2003
2	Sukhatme and Nayak , Solar Energy: Principles Of Thermal Collection & Storage, Tata McGrawHill, 2008
3	Nelson, J, The Physics of Solar Cells, Imperial College Press, 2003

4	Jef Poortmans and Vladimir Arkhipov, Thin Film Solar Cells, John Wiley and Sons, 2008
5	Thomas Markvart, Solar Electricity, John Wiley and Sons, 2007
6	A.R. Jha, Solar Cell Technology and Applications, Aurbach Publications, 2010

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Describe the fundamental principles of materials best suited for making solar collectors, their reliability, characteristics and possibility of using plastics.	Evaluate
CO2	Explore the materials for solar cells, principles, doping and fabrication and optimisations of solar cells.	Apply
CO3	Explore the novel materials for the fabrication of solar cell, their efficiency and organic solar cells.	Understand
CO4	Explain the concept and the diverse materials used for solar energy devices for diverse applications.	Analyze
CO5	Describe the requirements of system balance and analysis with reference to its cost.	Understand

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	2	2	0	2	1	2	0	0	0	0	0	1	1	1
CO2	2	2	2	2	2	2	0	0	0	0	0	1	1	2
CO3	2	2	2	2	2	1	0	0	0	0	0	2	2	2
CO4	2	1	1	2	2	1	0	0	0	0	0	1	1	1
CO5	2	2	2	2	2	0	0	0	0	0	0	1	1	2
Avg	2	1.8	1.4	2	1.8	1.2	0	0	0	0	0	1.2	1.2	1.6
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)														

22THE45	ENERGY SYSTEMS MODELLING AND ANALYSIS			Semester		II
PREREQUISITES		**Category**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To provide the fundamentals of energy analysis and model development for closed and control volume system
2	To introduce modelling concepts for heat exchanger and solar collectors
3	To provide knowledge to formulate the optimization problem and overview of various optimization techniques
4	To introduce the energy and environmental analysis and energy-economic analysis
5	To discuss the applications of optimization techniques using case studies

		L	T	P	TH
UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Primary energy analysis - energy balance for closed and control volume systems - applications of energy analysis for selected energy system design - modeling overview - levels and steps in model development - Examples of models – curve fitting and regression analysis

UNIT II	**MODELLING AND SYSTEMS SIMULATION**	**9**	**0**	**0**	**9**

Modeling of energy systems – heat exchanger - solar collectors – distillation -rectification turbo machinery components - refrigeration systems - information flow diagram - solution of set of non- linear algebraic equations - successive substitution - Newton Raphson method- examples of energy systems simulation

UNIT III	**OPTIMISATION TECHNIQUES**	**9**	**0**	**0**	**9**

Objectives - constraints, problem formulation - unconstrained problems - necessary and sufficiency conditions. Constrained optimization - Lagrange multipliers, constrained variations, Linear Programming - Simplex tableau, pivoting, sensitivity analysis - new generation optimization techniques – Genetic algorithm and simulated annealing – examples.

UNIT IV	**ENERGY- ECONOMY MODELS**	**9**	**0**	**0**	**9**

Multiplier Analysis - Energy and Environmental Input / Output Analysis - Energy Aggregation – Econometric Energy Demand Modeling - Overview of Econometric Methods - Dynamic programming- Search Techniques - Univariate / Multivariate

UNIT V	**APPLICATIONS AND CASE STUDIES**	**9**	**0**	**0**	**9**

Case studies of optimization in Energy systems problems- Dealing with uncertainty- probabilistic techniques – Trade-offs between capital and energy using Pinch analysis

TOTAL(45L) : 45 PERIODS

Reference Books:

1	Bejan, A, Tsatsaronis, G and Moran, M., Thermal Design and Optimization, John Wiley & Sons, 1996
2	Balaji C., Essentials of Thermal System Design and Optimization, Aue Books, 2011
3	Chang, Ni-Bin, Systems analysis for sustainable engineering: theory and applications, New York : McGraw-Hill, c2011
4	Stoecker W.F., Design of Thermal Systems, McGraw Hill, 2011

5	Yogesh Jaluria, Design and Optimization of Thermal Systems, CRC Press INC, 2008

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Apply mass and energy balances for the energy systems.	Apply
CO2	Do Simulation and Modeling of typical energy system.	Analyze
CO3	Use the optimization techniques to optimize the energy system.	Evaluate
CO4	Perform Energy-Economic Analysis for the typical applications.	Analyze
CO5	Have knowledge in optimization of Energy systems problems.	Analyze

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	2	0	0	2	0	0	0	0	0	0	0	0	0
CO2	2	3	3	3	3	0	0	2	0	0	1	0	2	3
CO3	2	3	3	3	3	0	0	2	0	0	1	0	2	3
CO4	3	2	0	2	0	2	0	2	0	0	2	0	3	0
CO5	3	2	0	2	0	2	0	2	0	0	2	0	3	0
Avg	2.6	2.4	1.2	2	1.6	0.8	0	1.6	0	0	1.2	0	2	1.2
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)														

22THE51	DESIGN OF SOLAR AND WIND SYSTEMS			Semester		III
PREREQUISITES		**Category**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To study the radiation principles and fundamentals and classification of solar collectors
2	To understand the solar thermal energy conversion and storage concepts
3	To understand PV principles and techniques for energy storage
4	To understand the fundamentals of wind energy and its conversion system
5	To understand the aerodynamics and types of loads, generators in wind turbines.

UNIT I	SOLAR RADIATION AND COLLECTORS	9	0	0	9

Sun angles - Sun path diagrams – Radiation - extra-terrestrial characteristics - measurement and estimation on horizontal and tilted surfaces - flat plate collector thermal analysis - testing methods-evacuated tubular collectors - concentrator collectors – classification - design and performance parameters - tracking systems - compound parabolic concentrators - parabolic trough concentrators - concentrators with point focus - Heliostats – performance of the collectors

UNIT II	SOLAR THERMAL TECHNOLOGIES	9	0	0	9

Principle of working, types, design and operation of - Solar heating and cooling systems - Thermal Energy storage systems – Solar Desalination – Solar cooker: domestic, community – Solar Pond – Solar drying

UNIT III	SOLAR PV SYSTEM DESIGN AND APPLICATIONS	9	0	0	9

Solar cells - p-n junction- Solar cell array system analysis and performance prediction- Shadow analysis: reliability - solar cell array design concepts - PV system design - design process and optimization - detailed array design - storage autonomy - voltage regulation - maximum tracking - centralized and decentralized SPV systems - stand-alone - hybrid and grid connected system - System installation - operation and maintenances – field

UNIT IV	WIND ENERGY FUNDAMENTALS AND WIND MEASUREMENTS	9	0	0	9

Wind Energy Basics, Wind Speeds and scales, Terrain, Roughness, Wind Mechanics, Power Content, Class of wind turbines, Atmospheric Boundary Layers, Turbulence. Instrumentation for wind measurements, Wind data analysis, tabulation, Wind resource estimation, Betz’s Limit, Turbulence Analysis

UNIT V	AERODYNAMICS THEORY AND WIND TURBINE TYPES	9	0	0	9

Airfoil terminology, Blade element theory, Blade design, Rotor performance and dynamics, Balancing technique (Rotor & Blade), Types of loads; Sources of loads Vertical Axis Type, Horizontal Axis, Constant Speed Constant Frequency, Variable speed Variable Frequency, Up Wind, Down Wind, Stall Control, Pitch Control, Gear Coupled Generator type, Direct Generator Drive /PMG/Rotor Excited Sync Generator

TOTAL(45L) : 45 PERIODS

Reference Books:

1	Goswami D.Y., Kreider, J. F. and Francis., “Principles of Solar Engineering’, Taylor and Francis, 2000
2	Chetan Singh Solanki, “Solar Photovoltatics – Fundamentals, Technologies and Applications”, PHI Learning Private limited, 2011

3	Mario Garcia –Sanz, Constantine H. Houpis, “Wind Energy Systems”,CRC Press 2012
4	Sukhatme S.P.,. Nayak.J.P, ‘Solar Energy – Principle of Thermal Storage and collection”, Tata McGraw Hill, 2008
5	Solar Energy International, “Photovoltaic – Design and Installation Manual” – New Society Publishers,2006
6	Duffie A. and Beckmann W. A., “Solar Engineering of Thermal Processes, John Wiley, 1991
7	John D Sorensen and Jens N Sorensen, “Wind Energy Systems”, Woodhead Publishing

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom’s Taxonomy Level**
CO1	Describe solar fundamentals, collectors and classify them.	Evaluate
CO2	Describe the principle and design the solar heating, cooling and other solar applications.	Apply
CO3	Explain the principle, working, design optimization of PV system for different applications.	Understand
CO4	Describe the basics and measurements of wind energy.	Analyze
CO5	Explain the aerodynamic constructional details of wind turbine.	Understand

COURSE ARTICULATION MATRIX

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	3	2	2	0	2	1	0	0	0	0	0	3	1	0
CO2	3	1	3	0	2	0	0	0	0	0	0	3	2	0
CO3	3	0	2	2	2	0	0	0	0	0	0	3	2	2
CO4	3	0	3	0	2	0	0	0	0	0	0	3	2	0
CO5	3	0	3	2	2	2	0	0	0	0	2	3	2	0
Avg	3	0.6	2.6	0.8	2	0.6	0	0	0	0	0.4	3	1.8	0.4
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)														

22THE52	DESIGN AND ANALYSIS OF TURBO MACHINES				Semester		III
PREREQUISITES			**Category**	**PE**	**Credit**		**3**
			Hours/Week	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Learning Objectives

1	To understand the energy transfer process in turbo machines and to derive equations to calculate work done and efficiency
2	To understand the functional aspects and performance of turbo machines
3	To learn about the components of combustion chamber and their functions
4	To understand the working and performance of turbines
5	To calculate the performance of gas turbines and jet engines

UNIT I	INTRODUCTION	9	0	0	9

Basics of isentropic flow – static and stagnation properties – diffuser and nozzle configurations– area ratio – mass flow rate – critical properties. Energy transfer between fluid and rotor velocity triangles for a generalized turbo machines – velocity diagrams. Euler's equation for turbo machines and its different forms. Degree of reaction in turbo-machines – various efficiencies – isentropic, mechanical, thermal, overall and polytropic.

