ARUNAI

Engineering College

Tiruvannamalai,Tamil Nadu

AN AUTONOMOUS INSTITUTION

DEPARTMENT OF MECHANICAL ENGINEERING

M.E- Thermal Engineering

Regulation 2024

CHOICE BASED CREDIT SYSTEM (CBCS)

CURRICULUM AND SYLLABUS

ARUNAI ENGINEERING COLLEGE

(An Autonomous Institution Affiliated to Anna University Chennai)

DEPARTMENT OF MECHANICAL ENGINEERING
M.E-THERMAL ENGINEERING
REGULATION 2024
CHOICE BASED CREDIT SYSTEM
CURRICULUM AND SYLLABUS
I TO IV SEMESTERS

DEPARTMENT VISION:

- To produce multi-skilled and ethical Mechanical Engineers with global perspectives and National ethos.
- To serve the needs of the National and International Industries.
- To impart training and technology transfer appropriate to the rural areas and industries.

DEPARTMENT MISSION:

- Providing suitable teaching methods and adequate high quality focused education in thrust areas of Mechanical Engineering like Energy, Materials and CAE.
- Training in problem solving, assisting in analytical skills and developing technical competence with practical exposure to the students to meet the challenges of new millennium.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

I. Analyze, design and evaluate thermal systems using state of the art engineering tools and techniques

II. Develop methods of energy conservation for sustainable growth

III. Communicate effectively and support constructively towards team work

IV. Pursue lifelong learning for professional growth with ethical concern for society and environment.

PROGRAMME OUTCOMES:

On successful completion of the programme,

1. An ability to independently carryout research/ investigation and development work to solve practical problems.
2. An ability to write and present a substantial technical report/document.
3. Demonstrate a degree of mastery over thermal engineering at a level higher than the Bachelor's program.
4. Design, develop and analyze thermal systems for improved performance
5. Identify viable energy sources and develop effective technologies to harness them
6. Engage in lifelong learning adhering to professional, ethical, legal, safety, environmental and societal aspects for career excellence.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1: Apply Advanced Thermal Concepts

PSO2. Design and Development of Thermal Systems

PSO3: Research and Innovation in Energy Systems

PEO/PO Mapping

Programme Educational Objectives	Programme Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
I	3	3	3	3	3	2
II	3	2	3	2	2	2
II	2	2	2	2	2	3
IV	3	3	3	3	3	3

Semester Course wise PEO mapping

YEAR	SEM	Subject Name	PO1	PO2	PO3	PO4	PO5	PO6
YEAR 1	SEM 1	Advanced Numerical Methods	3	3	3	1	2	1
		Advanced Heat Transfer	3	3	3	2	3	3
		Advanced Thermodynamics	3	3	3	2	3	3
		Advanced Fluid Mechanics	3	3	3	2	1	3
		Research Methodology and IPR	3	1	3	1	1	1
		Aircraft and Jet Propulsion	3	3	3	3	3	3
		Hydrogen and Fuel Cell Technologies	3	3	3	3	3	3
		Energy Resources	3	2	3	2	3	3
		Advanced Internal Combustion Engines	3	3	3	3	3	3
		Cryogenic Engineering	3	3	3	2	3	3
		Refrigeration Systems	2.5	2	3	2	2	2
		Electronic Engine Management Systems	2	2	3	2	1	2
		Cogeneration and Waste Heat Recovery Systems	2	2	3	2	2	2
		Thermal Engineering Laboratory	2	3	3			3
	SEM 2	Instrumentation for Thermal Engineering	2	2	3	3	3	3
		Computational Fluid Dynamics	3	3	3	3	2	2
		Fuels, Combustion and Pollution Control	3	3	3	3	1	3
		Fans, Blowers and Compressors	3	3	3	3	1	3
		Food Processing, Preservation and Transport	3	3	3	3	3	3
		Air Conditioning Systems	3	3	3	3	2	2
		Energy Management in Thermal Systems	2	2	3	2	1	3