UNIT II	CENTRIFUGAL AND AXIAL FLOW COMPRESSORS	9	0	0	9

Centrifugal compressor – configuration and working – slip factor – work input factor – ideal and actual work – pressure coefficient - pressure ratio. Axial flow compressor – geometry and working– velocity diagrams – ideal and actual work – stage pressure ratio – free vortex theory– performance curves and losses.

UNIT III	COMBUSTION CHAMBER	9	0	0	9

Basics of combustion. Structure and working of combustion chamber – combustion chamber arrangements – flame stability – fuel injection nozzles. Flame stabilization – cooling of combustion chamber.

UNIT IV	AXIAL AND RADIAL FLOW TURBINES	9	0	0	9

Elementary theory of axial flow turbines – stage parameters – multi-staging – stage loading and flow coefficients. Degree of reaction – stage temperature and pressure ratios – single and twin spool arrangements – performance. Matching of components. Blade Cooling. Radial flow turbines.

UNIT V	GAS TURBINE AND JET ENGINE CYCLES	9	0	0	9

Gas turbine cycle analysis – simple and actual. Reheated, Regenerative and Intercooled cycles for power plants. Working of Turbojet, Turbofan, Turboprop, Ramjet, Scramjet and Pulsejet Engines and cycle analysis – thrust, specific impulse, specific fuel consumption, thermal and propulsive efficiencies.

TOTAL(45L) : 45 PERIODS

Reference Books:

1	Ganesan, V., Gas Turbines, Tata McGraw Hill, 2011.
2	Cohen, H., Rogers, G F C and Saravan motto, H I H, Gas Turbine Theory, John Wiley, 5th Edition 2001.
3	Khajuria P.R and Dubey S.P., Gas Turbines and Propulsive Systems, Dhanpat Rai Publications, 2003
4	Hill P G and Peterson C R, Mechanics and Thermodynamics of Propulsion, Addition- Wesley, 1970.

5	Mattingly J D, Elements of Gas turbine Propulsion, McGraw Hill, 1st Edition. 1997

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Analyze the energy transfer process in thermodynamic systems.	Analyze
CO2	Calculate the performance of centrifugal flow and axial flow combustion systems.	Apply
CO3	Design and analyze the combustion chamber for turbomachines.	Analyze
CO4	Compute and analyze the performance of axial and radial flow turbines.	Evaluate
CO5	Predict the performance of gas turbines and thermodynamic energy systems.	Analyze

COURSE ARTICULATION MATRIX

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	3	2	2	0	0	2	0	0	0	0	0	2	2	0
CO2	3	0	3	2	0	2	0	0	0	0	0	2	2	0
CO3	3	2	3	2	0	2	0	0	0	0	0	2	2	0
CO4	3	2	3	2	0	2	0	0	0	0	0	2	2	0
CO5	3	2	3	2	0	2	0	0	0	0	0	2	2	0
Avg	3	1.6	2.8	2	0	2	0	0	0	0	0	2	2	0
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)														

22THE53	FIRE ENGINEERING AND EXPLOSION CONTROL				Semester		III
PREREQUISITES			**Category**	**PE**	**Credit**		**3**
			Hours/Week	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Learning Objectives

1	To understand and learn the fundamentals of fire, explosion and theory of combustion
2	To understand various classes of fires, types of fire extinguishers and protection techniques
3	To understand and learn various fire protection systems, components and their working
4	To understand the various fire-resistant materials and to design fireproof building
5	To understand the principles of explosion protection systems

UNIT I	**PHYSICS AND CHEMISTRY OF FIRE**	**9**	**0**	**0**	**9**

Fire properties of solid, liquid and gases - fire spread - toxicity of products of combustion - theory of combustion and explosion – vapour clouds – flash fire – jet fires – pool fires – unconfined vapour cloud explosion, shock waves - auto-ignition – boiling liquid expanding vapour explosion – case studies – Flix borough, Mexico disaster, Pasedena Texas, Piper Alpha, Peterborough and Bombay Victoria dock ship explosions.

UNIT II	**FIRE PREVENTION AND PROTECTION**	**9**	**0**	**0**	**9**

Sources of ignition – fire triangle – principles of fire extinguishing – active and passive fire protection systems – various classes of fires – A, B, C, D, E – types of fire extinguishers – fire stoppers – hydrant pipes – hoses – monitors – fire watchers – layout of stand pipes – fire station-fire alarms and sirens – maintenance of fire trucks – foam generators – escape from fire rescue operations – fire drills – notice-first aid for burns

UNIT III	**INDUSTRIAL FIRE PROTECTION SYSTEMS**	**9**	**0**	**0**	**9**

Sprinkler-hydrants-stand pipes – special fire suppression systems like deluge and emulsifier, selection criteria of the above installations, reliability, maintenance, evaluation and standards – alarm and detection systems. Other suppression systems – CO2 system, foam system, dry chemical powder (DCP) system, halon system – need for halon replacement – smoke venting. Portable extinguishers – flammable liquids – tank farms – indices of inflammability-fire fighting systems.

UNIT IV	**BUILDING FIRE SAFETY**	**9**	**0**	**0**	**9**

Objectives of fire safe building design, Fire load, fire resistant material and fire testing – structural fire protection – structural integrity – concept of egress design - exists – with calculations - fire certificates – fire safety requirements for high rise buildings –snookers.

UNIT V	**EXPLOSION PROTECTING SYSTEMS**	**9**	**0**	**0**	**9**

Principles of explosion-detonation and blast waves-explosion parameters – Explosion Protection, Containment, Flame Arrestors, isolation, suppression, venting, explosion relief of large enclosure-explosion venting-inert gases, plant for generation of inert gas rupture disc in process vessels and lines explosion, suppression system based on carbon dioxide (CO_2) and halons-hazards in LPG, ammonia (NH_3), Sulphur dioxide (SO_2), chlorine (CL_2) etc.

TOTAL(45L) : 45 PERIODS

Reference Books:

1	Gupta, R.S., “Hand Book of Fire Technology” Orient Longman, Bombay 1977.
2	“Accident Prevention manual for industrial operations” N.S.C., Chicago, 1982

3	Dinko Tuhtar, "Fire and explosion protection" .
4	"Davis Daniel et al, "Hand Book of fire technology".
5	Fire fighters hazardous materials reference book Fire Prevention in Factories", an Nostrand Rein Hold, New York, 1991.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Describe the fundamentals of fire, explosion and theory of combustion.	Apply
CO2	Classify the fire, class of fire and equipment for fire extinguishing.	Analyze
CO3	Explain various industrial fire protection systems components and their working.	Evaluate
CO4	Design the building with fire protection and concepts of their design.	Analyze
CO5	Describe the explosion protection system for various application.	Analyze

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	2	0	0	2	0	0	0	0	0	2	2	2	0	0
CO2	2	0	0	2	0	0	0	0	0	2	2	2	0	0
CO3	2	0	0	2	0	1	0	0	1	1	1	2	0	0
CO4	2	0	0	2	0	1	0	0	1	1	1	2	0	0
CO5	2	0	0	2	0	1	0	0	1	1	1	2	0	0
Avg	2	0	0	2	0	0.6	0	0	0.6	1.4	1.4	2	0	0
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)														

22THE54	WASTE TO ENERGY				Semester		III
PREREQUISITES			**Category**	**PE**	**Credit**		**3**
			Hours/Week	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Learning Objectives

1	To identify wastes from which energy can be generated
2	To acquire the knowledge on biomass pyrolysis process and its applications
3	To acquire knowledge on various types of biomass gasifiers and their operations
4	To understand the construction and working of on biomass combustors and its applications for generating energy
5	To summarize the principles of bio-energy systems and their features

UNIT I	**INTRODUCTION TO EXTRACTION OF ENERGY FROM WASTE**	**9**	**0**	**0**	**9**

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

UNIT II	**BIOMASS PYROLYSIS**	**9**	**0**	**0**	**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**	**0**	**0**	**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**	**0**	**0**	**9**

Biomass stoves – Improved challahs, 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	**BIO ENERGY**	**9**	**0**	**0**	**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

TOTAL(45L) : 45 PERIODS

Reference Books:

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

Course Outcomes: Upon completion of this course, the students will be able to:		Bloom's Taxonomy Level
CO1	Understand the various types of wastes from which energy can be generated.	Understand
CO2	Gain knowledge on biomass pyrolysis process and its applications.	Analyze
CO3	Develop knowledge on various types of biomass gasifiers and their operations.	Evaluate
CO4	Gain knowledge on biomass combustors and its applications on generating energy.	Analyze
CO5	Understand the principles of bio-energy systems and their features.	Understand

COURSE ARTICULATION MATRIX

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	3	0	0	2	0	2	0	0	0	0	0	2	2	0
CO2	3	0	0	3	3	2	0	0	0	2	0	2	2	0
CO3	3	3	3	2	0	2	0	0	0	0	0	2	2	0
CO4	3	3	3	2	0	2	0	0	0	0	0	2	2	0
CO5	3	0	3	0	0	2	0	0	0	0	0	2	2	2
Avg	3	1.2	1.8	1.8	0.6	2	0	0	0	0	0	2	2	0.4
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)														

22THE55	SOLAR REFRIGERATION AND AIR-CONDITIONING			Semester		III
PREREQUISITES		**Category**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To impart the knowledge on thermodynamics cycle, refrigerant, refrigerator and environmental impacts
2	To impart the knowledge the components, classification and working principles of solar cooling system
3	To impart the knowledge the components, classification and working principles of solar space conditioning system
4	To explain the various ways of exploiting solar energy for day-to-day applications
5	To detail about the economics involved with the soalr systems

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Carnot cycle – Refrigerator – Heat Pump – Heat Transformer, Refrigerants – Types and historical developments – Environmental impacts - Thermodynamic Processes.