YEAR 1	SEM 2	Alternative Fuels for IC Engines	3	2	3	2	3	3
		Design of Heat Exchangers	3	3	3	3	2	3
		Heat Transfer Enhancement Techniques	3	3	3	3	3	3
		Electronic Packaging And Cooling Of Electronic Systems	2	1	3	3	1	3
		Battery Thermal Management Systems	2	2	3	2	1	3
		Energy Storage Technologies	3	2	2	2	3	2
		Electric And Hybrid Vehicles	3	2	3	3	3	3
		Advanced power plant Engineering	3	3	3	3	2	3
		Thermal Systems Simulation Laboratory	2	3	3	2	3	2
		Technical Seminar–I	2	3	2	3	2	3
YEAR 2	SEM 3	Design and Optimization of Thermal Energy Systems	3	3	2	3	3	3
		Design and Analysis of Turbo machines	3	3	3	3	3	3
		Boundary Layer Theory and Turbulence	3	3	3	3	2	2
		Steam Generator Technology	3	3	3	3	3	3
		Fluidized Bed Systems	3	2	3	3	3	3
		Data analytics and IOT for thermal systems	2	3	2	3	2	1
		Energy Efficient Building	3	3	3	2	3	3
		Engine Pollution And Control	2	3	2	1	1	3
		Solar Energy Technologies	3	3	3	3	3	3
		Industrial Safety Engineering	2	2	2	2	2	3
		Technical Seminar–II	3	3	3	2	3	2
		Project work–I	3	3	3	3	3	3
	SEM 4	Project work Phase–II	3	3	3	3	3	3

ARUNAI ENGINEERING COLLEGE

(AUTONOMOUS)

TIRUVANNAMALAI

REGULATIONS 2024

CHOICE BASED CREDIT SYSTEM

M.E THERMAL ENGINEERING

CURRICULAM AND SYLLABI FOR SEMESTER I TO IV

SEMESTER I

S.NO	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
THEORY				L	T	P		
1	MA24101	Advanced Numerical Methods	FC	4	0	0	4	4
2	TE24101	Advanced Heat Transfer	FC	4	0	0	4	4
3	TE24102	Advanced Thermodynamics	PCC	3	1	0	4	4
4	TE24103	Advanced Fluid Mechanics	PCC	3	0	0	3	3
5	RM24101	Research Methodology and IPR	RMC	2	0	0	2	2
6		Professional Elective - I	PEC	3	0	0	3	3
7		Professional Elective - II	PEC	3	0	0	3	3
8		Audit Course I*	AC	2	0	0	2	0
PRACTICALS								
9	TE24111	Thermal Engineering Laboratory	PCC	0	0	4	4	2
TOTAL				24	1	4	29	25

*** Audit Course is optional**

SEMESTER II

S.NO	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
THEORY				L	T	P		
1	TE24201	Instrumentation for Thermal Engineering	PCC	3	0	0	3	3
2	IC24201	Computational Fluid Dynamics	PCC	3	0	0	3	3
3	TE24202	Fuels, Combustion and Emission Control	PCC	4	0	0	4	4
4		Professional Elective - III	PEC	3	0	0	3	3
5		Professional Elective - IV	PEC	3	0	0	3	3
6		Professional Elective - V	PEC	3	0	0	3	3
7		Audit Course II*	AC	2	0	0	2	0
PRACTICALS								
8	TE24211	Thermal Systems Simulation Laboratory	PCC	0	0	4	4	2
9	TE24212	Technical Seminar – I	EEC	0	0	2	2	1
TOTAL				21	0	6	27	22

*** Audit Course is optional**

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SEMESTER III

S.NO	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
THEORY				L	T	P		
1	TE24301	Design and Optimization of Thermal Energy Systems	PCC	3	0	0	3	3
2		Professional Elective - VI	PEC	3	0	0	3	3
3		Open Elective	OEC	3	0	0	3	3
PRACTICALS								
8	TE24311	Technical Seminar – II	EEC	0	0	2	2	1
9	TE24312	Project Work - I	EEC	0	0	12	12	6
TOTAL				**9**	**0**	**14**	**23**	**16**

SEMESTER IV

S.NO	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
PRACTICALS								
9	TE24411	Project Work - II	EEC	0	0	24	24	12
TOTAL				**0**	**0**	**24**	**24**	**12**

TOTAL CREDITS: 75

Name of the Programme: M.E THERMAL ENGINEERING						
S.No	Subject Area	Credits per Semester				Total Credits
		I	II	III	IV	
1.	FC	8				8
2.	PCC	9	12	3		24
3.	RMC	2				2
4.	PEC	6	9	3		18
5.	OEC			3		3
6.	EEC		1	7	12	20
7.	Non Credit/ Audit Course	✓	✓			
TOTAL		25	22	16	12	75