UNIT II	**SOLAR COOLING**	**9**	**0**	**0**	**9**

Types of solar cooling systems – Solar collectors and storage systems for solar refrigeration and air conditioning – Jet ejector solar cooling systems - Fuel assisted solar cooling systems Solar thermos-acoustic cooling and hybrid air-conditioning - Solar desiccant cooling systems – Advanced solar cooling systems.

UNIT III	**SOLAR SPACE CONDITIONING SYSTEMS**	**9**	**0**	**0**	**9**

Liquid Type Solar Heating System With / Without Storage - Heat Storage Configurations – Heat Delivery Methods - Air-Type Solar Heating Systems - Solar Refrigeration and Air Conditioning.

UNIT IV	**OTHER SOLAR APPLICATIONS**	**9**	**0**	**0**	**9**

Solar Cooking – Distillation - Desalination - Solar Ponds – Solar Passive Architecture – Solar Drying – Solar Chimney.

UNIT V	**SOLAR ECONOMICS**	**9**	**0**	**0**	**9**

Application of economic methods to analyze the feasibility of solar systems to decide project / policy alternatives - Net energy analysis - and cost requirements for active and passive heating and cooling - for electric power generation - and for industrial process-heating. Economics – Fixed and variable cost - Payback period - Net Present Value - Internal Rate of Return - Carbon credit – Embodied energy analysis.

TOTAL(45L) : 45 PERIODS

Reference Books:

1	Duffie, J.A., and Beckman, W.A. Solar Energy Thermal Process - 4th Edition (2013), John Wiley and Sons, New York, ISBN: 978-0-470-87366-3, Solar Energy Laboratory, University of Wisconsin-Madison, pp. 944.
2	H P Garg, M Dayal, G Furlan, Physics and Technology of Solar Energy- Volume I: Solar Thermal Applications, Springer, 2007.
3	Sukhatme S.P. J K Nayak, Solar Energy, Tata McGraw Hills P Co., ISBN: 9789352607112, 4th Edition, 2017, pp. 568.
4	Charles Christopher Newton - Concentrated Solar Thermal Energy- Published by VDM Verlag, 2008.
5	H.P.Garg, S.C.Mullick, A.K.Bhargava, D.Reidal, Solar Thermal Energy Storage Springer, 2005.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Explain the concept of Carnot cycle, thermodynamic process and environmental effects.	Evaluate
CO2	Classify and explain solar cooling and hybrid air conditioning system.	Apply
CO3	Articulate the technical fundamentals of solar thermal energy storage and heating systems.	Understand
CO4	Describe the spectrum of possible solar thermal applications for day-to-day life.	Analyze
CO5	Communicate technological and socio-economic issues involved in solar energy.	Understand

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	0	1	0	0	0	2	0	0	0	0	2	2	0
CO2	3	2	0	0	0	1	1	0	0	0	0	0	0	2
CO3	3	2	0	1	0	1	0	0	0	0	0	3	3	0
CO4	3	2	0	1	0	0	0	0	0	0	0	2	3	0
CO5	3	2	2	0	0	0	0	0	0	2	0	0	0	0
Avg	3	1.6	0.6	0.4	0	0.4	0.6	0	0	0.4	0	1.4	1.6	0.4
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)														

22THE61	ENVIRONMENTAL AND POLLUTION CONTROL			Semester		III
PREREQUISITES		**Category**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To impart knowledge on the atmospheric change and its present condition, global warming and eco-legislations
2	To detail on the sources of air pollution and possible solutions for mitigating their degradation
3	To detail on the sources of water pollution and possible solutions for mitigating their degradation
4	To elaborate on the technologies available to manage all types of waste
5	To study source, effect and control of hazardous and non-hazardous wastes

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**
Global atmospheric change – greenhouse effect – Ozone depletion - natural cycles - mass and energy transfer – material balance – environmental chemistry and biology – impacts – environmental. Legislations.					
UNIT II	**AIR POLLUTION**	**9**	**0**	**0**	**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.					
UNIT III	**WATER POLLUTION**	**9**	**0**	**0**	**9**
Water resources - water pollutants - characteristics – quality - water treatment systems – waste water treatment - treatment, utilization and disposal of sludge - monitoring compliance with standards.					
UNIT IV	**WASTE MANAGEMENT**	**9**	**0**	**0**	**9**
Sources and Classification – Solid waste – Hazardous waste - Characteristics – Collection and Transportation - Disposal – Processing and Energy Recovery – Waste minimization					
UNIT V	**OTHER TYPE OF POLLUTION FROM INDUSTRIES**	**9**	**0**	**0**	**9**
Noise pollution and its impact - oil pollution - pesticides - instrumentation for pollution control - water pollution from tanneries and other industries and their control – environment impact assessment for various projects – case studies. Radiation pollution: types, sources, effects, control of radiation pollution.					
					TOTAL(45L) : 45 PERIODS

Reference Books:

1	Arcadio P Sincero and G.A. Sincero, Environmental Engineering – A Design Apporach, Prentice Hall of India Pvt Ltd, New Delhi, 2002.
2	Bishop P., Pollution Prevention: Fundamentals and Practice, McGraw-Hill International Edition, McGraw-Hill book Co, Singapore, 2000.
3	G.Masters, Introduction to Environmental Engineering and Science Prentice Hall of India Pvt Ltd, New Delhi, 2003
4	Gilbert M. Masters, Introduction to Environmental Engineering and Science, 2nd Edition, Prentice Hall, 1998.
5	H.Ludwig, W.Evans, Manual of Environmental Technology in Developing Countries, International Book Company, Absecon Highlands N.J. (1991).

6	H.S.Peavy, D.R.Rowe and G.Tchobanoglous, Environmental Engineering McGraw- Hill Book Company, NewYork, (1985).

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	To describe the background of present condition of the environment and remedial action required.	Evaluate
CO2	Elaborate the sources of air pollution and the equipment for control them.	Apply
CO3	Elaborate the sources of water pollution and the equipment for control them.	Understand
CO4	Elaborate the sources of solid waste, their characteristics and managements.	Analyze
CO5	Describe the other sources of pollution from the industries and their controlling techniques.	Understand

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	1	1	2	1	1	2	0	3	0	2	0	1	1	1
CO2	1	1	2	1	1	2	0	3	0	2	0	1	1	1
CO3	1	1	2	1	1	2	0	3	0	2	0	1	1	1
CO4	1	1	2	1	1	2	0	3	0	2	0	1	1	1
CO5	1	1	2	1	1	2	0	3	0	2	0	1	1	1
Avg	1	1	2	1	1	2	0	3	0	2	0	1	1	1
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)														

22THE62	NANOTECHNOLOGY			Semester		III
PREREQUISITES		**Category**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To impart the knowledge on the fundamental concepts, synthesis and various properties of nanomaterials
2	To explain the different routes for the synthesis of nanomaterials
3	To demonstrate the characterization techniques available for nanomaterials
4	To understand the fundamentals of micro and nano-sensors and their applications
5	To study the preparation methods, properties and applications of nanofluids

UNIT I	INTRODUCTION	9	0	0	9

Importance of Nano-Technology - Emergence of Nano-Technology - Bottom-Up and Top-down approaches- challenges in Nano-Technology. Properties of materials and Nano-materials- The role of size in Nano-materials- Electronic Properties- Magnetic Properties- Thermal Properties- Mechanical Properties- Optical Properties.

UNIT II	SYNTHESIS TECHNIQUES OF NANO-MATERIALS	9	0	0	9

Physical methods - Inert gas condensation - Ball Milling - Chemical vapour deposition method Electrochemical synthesis - Sol-gel- Micelles and microemulsions - Cluster compounds. M based nanolithography and Nano- manipulation- E beam lithography and SEM-based nanolithography and Nano-manipulation- Ion beam lithography- oxidation and metallization- Mask and its application

UNIT III	CHARACTERIZATIONS OF NANO-MATERIALS	9	0	0	9

Scanning Electron Microscopy (SEM) - Scanning Probe Microscopy (SPM) - TEM and EDAX analysis - X-ray Diffraction- Optical Microscope - Operational principle and application for analysis of Nano-materials- UV-VIS-IR Spectrophotometers- Principle of operation and application for band gap measurement.

UNIT IV	NANO SENSORS AND NANO DEVICES	9	0	0	9

Micro and Nano-sensors - Fundamentals of sensors – Biosensor- Micro fluids- MEMS and NEMS - Packaging and characterization of sensors - Method of packaging at zero level - Dye level and first level. Sensors for aerospace and defense: Accelerometer - Pressure Sensor- Night Vision System - Nano-cutting tools - Integration of sensor with actuators and electronic circuitry.

UNIT V	NANO FLUIDS AND THEIR APPLICATIONS	9	0	0	9

Preparation of Nano-fluids – Thermal and optical Properties of Nano-Fluids – Characterization of Nano-fluids - Mechanism of Heat Transfer – Role of Brownian Motion – Constraints for nano-fluids -Models for the measurements of thermal conductivities of Nano-fluids - current Applications– Issues with the Environment

TOTAL(45L) : 45 PERIODS

Reference Books:

1	B.S.Murthy, P.Shankar, Baldevraj, B.B.Rath and James Murday, “Text Book of Nanoscience and Nanotechnology”, Universities Press (India) Private Limited, 2013 Mark Ratneer, Daniel Ratner, “Nanotechnology” Pearson Education, Inc, 2003

2	Guozhong Cao , “Nanostructures &Nanomaterials: Synthesis- Properties and Applications”, Imperial College Press, 2004
3	Bharat Bhusan (Ed.), “Springer Handbook of Nanotechnology”, Springer Verlag Berlin- Heidelberg, 2004.
4	Rainer Wasser (Ed.), “Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel Devices” Wiley-VchVerlag GmbH & Co, 2003
5	Charles P. Poole- Jr. and Frank J. Owens , “Introduction to Nanotechnology”, Wiley Interscience, 2003
6	M.J. Madou, “Fundamentals of Microfabrication: Science of Miniaturization”, CRC Press- 2nd Edition, 2002

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom’s Taxonomy Level**
CO1	Understand the evaluation of nanotechnology and various properties of nanomaterials.	Evaluate
CO2	Explain the different synthesis techniques for nanomaterials.	Apply
CO3	Explain the principles of microscopical analysis and other techniques for characterization of nanomaterials.	Understand
CO4	Understand the fundamentals, classification of nano sensor and nanodevices.	Analyze
CO5	Describe the preparation, characterization, mechanism and application of nanofluids.	Understand

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	0	0	0	0	0	0	0	0	0	0	0	0	0
CO2	3	3	0	2	3	0	0	0	0	0	0	0	0	0
CO3	3	3	0	2	3	0	0	0	0	0	0	0	0	0
CO4	2	0	0	0	3	0	0	0	0	0	0	0	0	0
CO5	2	0	3	2	0	0	0	0	0	0	0	3	3	0
Avg	2.6	1.2	0.6	1.2	1.8	0	0	0	0	0	0	0.6	0.6	0
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)														

22THE63	**SOLAR ENERGY FOR INDUSTRIAL PROCESS HEATING**		**Semester**			**III**
PREREQUISITES		**Category**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To study the construction and working, merits and demerits of various solar collectors
2	To study the construction and working, merits and demerits of various solar water heating systems
3	To study the concept, components and working of solar absorption system
4	To study the concept, components and working of solar vapor compression refrigeration system
5	To explain the techniques to implement solar refrigeration for practical applications

UNIT I	**SOLAR COLLECTORS**	**9**	**0**	**0**	**9**
Collectors: Flat plate: Water, Air - Evacuated tube – Concentrated – Construction – Function- Suitability – Comparison – Design of Storage Tank - Solar Fluids.					
UNIT II	**SOLAR WATER HEATING SYSTEMS**	**9**	**0**	**0**	**9**
Integral Collector Storage System - Thermosyphon System - Open Loop, Drain Down, Drain Back, Antifreeze Systems - Refrigerant Solar Water Heaters - Solar Heated Pools - Solar Heated Hot Tubs and Spas.					
UNIT III	**SOLAR ABSORPTION COOLING**	**9**	**0**	**0**	**9**
Basics of absorption cooling - Principle of absorption cooling - Solar operation of vapor absorption refrigeration cycle - Open cycle absorption / desorption solar cooling alternatives – Lithium Bromide- Water absorption System – Aqua-ammonia absorption system – Intermittent absorption refrigeration System - Refrigerant storage for solar absorption cooling systems					
UNIT IV	**VAPOUR COMPRESSION REFRIGERATION SYSTEM**	**9**	**0**	**0**	**9**
Vapour compression refrigeration cycles - Rankine cycle - Sterling cycle based solar cooling systems - Thermal modelling for continuous and intermittent solar refrigeration and air-conditioning systems.					
UNIT V	**IMPLEMENTATION TECHNIQUES**	**9**	**0**	**0**	**9**
PV powered refrigerator – Free cooling - Solar thermoelectric refrigeration and air- conditioning –Solar economics of cooling systems - Case studies.					
					TOTAL(45L) : 45 PERIODS

Reference Books:

1	Alefeld G. and Radermacher R., Heat Conversion Systems, CRC Press, 2004
2	ASHRAE Hand Book–HVAC Systems & Equipment, ASHRAE Inc. Atlanta, 2008
3	McVeigh J.C. and Sayigh A.A.M. Solar Air Conditioning and Refrigeration, PergamonPress,1992
4	Rakosh Das Begamudre, Energy Conversion Systems, New Age International, 2007
5	Reinhard Radermacher, S AKelin and K Herold, Absorption chillers and heat pumps, CRCPress, 1996
6	Tom P. Hough, Solar Energy: New Research, Nova Publishers, 2006

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Design the different types of solar collectors for a given cooling load.	Understand
CO2	Delineate systems for solar water heating.	Evaluate
CO3	Describe the principles and working of absorption cooling system.	Apply
CO4	Design the solar powered vapor compression refrigeration system.	Understand
CO5	Describe the various techniques for the implementation of solar energy in refrigeration and air conditioning system.	Analyze

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	3	3	3	1	2	2	0	0	0	1	3	2	0
CO2	3	3	3	3	1	2	2	0	0	0	1	3	2	0
CO3	3	3	3	3	1	2	2	0	0	0	1	3	2	0
CO4	3	3	2	2	1	3	2	0	0	1	1	3	2	0
CO5	3	3	0	0	1	1	0	0	0	1	0	3	2	0
Avg	3	3	2.2	2.2	1	2	1.6	0	0	0.4	0.8	3	2	0
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)														

22THE64	ENERGY EFFICIENT BUILDINGS DESIGN				Semester		III
PREREQUISITES		**Category**	**PE**	**Credit**			**3**
		Hours/Week	**L**	**T**	**P**		**TH**
			3	**0**	**0**		**3**

Course Learning Objectives

1	To provide the overall perspective of green buildings concept design
2	To familiarize with basic terminologies related to energy efficient building design and materials
3	To provide knowledge on concepts of passive heating and cooling
4	To provide the knowledge on heat transfer in buildings
5	To provide the knowledge to utilize renewable energy systems in buildings

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Climate and Building, Historical perspective, Aspects of green building design – Sustainable Site, Water, Energy, Materials and IAQ, ECBC Standards

UNIT II	**LANDSCAPE AND BUILDING ENVELOPES**	**9**	**0**	**0**	**9**

Energy efficient Landscape design – Microclimate, Shading, Arbors, Windbreaks, Xeriscaping, Building envelope – Thermal comfort, Psychrometry, Comfort indices, Thermal Properties of Building Materials, Thermal Time Constant (TTC), Diurnal Heat Capacity (DHC), Thermal Lag, Decrement Factor, Effect of Solar Radiation – Sol-air Temperature, Processes of heat exchange of building with environment, Insulation

UNIT III	**PASSIVE HEATING AND COOLING**	**9**	**0**	**0**	**9**

HVAC introduction, Passive Heating – Solar radiation basics, Sun Path Diagram, Direct Heating, Indirect Heating and Isolated heating, Concept of Daylighting, Passive Cooling – Natural Ventilation (Stack and Wind), Evaporative Cooling and Radiative Cooling.

UNIT IV	**HEAT TRANSFER IN BUILDINGS**	**9**	**0**	**0**	**9**

Heat transfer due to fenestration/infiltration, Calculation of Overall Thermal Transmittance, Estimation of building loads: Steady state method, network method, numerical method, correlations, Thermal Storage integration in buildings

UNIT V	**RENEWABLE ENERGY IN BUILDINGS**	**9**	**0**	**0**	**9**

Introduction of renewable sources in buildings, BIPV, Solar water heating, small wind turbines, stand-alone PV systems, Hybrid system – Economics.