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PROFESSIONAL ELECTIVES
SEMESTER I, ELECTIVE I & II

S.NO	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1	TE24001	Aircraft and Jet Propulsion	PEC	3	0	0	3	3
2	TE24002	Hydrogen and Fuel Cell Technologies	PEC	3	0	0	3	3
3	TE24003	Energy Resources	PEC	3	0	0	3	3
4	TE24004	Advanced Internal Combustion Engines	PEC	3	0	0	3	3
5	TE24005	Cryogenic Engineering	PEC	3	0	0	3	3
6	TE24006	Refrigeration Systems	PEC	3	0	0	3	3
7	IC24001	Electronic Engine Management Systems	PEC	3	0	0	3	3
8	TE24007	Cogeneration and Waste Heat Recovery Systems	PEC	3	0	0	3	3

PROFESSIONAL ELECTIVES
SEMESTER II, ELECTIVE III, IV & V

S.NO	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1	TE24008	Design of Turbo Machines	PEC	3	0	0	3	3
2	TE24009	Electronics Cooling and Packaging	PEC	3	0	0	3	3
3	TE24010	Air Conditioning Systems	PEC	3	0	0	3	3
4	IC24002	Alternate Fuels for IC Engines	PEC	3	0	0	3	3
5	TE24011	Design of Heat Exchangers	PEC	3	0	0	3	3
6	TE24012	Battery Thermal Management System	PEC	3	0	0	3	3
7	EY24001	Advanced Energy Storage Technologies	PEC	3	0	0	3	3
8	IC24003	Hybrid and Electric Vehicles	PEC	3	0	0	3	3
9	TE24013	Advanced Power Plant Engineering	PEC	3	0	0	3	3

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PROFESSIONAL ELECTIVES

SEMESTER III, ELECTIVE VI

S.NO	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1	IC24004	Boundary Layer Theory and Turbulence	PEC	3	0	0	3	3
2	TE24014	Steam Generator Technology	PEC	3	0	0	3	3
3	EY24002	Fluidized Bed Systems	PEC	3	0	0	3	3
4	TE24015	Energy Efficient Buildings	PEC	3	0	0	3	3
5	IC24005	Engine Pollution and Control	PEC	3	0	0	3	3
6	TE24016	Solar Thermal Technologies	PEC	3	0	0	3	3

AUDIT COURSES - I

REGISTRATION FOR ANY OF THESE COURSES IS OPTIONAL TO STUDENTS

S.NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
			L	T	P		
1	AX24001	English for Research Paper Writing	2	0	0	2	0
2	AX24002	Disaster Management	2	0	0	2	0
3	AX24003	Constitution of India	2	0	0	2	0
4	AX24004	நற்றமிழ்இலக்கியம்	2	0	0	2	0

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LIST OF OPEN ELECTIVES FOR PG PROGRAMMES

SL.NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
			L	T	C		
1	OCE24001	Integrated Water Resources Management	3	0	0	3	3
2	OCE24002	Water, Sanitation and Health	3	0	0	3	3
3	OCE24003	Principles of Sustainable Development	3	0	0	3	3
4	OCE24004	Environmental Impact Assessment	3	0	0	3	3
5	OIC24001	Block chain Technologies	3	0	0	3	3
6	OIC24002	Deep Learning	3	0	0	3	3
7	OBA24001	Sustainable Management	3	0	0	3	3
8	OBA24002	Micro and Small Business Management	3	0	0	3	3
9	OBA24003	Intellectual Property Rights	3	0	0	3	3
10	OBA24004	Ethical Management	3	0	0	3	3
11	ET24003	IoT for Smart Systems	3	0	0	3	3
12	ET24002	Machine Learning and Deep Learning	3	0	0	3	3
13	PX24010	Renewable Energy Technology	3	0	0	3	3
14	PS24003	Smart Grid	3	0	0	3	3
15	CP24007	Security Practices	3	0	0	3	3
16	MP24002	Cloud Computing Technologies	3	0	0	3	3
17	IF24001	Design Thinking	3	0	0	3	3
18	MU24001	Principles of Multimedia	3	0	0	3	3
19	DS24001	Big Data Analytics	3	0	0	3	3
20	NC24001	Internet of Things and Cloud	3	0	0	3	3
21	MX24001	Medical Robotics	3	0	0	3	3
22	VE24001	Embedded Automation	3	0	0	3	3
23	CX24001	Environmental Sustainability	3	0	0	3	3
24	TX24001	Textile Reinforced Composites	3	0	0	3	3
25	NT24001	Nano composite Materials	3	0	0	3	3
26	BY24001	IPR, Biosafety and Entrepreneurship	3	0	0	3	3