TOTAL(45L) : 45 PERIODS

Reference Books:

1	Baruch Givoni: Climate considerations in building and Urban Design, John Wiley & Sons, 1998
2	Baruch Givoni: Passive Low Energy Cooling of Buildings by, John Wiley & Sons, 15-Jul-1994
3	JA Duffie and WA Beckman: Solar Engineering of Thermal Processes, Third Edition, John Wiley & Sons, 2006
4	Jan F. Kreider, Peter S. Curtiss, Ari Rabl, Heating and cooling of buildings: Design for Efficiency, Revised Second Edition, CRC Press, 28-Dec-2009

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Will be familiar with climate responsive building design and basic concepts.	Evaluate
CO2	Will Know the basic terminologies related to buildings.	Apply
CO3	Will Know the passive (air) conditioning techniques.	Understand
CO4	Will be able to evaluate the performance of buildings.	Analyze
CO5	Gets acquainted with Renewable energy systems in buildings.	Understand

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	3	1	1	2	2	1	2	1	0	0	3	0	0
CO2	3	3	3	1	1	0	0	0	0	1	1	3	0	0
CO3	3	1	3	0	1	2	0	1	0	2	2	3	0	3
CO4	3	3	3	2	2	2	0	0	0	2	2	2	0	2
CO5	3	2	3	0	3	1	0	2	0	2	2	2	0	2
Avg	3	2.4	2.6	0.8	1.8	1.4	0.2	1	0.2	1.4	1.4	2.6	0	1.4
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)														

22THE65	ANALYSIS OF THERMAL POWER CYCLES			Semester		III
PREREQUISITES		**Category**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To demonstrate the working of steam power cycles and calculations of efficiency
2	To provide techniques to modify the steam cycles and estimate efficiencies
3	To impart the knowledge to analyse the air cycles with variable specific heats
4	To impart the knowledge to analyse the performance of Brayton cycle with regeneration and reheating
5	To study and analyse various refrigeration cycles

UNIT I	**STEAM POWER CYCLES**	**9**	**0**	**0**	**9**
Steam power plant cycle - Rankine cycle - Reheat cycle - Regenerative cycle with one and more feed heaters - Types of feed heaters - Open and closed types - Steam traps types.					
UNIT II	**MODIFIED STEAM POWER CYCLES**	**9**	**0**	**0**	**9**
Cogeneration - Condensing turbines - Combined heat and power - Combined cycles - Brayton cycle Rankine cycle ombinations - Binary vapour cycle.					
UNIT III	**AIR CYCLES**	**9**	**0**	**0**	**9**
Air standard cycles - Cycles with variable specific heat - fuel air cycle - Deviation from actual cycle.					
UNIT IV	**MODIFIED BRAYTON CYCLES**	**9**	**0**	**0**	**9**
Brayton cycle - Open cycle gas turbine - Closed cycle gas turbine - Regeneration - Inter cooling and reheating between stages.					
UNIT V	**REFRIGERATION CYCLE**	**9**	**0**	**0**	**9**
Refrigeration Cycles - Vapour compression cycles - Cascade system - Vapour absorption cycles - GAX Cycle					
					TOTAL(45L) : 45 PERIODS

Reference Books:

1	Culp, R., Principles of Energy Conversion, McGraw-Hill, 2000.
2	Nag. P.K., Power Plant Engineering, 2nd Tata McGraw-Hill, 2002
3	Nag. P.K., Engineering Thermodynamics, 3rd ed., Tata McGraw-Hill, 2005
4	Arora, C.P., Refrigeration and Air Conditioning, 2nd ed., Tata McGraw-Hill, 2004

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Analyze the steam power cycle efficiency and work done and techniques to improve them.	Analyze
CO2	Analyze the modified steam power cycle efficiency and work done.	Analyze
CO3	Derive the equation for efficiency and work done and analyze the deviation from actual cycles.	Evaluate
CO4	Analyze the Rankine cycle efficiency and work done and techniques to improve them.	Analyze
CO5	Analyze various refrigeration cycles and their performances.	Analyze

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	3	2	2	0	0	0	0	0	0	0	3	3	0
CO2	3	3	2	2	0	0	0	0	0	0	0	3	3	0
CO3	3	3	2	2	0	0	0	0	0	0	0	3	3	0
CO4	3	3	2	2	0	0	0	0	0	0	0	3	3	0
CO5	3	3	2	2	0	0	0	0	0	0	0	3	3	0
Avg	3	3	2	2	0	0	0	0	0	0	0	3	3	0
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)														

22THE71	ENERGY FORECASTING, MODELING AND PROJECT MANAGEMENT				Semester		III
PREREQUISITES			**Category**	**PE**	**Credit**		**3**
			Hours/Week	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Learning Objectives

1	To explain about National energy scenario
2	To demonstrate the energy demand using various forecasting models
3	To provide insights to the optimization models for the effective utilization of energy sources
4	To understand the procedure to the write the project proposal
5	To understand the energy policies in the country

UNIT I	**ENERGY SCENARIO**	**9**	**0**	**0**	**9**
Role of energy in economic development and social transformation: Energy & GDP, GNP and its dynamics - Energy Sources and Overall Energy demand and Availability - Energy Consumption in various sectors and its changing pattern - Status of Nuclear and Renewable Energy: Present Status and future promise.					
UNIT II	**FORECASTING MODEL**	**9**	**0**	**0**	**9**
Forecasting Techniques - Regression Analysis - Double Moving Average - Double Experimental Smoothing - Triple Exponential Smoothing – ARIMA model- Validation techniques – Qualitative forecasting – Delphi technique - Concept of Neural Net Works.					
UNIT III	**OPTIMIZATION MODEL**	**9**	**0**	**0**	**9**
Principles of Optimization - Formulation of Objective Function - Constraints - Multi Objective Optimization – Mathematical Optimization Software – Development of Energy Optimization Model - Development of Scenarios – Sensitivity Analysis - Concept of Fuzzy Logic.					
UNIT IV	**PROJECT MANAGEMENT**	**9**	**0**	**0**	**9**
Project Preparation – Feasibility Study – Detailed Project Report - Project Appraisal – Social-cost benefit Analysis - Project Cost Estimation – Project Risk Analysis - Project Financing – Financial Evaluation.					
UNIT V	**ENERGY POLICY**	**9**	**0**	**0**	**9**
National & State Level Energy Issues - National & State Energy Policy - Energy Security - National solar mission - state solar energy policy - Framework of Central Electricity Authority (CEA), Central & States Electricity Regulatory Commissions (CERC & ERCs)-Costing.					
					TOTAL(45L) : 45 PERIODS

Reference Books:

1	Armstrong J.Scott (ed.), Principles of forecasting: a hand book for researchers and practitioners, Norwell, Massachusetts: Kluwer Academic Publishers.2001.
2	DhandapaniAlagiri, Energy Security in India Current Scenario, The ICFAI University Press, 2006. 3. Fred Luthans, Brett C. Luthan, Kyle W. Luthans, Organisational Behaviour: An Evidence- Based Approach, Information Age Publishing; 13 edition, 2015
3	Spyros G. Makridakis, Steven C. Wheelwright, Rob J. Hyndman, Forecasting: Methods and Applications, 4th Edition, ISBN: 978-0-471-53233-0,2003

4	Yang X.S., Introduction to mathematical optimization: From linear programming to Metaheuristics, Cambridge, Int. Science Publishing, 2008

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Have knowledge in the National energy scenario.	Evaluate
CO2	Do Energy prediction using various forecasting techniques.	Apply
CO3	Develop optimization model for energy planning.	Evaluate
CO4	Capable of writing project proposals.	Apply
CO5	Understand the National and state energy policies.	Understand

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	0	1	2	1	1	1	1	1	0	3	3	0	1	0
CO2	0	2	3	3	3	2	0	0	0	2	2	1	3	2
CO3	0	3	3	3	3	0	2	0	0	1	1	0	0	2
CO4	0	1	1	2	0	2	2	2	0	2	2	0	0	2
CO5	0	1	0	0	0	2	2	2	0	2	2	0	1	1
Avg	0	1.6	1.8	1.8	1.4	1.4	1.4	1	0	2	2	0.2	1	1.4
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)														

22THE72	ENERGY MANAGEMENT AND E NVIRONMENTAL BENEFITS				Semester		III
PREREQUISITES			**Category**	**PE**	**Credit**		**3**
			Hours/Week	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Learning Objectives

1	To create awareness on the energy scenario of India with respect to world
2	To learn the methodology adopted for an energy audit
3	To appreciate the concepts adopted in project management
4	To study the different techniques adopted for financial appraisal of a project
5	To comprehend the impact of energy on environment

UNIT I	**ENERGY SCENARIO**	**9**	**0**	**0**	**9**

Comparison of energy scenario – India and World (energy sources, generation mix, consumption pattern, T&D losses, energy demand, per capita energy consumption) – energy pricing – energy security - energy conservation and its importance Energy Conservation Act 2001

UNIT II	**ENERGY MANAGEMENT**	**9**	**0**	**0**	**9**

Energy audit - need – types – methodology – barriers - analysis on energy costing and sharing bench marking fuel and energy substitution – billing parameters in TANGEDCO – demand side management - instruments for energy audit – energy monitoring and targeting – CUSUM energy labelling

UNIT III	**PROJECT MANAGEMENT**	**9**	**0**	**0**	**9**

Four Basic Elements of Project Management - Project Management Life Cycle Steps in Project Management - Project Definition and Scope, Technical Design, Financing, Contracting, Implementation Techniques (Gantt Chart, CPM and PERT) and Performance Monitoring

UNIT IV	**FINANCIAL MANAGEMENT**	**9**	**0**	**0**	**9**

Investment appraisal for energy conservation projects - Financial analysis techniques Simple payback period, Return on investment, Net present value, Internal rate of return - Cash flows Risk and sensitivity analysis: micro and macro factors - Financing options - energy performance contracts ESCOs.

UNIT V	**ENERGY AND ENVIRONMENT**	**9**	**0**	**0**	**9**

Greenhouse effect and the carbon cycle - current evidence and future effects of climate change Global Environmental Concerns United Nations Framework Convention on Climate Change (UNFCC), Kyoto Protocol, Conference of Parties (COP), Emissions trading (ET), Joint implementation (JI), Clean Development Mechanism (CDM), Prototype Carbon Fund (PCF), Sustainable Development

TOTAL(45L) : 45 PERIODS

Reference Books:

1	Energy Manager Training Manual (4Volumes) available at http://www.em- ea.org/gbook1.asp, a website administered by Bureau of Energy Efficiency (BEE), a statutory body under Ministry of Power, Government of India.2004
2	L.C. Witte, P.S. Schmidt, D.R. Brown, “Industrial Energy Management and Utilisation” Hemisphere Publ, Washington, 1988

3	W.C. turner, "Energy Management Hand book" Wiley, New York, 1982
4	W.R. Murphy and G. McKay "Energy Management" Butterworths, London 1987
5	Eastop.T.D& Croft D.R, Energy Efficiency for Engineers and Technologists,.Logman Scientific & Technical, ISBN-0-582-03184, 1990.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Recognize the importance of energy conservation and suggest measures for improving per capita energy consumption.	Apply
CO2	Analyses the energy sharing and cost sharing pattern of fuels used in industries.	Analyze
CO3	Apply Gantt Chart, CPM and PERT in energy conservation projects.	Evaluate
CO4	Evaluate the techno-economics of a project adopting discounting and non- discounting cash flow techniques.	Analyze
CO5	Assess the sources of additional revenue generation for energy conservation projects adopting UNFCC.	Analyze

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	0	0	0	0	0	0	0	0	1	1	0	2	2
CO2	3	2	2	2	1	1	0	0	2	2	2	0	2	0
CO3	2	1	1	1	2	0	1	2	3	0	0	0	2	3
CO4	2	1	0	1	1	0	1	1	3	2	2	0	0	2
CO5	2	0	0	0	0	2	1	0	2	1	1	0	0	0
Avg	2.4	0.8	0.6	0.8	0.8	0.6	0.6	0.6	2	1.2	1.2	0	1.2	1.4
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)														

22THE73	SOLAR ENERGY APPLIANCES				Semester		III
PREREQUISITES		Category	PE	Credit			3
		Hours/Week	L	T		P	TH
			3	0		0	3

Course Learning Objectives	
1	To learn the principle of operation of solar PV cell and its application in lighting system
2	To understand the principle of working of solar cooker, types and its applications.
3	To learn the need for solar drying and working of different dryer types
4	To learn about various desalination techniques and factors influencing productivity of solar still with its types
5	To understand the construction and working of solar furnaces

UNIT I	SOLAR LIGHTING	9	0	0	9
Solar cell – Working principle of a solar cell – Solar home lighting systems – solar street lighting systems - Solar lanterns – Applications - Rural electrification process – Case studies					
UNIT II	**SOLAR COOKING**	**9**	**0**	**0**	**9**
Introduction – Types of solar cookers – Advantages and disadvantages - Box type – Parabolic dish cooker - Performance evaluation of solar cookers – Testing of a solar cooker – Applications of solar cooking - Case studies.					
UNIT III	**SOLAR DRYING**	**9**	**0**	**0**	**9**
Introduction – Need for solar drying - Basics of solar drying – Types of solar dryers – Direct type solar dryer – Mixed mode type solar dryer – Forced circulation type dryers – Hybrid dryer – Bin type dryer – Solar timber drying – Applications - Case studies.					
UNIT IV	**SOLAR DESALINATION**	**9**	**0**	**0**	**9**
Introduction – Necessity for desalination – Study on various desalination techniques – Comparison between conventional and solar desalination – Basics of solar still - Simple solar still – Material problems in solar still – Solar disinfection and its methods – Case studies on various desalination techniques.					
UNIT V	**SOLAR FURNACES**	**9**	**0**	**0**	**9**
Introduction – Types of solar furnaces – Components of solar furnaces – Concentrator – Heliostat – Sun tracking – Typical solar furnace designs – Single concentrator furnace – Single heliostat solar furnace - Multiple heliostats solar furnace - Case studies on solar furnaces.					
					TOTAL(45L) : 45 PERIODS

Reference Books:

1	Suhatme and Nayak, Solar Energy: Principles of Thermal Collection and Storage, Tata McGraw Hill, 2008
2	HP Garg and J Prakash: Solar Energy: Fundamentals and Applications, Tata McGraw Hill, 2010
3	Rai, G.D., Solar Energy Utilization, Khanna Publishers, Delhi, 2010.
4	Michael Grupp, Time to Shine: Applications of Solar Energy Technology, John Wiley & Sons, 2012.
5	SM Sze, Kwok K Ng: Physics of semiconductor devices, third edition, John Wiley & Sons, 2007

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Diagnose the fundamental concepts about solar energy systems and devices.	Evaluate
CO2	Will be familiar with concepts of solar home lighting and solar street lighting systems.	Apply
CO3	Identify the solar cooker technologies for suitable applications.	Understand
CO4	Recognize the applications and types of solar dryers.	Analyze
CO5	Aware about various desalination techniques and material problems in solar still.	Understand

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	2	0	1	0	2	1	0	0	0	0	0	2	2	2
CO2	2	2	3	3	0	0	0	0	0	0	2	2	2	0
CO3	2	2	3	2	0	0	0	0	0	0	2	2	2	0
CO4	2	2	3	2	0	0	0	0	0	0	2	2	2	0
CO5	2	0	2	2	0	0	0	0	0	0	0	2	2	0
Avg	2	1.2	2.4	1.8	0.4	0.2	0	0	0	0	1.2	2	2	0.4
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)														

<table>
<tr><td>22THE74</td><td colspan="3">COST MANAGEMENT OF ENGINEERING PROJECTS</td><td colspan="3">Semester</td><td>III</td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>Category</td><td>PE</td><td colspan="3">Credit</td><td>3</td></tr>
<tr><td colspan="2" rowspan="2"></td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td colspan="2">P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td colspan="2">0</td><td>3</td></tr>
<tr><td colspan="8">Course Learning Objectives</td></tr>
<tr><td>1</td><td colspan="7">To introduce the costing concepts and their role in decision making</td></tr>
<tr><td>2</td><td colspan="7">To introduce the project management concepts and their various aspects</td></tr>
<tr><td>3</td><td colspan="7">To provide detailed knowledge for project execution and costing concepts</td></tr>
<tr><td>4</td><td colspan="7">To provide detailed knowledge on costing techniques in service sector and various budgetary control techniques</td></tr>
<tr><td>5</td><td colspan="7">To Illustrate with quantitative techniques in cost management</td></tr>
<tr><td>UNIT I</td><td colspan="2">INTRODUCTION TO COSTING CONCEPTS</td><td>9</td><td>0</td><td colspan="2">0</td><td>9</td></tr>
<tr><td colspan="8">Objectives of a Costing System; Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost; Creation of a Database for operational control.</td></tr>
<tr><td>UNIT II</td><td colspan="2">INTRODUCTION TO PROJECT MANAGEMENT</td><td>9</td><td>0</td><td colspan="2">0</td><td>9</td></tr>
<tr><td colspan="8">Project: meaning, Different types, why to manage, cost overruns centers, 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.</td></tr>
<tr><td>UNIT III</td><td colspan="2">PROJECT EXECUTION AND COSTING CONCEPTS</td><td>9</td><td>0</td><td colspan="2">0</td><td>9</td></tr>
<tr><td colspan="8">Project execution: Project cost control, Bar charts and Network diagram, Project commissioning: mechanical and process, 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, Pricing strategies: Pareto Analysis, Target costing, Life Cycle Costing.</td></tr>
<tr><td>UNIT IV</td><td colspan="2">COSTING OF SERVICE SECTOR AND BUDGETERY CONTROL</td><td>9</td><td>0</td><td colspan="2">0</td><td>9</td></tr>
<tr><td colspan="8">Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Activity- Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis, Budgetary Control: Flexible Budgets; Performance budgets; Zero-based budgets.</td></tr>
<tr><td>UNIT V</td><td colspan="2">QUANTITATIVE TECHNIQUES FOR COST MANAGEMENT</td><td>9</td><td>0</td><td colspan="2">0</td><td>9</td></tr>
<tr><td colspan="8">Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Learning Curve Theory</td></tr>
<tr><td colspan="8">TOTAL(45L) : 45 PERIODS</td></tr>
</table>

Reference Books:	
1	K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher, 1991
2	Charles T. Horngren and George Foster, Advanced Management Accounting, 1988 50
3	Charles T. Horngren et al Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi, 2011

4	S Kaplan Anthony A. Alkinson, Management & Cost Accounting, 2003
5	Vohra N.D., Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd, 2007

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Understand the costing concepts and their role in decision making.	Understand
CO2	Understand the project management concepts and their various aspects in selection.	Understand
CO3	Interpret costing concepts with project execution.	Evaluate
CO4	Gain knowledge of costing techniques in service sector and various budgetary control techniques.	Apply
CO5	Become familiar with quantitative techniques in cost management.	Apply

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	0	2	0	0	3	2	0	0	1	0	0	0	0	2
CO2	0	0	0	0	0	0	0	0	3	0	3	0	0	2
CO3	0	2	0	0	2	0	0	0	3	0	3	0	0	2
CO4	0	2	0	0	0	0	0	0	2	0	2	0	0	2
CO5	0	2	0	0	3	0	0	0	2	0	2	0	0	2
Avg	0	1.6	0	0	1.6	0.4	0	0	2.2	0	2	0	0	2
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)														

22THE75	ADVANCED COMPOSITE MATERIALS				Semester		III
PREREQUISITES			**Category**	**PE**	**Credit**		**3**
			Hours/Week	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Learning Objectives

1	To understand composite material, reinforcements and their selection
2	To develop and processing of metal- matrix, ceramic -matrix and carbon- carbon composites
3	To understand engineering mechanics, analysis and design, macro and micro mechanics of composites
4	To understand and analyze the properties and performance of composite
5	To understand the basics of nanocomposite materials

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Definition and Classification of Composites, MMC, PMC, CMC. Reinforcing fibres- Natural fibres (cellulose, jute, coir etc), boron, carbon, ceramic glass, aramids etc. Particulate fillers-importance of particle shape and size. Matrix resins- thermoplastics and thermosetting matrix resins. Coupling agents-surface treatment of fillers and fibres, significance of interface in composites.