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Subject Code	Subject Name	Category	L	T	P	C
MA24101	ADVANCED NUMERICAL METHODS	FC	4	0	0	4

Course Objectives:

- To study various numerical techniques to solve linear and non-linear algebraic and transcendental equations.
- To compare ordinary differential equations by finite difference and collocation methods.
- To establish finite difference methods to solve Parabolic and hyperbolic equations.
- To establish finite difference method to solve elliptic partial differential equations.
- To provide basic knowledge infinite elements method in solving partial differential equations.

UNIT – I	**ALGEBRAIC EQUATIONS**	**12**

Systems of linear equations : Gauss elimination method – Pivoting techniques – Thomas algorithm for tri diagonal system – Jacobi, Gauss Seidel, SOR iteration methods – Conditions for convergence - Systems of nonlinear equations : Fixed point iterations, Newton's method, Eigenvalue problems : Power method and Given's method.

UNIT – II	**ORDINARY DIFFERENTIAL EQUATIONS**	**12**

Runge - Kutta methods for system of IVPs – Numerical stability of Runge - Kutta method – Adams - Bashforth multistep method, Shooting method, BVP : Finite difference method, Collocation method and orthogonal collocation method.

UNIT – III	**FINITE DIFFERENCE METHOD FOR TIME DEPENDENT PARTIAL DIFFERENTIAL EQUATIONS**	**12**

Parabolic equations: Explicit and implicit finite difference methods – Weighted average approximation - Dirichlet's and Neumann conditions – Two dimensional parabolic equations – DI method: First order hyperbolic equations – Method of numerical integration along characteristics – Wave equation : Explicit scheme – Stability.

UNIT – IV	**FINITE DIFFERENCE METHODS FOR ELLIPTIC EQUATIONS**	**12**

Laplace and Poisson's equations in a rectangular region: Five point finite difference schemes, Leibmann's iterative methods, Dirichlet's and Neumann conditions – Laplace equation in polar coordinates: Finite difference schemes – Approximation of derivatives near a curved boundary while using a square mesh.

UNIT – V	**FINITE ELEMENT METHOD**	**12**

Basics of finite element method: Weak formulation, Weighted residual method – Shape functions for linear and triangular element – Finite element method for two point boundary value problems, Laplace and Poisson equations.

Total Contact Hours : 60

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Solve an algebraic or transcendental equation, linear system of equations and differential equations using an appropriate numerical method.
CO2	Solving the initial boundary value problems and boundary value problems using finite difference and finite element methods.
CO3	Solving parabolic and hyperbolic partial differential equations by finite difference methods.
CO4	Compute solution of elliptic partial differential equations by finite difference methods.

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CO5	Selection of appropriate numerical methods to solve various types of problems in engineering and science in consideration with the minimum number of mathematical operations involved accuracy requirements and available computational resources.

Textbooks:	
1.	Burden, R.L., and Faires, J.D., "Numerical Analysis – Theory and Applications", 9thEdition, Cengage Learning,NewDelhi,2016.
2.	Gupta S.K., "Numerical Methods forEngineers",4th Edition, New Age Publishers,2019.
3.	JainM.K., IyengarS.R., Kanchi M.B., Jain, "Computational Methods for Partial Differential Equations", New Age Publishers ,1993.

Reference books/other materials/web resources:	
1.	Sastry, S.S., "Introductory Methods ofNumericalAnalysis",5th Edition, PHILearning,2015.
2.	SaumyenGuhaandRajeshSrivastava,"NumericalmethodsforEngineeringandScience",Oxford Higher Education,NewDelhi,2010.
3.	Smith, G. D., "Numerical Solutions of Partial Differential Equations: Finite Difference Methods", Clarendon Press,1985.