UNIT II	**PROPERTIES AND PERFORMANCE**	**9**	**0**	**0**	**9**

Properties and microstructure of high-strength fiber materials (glass, carbon, polymer, ceramic fibers) and matrix materials (polymer, metal, ceramic, and carbon matrices). Specific strength and stiffness of high-performance composites. Rule of mixtures. Stress, strain transformations.

UNIT III	**MECHANICS AND MANUFACTURING**	**9**	**0**	**0**	**9**

Engineering mechanics analysis and design- concepts of Isotropy vs. Anisotropy, composite micromechanics, Classical amination Plate theory (CLPT). Fabrication techniques- pultrusion, filament winding, prepreg technology, injection and compression moulding, bag moulding, resin transfer moulding, reaction injection moulding.

UNIT IV	**FAILURE CRITERIA AND APPLICATIONS**	**9**	**0**	**0**	**9**

Hygrothermal stresses, bending of composite plates, analysis of sandwich plates, buckling analysis of laminated composite plates, inter-laminar stresses, First Order Shear Deformation Theory (FSDT). Applications: Industrial, aerospace, automobile, house hold etc.

UNIT V	**NANOCOMPOSITIES**	**9**	**0**	**0**	**9**

Introduction-Types of nanocomposite (i.e. metal oxide, ceramic, glass and polymer based); Core-Shell structured nanocomposites, Super hard Nanocomposite: Synthesis, applications and milestones.

TOTAL(45L) : 45 PERIODS

Reference Books:

1	Mallick P.K., “Fibre-Reinforced Composites: Materials- Manufacturing and Design”, Maneel Dekker Inc, 1993
2	Krishan K. Chawla, Composite Materials, Science and Engineering, Springer, 2001
3	Steven L. Donaldson, ASM Handbook Composites Volume 21, 2001
4	Nanocomposite science and technology – P.M. Ajayan, L.S. Schadler, P.V. Braun, Wiley, New York, 2003

5	Suresh G. Advani, E. Murat Sozer, Process Modelling in Composites Manufacturing, 2nd Ed. CRC Press, 2009

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Choose and select the suitable composite material and their reinforcements.	Apply
CO2	Select constituent materials glass, carbon, aramid, ceramic fibres and resins.	Analyze
CO3	Understand & Apply engineering mechanics, analysis and design, macro and micro mechanics of composites.	Evaluate
CO4	Highlight the appropriate use of composite structures in the industry.	Analyze
CO5	Describe the concepts of nanocomposite and their chrematistics.	Analyze

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	1	2	1	3	1	0	0	0	2	0	1	0	0	0
CO2	1	1	1	2	2	1	0	0	0	0	1	0	0	1
CO3	2	2	1	1	2	2	3	0	0	2	1	1	0	0
CO4	1	1	1	1	2	0	0	0	1	0	1	0	1	0
CO5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Avg	1	1.2	0.8	1.4	1.4	0.6	0.6	0	0.6	0.4	0.8	0.2	0.2	0.2
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)														

AUDIT COURSE

22AC01	ENGLISH FOR RESEARCH PAPER WRITING			SEMESTER I/II			
PREREQUISITES			**CATEGORY**	**PE**	**Credit**		**0**
			Hours/Week	**L**	**T**	**P**	**TH**
				2	**0**	**0**	**2**

COURSE OBJECTIVES:

1.	To help the learners to realize the necessity of English in writing a Research paper
2.	To enable the learners to write different sections of a research paper
3.	To train the learners to become better writers of research papers

UNIT I		**6**	**0**	**0**	**6**
Research paper and its importance, Structure of a research paper, Planning and preparation.					
UNIT II		**6**	**0**	**0**	**6**
English in research papers, Basic word order, Collocation, Being concise, Redundancy, Common errors.					
UNIT III		**6**	**0**	**0**	**6**
Key factors that determine the style of a paper, Journal's background, Passive form, Right tense forms, Cohesion and coherence.					
UNIT IV		**6**	**0**	**0**	**6**
Hedging and criticizing, Paraphrasing, Plagiarism, Ensuring quality of the paper and Useful phrases.					
UNIT V		**6**	**0**	**0**	**6**
Key skills in writing Title, Abstract, Introduction, Review of Literature, Discussion and Conclusion, Highlighting findings.					
					Total(30L) = 30 Periods

REFERENCE BOOKS:

1	Adrian Wallwork, "English for Writing Research Papers," Springer New York Dorecht Heidelberg London, 2016
2	Howe, Stephen. "Phrase Book for Writing papers and Research in English," Cambridge University Press, 2012.
3	Goldbort R. "Writing for Science," Yale University press, 2006.
4	Gabor L Lovei. "Writing and Publishing Scientific Paper," Open Book Publishers, 2021

COURSE OUTCOMES: On completion of the course the student will be able to		**Bloom's Taxonomy Mapped**
CO1	understand and appreciate the role of English in writing a good research paper	Understand
CO2	apply their knowledge in writing a research paper	Apply
CO3	analyze and assess the quality of their research paper	Analysis

22AC02	DISASTER MANAGEMENT				SEMESTER I/II			
PREREQUISITES				**CATEGORY**	**PE**	**Credit**		**0**
				Hours/Week	**L**	**T**	**P**	**TH**
					2	**0**	**0**	**2**

COURSE OBJECTIVES

To have a critical understanding of key concepts in disaster risk reduction and humanitarian response and critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives. Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations and evaluate the strengths and weaknesses of disaster management approaches. Planning and programming in different countries, particularly their home country or the countries they work in.

UNIT I	**INTRODUCTION**	**4**	**0**	**0**	**4**

Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.
Disaster Prone Areas in India: Study of Seismic Zones; Area Prone to floods and droughts, Landslides and avalanches; Areas prone to cyclonic and coastal hazards with special reference to Tsunami; Post- Disaster diseases and epidemics.

UNIT II	**REPERCUSSIONS OF DISASTERS AND HAZARDS**	**4**	**0**	**0**	**4**

Economic Damage, Loss of Human And Animal Life, Destruction of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks of Disease And Epidemics, War And Conflicts.

UNIT III	**DISASTER PREPAREDNESS AND MANAGEMENT**	**4**	**0**	**0**	**4**

Preparedness: Monitoring of Phenomena Triggering A Disaster or Hazard; Evaluation of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.

UNIT IV	**RISK ASSESSMENT**	**4**	**0**	**0**	**4**

Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival.

UNIT V	**DISASTER MITIGATION**	**4**	**0**	**0**	**4**

Meaning, Concept And Strategies of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation and Non-Structural Mitigation, Programs of Disaster Mitigation In India.

Total(20L)= 20 Periods

REFERENCE BOOKS:

1	R. Nishith, Singh AK 2012 Disaster Management in India:Perspectives, issues and strategies New Royal Book Company, Lucknow
2	Sahni, PardeepEt.Al. (Eds.) 2002 Disaster Mitigation Experiences And Reflections. Prentice Hall Of India, New Delhi.

COURSE OUTCOMES: On completion of the course the student will be able to		**Bloom's Taxonomy Mapped**
CO1	Learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.	Understand
CO2	Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.	Evaluate
CO3	develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations	Create
CO4	Critically understand the strengths and weaknesses of disaster management approaches.	Understand

22AC03	SANSKRIT FOR TECHNICAL KNOWLEDGE				SEMESTER I/II		
PREREQUISITES			**CATEGORY**	**PE**	**Credit**		**0**
			Hours/Week	**L**	**T**	**P**	**TH**
				2	**0**	**0**	**2**

COURSE OBJECTIVES

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

UNIT I	**ALPHABETS**	**8**	**0**	**0**	**8**
Alphabets in Sanskrit –Past/Present/Future Tense –Simple Sentences.					
UNIT II	**LITERATURE**	**8**	**0**	**0**	**8**
Order –Introduction of roots –Technical information about Sanskrit Literature					
UNIT III	**CONCEPTS**	**8**	**0**	**0**	**8**
Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics					
					Total(24L)= 24 Periods

REFERENCE BOOKS:

1	" Abhyasa Pustakam"- Dr.Vishwas, Samskrita- Bharati Publication,New Delhi
2	"Tech Yourself Sanskrit" PrathamaDeeksha-Vempatikutumbshastri,Rashtriya Sanskrit Sansthan,New Delhi Publication
3	India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi.

COURSE OUTCOMES: On completion of the course the student will be able to		**Bloom's Taxonomy Mapped**
CO1	Understanding basic Sanskrit language	Understand
CO2	Ancient Sanskrit literature about science & technology can be understood	Remembering
CO3	Being a logical language will help to develop logic in students	Apply

22AC04	VALUE EDUCATION			SEMESTER I/II		
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**0**
		Hours/Week	**L**	**T**	**P**	**TH**
			2	**0**	**0**	**2**

COURSE OBJECTIVES

To understand the Importance of value education and self-development. To imbibe good values in students and also know about the importance of character.

UNIT I	**BASIC VALUES**	**4**	**0**	**0**	**4**

Values and self-development- Social values and individual attitudes-Work ethics, Indian vision of Humanism Moral and Non Moral valuation-Standards and principles-Value judgements.

UNIT II	**CONFIDENCE**	**6**	**0**	**0**	**6**

Importance of cultivation of values- Sense of Duty-Devotion-Self-reliance-Confidence-Concentration-Truthfulness-Cleanlines-Honesty-Humanity-Power of faith-National Unity-Patriotism-Love for nature-Discipline.

UNIT III	**PERSONALITY DEVELOPMENT**	**6**	**0**	**0**	**6**

Personality and Behavior Development-Soul and Scientific attitude - Positive – Thinking - Integrity and discipline -Punctuality – Love and Kindness - Avoid fault Thinking - Free from anger - Dignity of labor - Universal brotherhood and religious tolerance –True friendship –Happiness Vs suffering –love for truth – Aware of self destructive habits- Association and Cooperation –Doing best for saving nature.

UNIT IV	**LOVE AND COMPASSION**	**6**	**0**	**0**	**6**

Character and Competence –Holy books vs Blind faith –Self –management and Good health – Science of reincarnation –Equality – Nonviolence –Humility -Role of Women –All religions and same message –Mind your Mind –Self -control –Honesty –Studying effectively.

Total(22L)= 22 Periods

REFERENCE BOOKS:

1	Chakraborty, S.K. “Values and Ethics for Organization Theory and Practice”, Oxford University Press, New Delhi, 1998.

COURSE OUTCOMES: On completion of the course the student will be able to		**Bloom’s Taxonomy Mapped**
CO1	Knowledge of self-development	Understand
CO2	Learn the importance of Human values	Remembering
CO3	Developing the overall personality	Create

22AC05	CONSTITUTION OF INDIA		SEMESTER I/II			
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**0**
		Hours/Week	**L**	**T**	**P**	**TH**
			2	**0**	**0**	**2**

COURSE OBJECTIVES

Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective. To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.

UNIT I	**HISTORY OF MAKING OF INDIAN CONSTITUTION**	**4**	**0**	**0**	**4**

History, Drafting Committee (Composition & working)

UNIT II	**PHILOSOPHY OF THE INDIAN CONSTITUTION**	**4**	**0**	**0**	**4**

Preamble, Salient Features.

UNIT III	**CONTOURS OF CONSTITUTIONAL RIGHTS & DUTIES**	**4**	**0**	**0**	**4**

Fundamental rights, right to equality, right to freedom, right against exploitation, right to freedom of religion, cultural and education rights, right to constitutional remedies, directive principles of state policy, fundamental duties.

UNIT IV	**ORGANS OF GOVERNANCE**	**4**	**0**	**0**	**4**

Parliament, composition, qualifications and disqualifications, powers and functions, executive, president, governor, council of ministers, judiciary, appointment and transfer of judges, qualifications, powers and functions.

UNIT V	**LOCAL ADMINISTRATION**	**4**	**0**	**0**	**4**

Districts administration head: role and importance, municipalities: introduction, mayor and role of elected representative, CEO of municipal corporation. Panchayati raj: introduction, PRI: zila panchayat. Elected officials and their roles, CEO zila panchayat: position and role. Block level: organizational hierarchy (different departments), village level: role of elected and appointed officials, importance of grass root democracy.

UNIT VI	**ELECTION COMMISSION**	**4**	**0**	**0**	**4**

Election Commission: role and functioning. Chief election commissioner and election commissioners. State election commission: role and functioning. Institute and bodies for the welfare of SC/ST/OBC and women.

Total(24L)= 24 Periods

REFERENCE BOOKS:

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

COURSE OUTCOMES: On completion of the course the student will be able to		**Bloom's Taxonomy Mapped**
CO1	Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics	Understand
CO2	Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.	Understand
CO3	Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution	Understand
CO4	Discuss the passage of the Hindu Code Bill of 1956.	Understand

22AC06	PEDAGOGY STUDIES					SEMESTER I/II			
PREREQUISITES			**CATEGORY**	**PE**	**Credit**		**0**		
			Hours/Week	**L**	**T**	**P**	**TH**		
				2	**0**	**0**	**2**		

COURSE OBJECTIVES

To Review existing evidence on the review topic to inform programme design and policy making undertaken by the DFID, other agencies and researchers. Identify critical evidence gaps to guide the development.

UNIT I		**4**	**0**	**0**	**4**

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

UNIT II		**2**	**0**	**0**	**2**

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

UNIT III		**4**	**0**	**0**	**4**

Evidence on the effectiveness of pedagogical practices, Methodology for the in depth stage: quality assessment of included studies, How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? Theory of change. Strength and nature of the body of evidence for effective pedagogical practices, Pedagogic theory and pedagogical approaches, Teachers' attitudes and beliefs and Pedagogic strategies.

UNIT IV		**4**	**0**	**0**	**4**

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

UNIT V		**2**	**0**	**0**	**2**

Research gaps and future directions, Research design, Contexts, pedagogy, teacher education, curriculum and assessment, dissemination and research impact

Total(16L)= 16 Periods

REFERENCE BOOKS:	
1	Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.
2	Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3) 361-379.
3	Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID
4	Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic math and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272-282.
5	Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.

COURSE OUTCOMES: On completion of the course the student will be able to		**Bloom's Taxonomy Mapped**
CO1	What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?	Create
CO2	What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?	Understand
CO3	How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?	Remembering

22AC07	STRESS MANAGEMENT BY YOGA				SEMESTER I/II			
PREREQUISITES				**CATEGORY**	**PE**	**Credit**		**0**
				Hours/Week	**L**	**T**	**P**	**TH**
					2	**0**	**0**	**2**

COURSE OBJECTIVES

To create a healthy, strong willed and intelligent young society through yoga practices.

UNIT I	**PHYSICAL AND MENTAL HEALTH**	**4**	**0**	**0**	**4**
Pain and disease - free life, Simplified Physical Exercise- Pranayama. Concentration on Pituitary gland- Practical, Goal fixing.					
UNIT II	**REJUVENATION OF LIFE FORCE AND WILL POWER**	**4**	**0**	**0**	**4**
Principle of kayakalpa yoga, mind, life force and Biomagnetism, Practical, Concentration on Muladhara- Practical, Analysis of thought –Will power					
UNIT III	**DEVELOPMENT OF VIRTUES**	**4**	**0**	**0**	**4**
Activation of Dormant Brain cells- Practical, Moralization of dezire and its classification, Neutralization of Anger, Results of anger.					
UNIT IV	**STREAM LINING OF MIND**	**4**	**0**	**0**	**4**
Definition of Mind-Worries, Eradication of Worries. The science behind blessings. Blessing techniques. Benefits, five basic duties					
UNIT V	**CAUSE AND EFFECT SYSTEM**	**4**	**0**	**0**	**4**
Law of nature, Hereditary Imprints, Fivefold and Two-fold culture, good values and Resolution for world peace					
					Total(24L)= 24 Periods

REFERENCE BOOKS:

1	"Thirukkural" , Pearls of Inspiration, Translation by Rajaram, Publisher :RUPA
2	"Bharathiyar Poems", Amazon Asia – Pacific Holdings Private Limited.
3	"Yoga for Humane Excellence" , Vethathiri Maharishi, Vision for Wisdom, Vethathiri Publications

COURSE OUTCOMES: On completion of the course the student will be able to		**Bloom's Taxonomy Mapped**
CO1	maintain good Physical health	Apply
CO2	develop will power	Create
CO3	take quick and right decisions	Evaluate
CO4	maintain good relationship with everyone around them his creating a Health Society	Apply

22AC08	PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS			SEMESTER I/II			
PREREQUISITES			**CATEGORY**	**PE**	**Credit**		**0**
			Hours/Week	**L**	**T**	**P**	**TH**
				2	**0**	**0**	**2**

COURSE OBJECTIVES

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

UNIT I		**8**	**0**	**0**	**8**

Neetisatakam – Holistics development of personality
Verses- 19,20,21,22 (wisdom)
Verses- 29,31,32 (pride & heroism)
Verses- 26,28,63,65 (virtue)
Verses-52,53,59(dont"s)
Verses71,73,75,78(do''s)

UNIT II		**8**	**0**	**0**	**8**

Approach to day to day work and duties.
Shrimad Bhagwad Geeta:
Chapter 2-Verses 41, 47, 48,
Chapter 3-Verses 13, 21, 27, 35,
Chapter 6-Verses 5,13,17,23,35,
Chapter 18-Verses 45, 46, 48

UNIT III		**8**	**0**	**0**	**8**

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

Total(24L)= 24 Periods

REFERENCE BOOKS:	
1	"Srimad Bhagavad Gita" by Swami SwarupanandaAdvaita Ashram (Publication Department), Kolkata.
2	Bhartrihari's Three Sataskam (Niti- Sringar – Vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.

COURSE OUTCOMES: On completion of the course the student will be able to		**Bloom's Taxonomy Mapped**
CO1	Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve The highest goal in life	Understand
CO2	The person who has studied Geeta will lead the nation and mankind to peace and prosperity	Remembering
CO3	Study of Neetishatakam will help in developing versatile personality of students.	Understand