	CO-PO Mapping						CO-PSO Mapping		
PO & PSO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	2	1			2		
CO2	3	3	2	2			2		
CO3	3	3	3	2	1		2	2	
CO4	3	2	3	2			2	2	
CO5	3	3	3	3	1		3	2	1
Average:	3	2.6	2.6	2	0.4		2.2	1.2	0.2

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Subject Code	Subject Name	Category	L	T	P	C
TE24101	ADVANCED HEAT TRANSFER	FC	4	0	0	4

Course Objectives:

- To impart knowledge on conduction heat transfer associated with radiation.
- To impart knowledge on the turbulent forced convective heat transfer.
- To impart knowledge on the significance of Phase Change Heat Transfer and Mass Transfer.
- To teach the heat exchanger design aspects including compact heat exchangers.
- To impart knowledge on Mass transfer as an engineering phenomenon.

UNIT – I	**CONDUCTION AND RADIATION HEAT TRANSFER**	**12**

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

UNIT – II	**TURBULENT FORCED CONVECTIVE HEAT TRANSFER**	**12**

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**	**12**

Condensation on bank of tubes - boiling – pool and flow boiling - heat Transfer Enhancement Techniques.

UNIT – IV	**HEAT EXCHANGERS**	**12**

Heat Exchanger – Є- NTU approach and design procedure – compact heat exchangers – Plate heat exchangers– Mini and Micro Channel heat exchangers, Heat transfer correlations for specific cases.

UNIT – V	**MASS TRANSFER**	**12**

Mass transfer - vaporization of droplets - combined heat and mass transfers applications – Cooling Towers, Evaporative condensers, solar pond, Cooling and dehumidification systems – porous media heat transfer

Total Contact Hours : 60

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Analyse problems on heat transfer associated with conduction and convection and radiation through vapours and gases.
CO2	Analyse problems on turbulent heat transfer and also solve high speed flow problems.
CO3	Analyse problems on phase change heat transfer.
CO4	Estimate the performance of compact heat exchangers and also understand the use of correlations to predict heat transfer from specific devices.
CO5	Understand and analyse the mass transfer associated with heat transfer in engineering systems.

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Textbooks:	
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.

Reference books/other materials/web resources:	
1.	Nag.P.K., Heat Transfer, Tata McGraw-Hill, 2002.
2.	Ozisik. M.N., Heat Transfer – A Basic Approach, McGraw-Hill Co., 1985.
3.	Yadav, R., Heat and Mass Transfer, Central Publishing House, 1995.

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	2	1	3				3	2	1
CO2	2	2	3				3	3	2
CO3	2	1	3				3	2	3
CO4	2	2	3				3	3	2
CO5	2	2	2				3	2	3
Average:	2	1.6	2.6				3	2.4	2.2

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Subject Code	Subject Name	Category	L	T	P	C
TE24102	ADVANCED THERMODYNAMICS	PCC	3	1	0	4

Course Objectives:

- To achieve an understanding of basic principle and scope of thermodynamics.
- To predict the availability and irreversibility associated with the thermodynamic processes.
- To analyse the properties of ideal and real gas mixtures and to understand the basic concepts of thermal systems
- To evaluate fuel-air cycles using simulation and availability concepts
- To apply thermo chemistry and chemical equilibrium in combustion systems

UNIT – I	**THERMODYNAMIC PROPERTY RELATIONS**	**12**

Thermodynamic Potentials, Maxwell relations, Generalized relations for changes in Entropy, Internal Energy and Enthalpy, Generalized Relations for Cp and Cv, Clausius Clapeyron Equation, Joule Thomson Coefficient, Bridgeman Tables for Thermodynamic Relations.

UNIT – II	**REAL GAS BEHAVIOUR AND MULTI-COMPONENT SYSTEMS**	**12**

Equations of State (mention three equations), Fugacity, Compressibility, Principle of Corresponding States, use of generalized charts for enthalpy and entropy departure, fugacity coefficient, Lee-Kesler generalized three parameter tables. Fundamental property relations for systems of variable composition, partial molar properties, Real gas mixtures, Ideal solution of real gases and liquids, Equilibrium in multi-phase systems, Gibb's phase rule for non-reactive components.

UNIT – III	**AVAILABILITY ANALYSIS**	**12**

Introduction, Reversible work, Availability, Irreversibility and Second - Law Efficiency for a closed System and Steady-State Control Volume. Availability Analysis of Simple Cycles. Chemical availability of closed and control volume. Fuel Chemical availability, Evaluation of the availability of hydrocarbon fuels.

UNIT – IV	**FUEL – AIR CYCLES AND THEIR ANALYSIS**	**12**

Ideal Models of Engine Processes, Fuel–Air Cycle Analysis – SI Engine Cycle Simulation, CI Engine Cycle Simulation, Results of Cycle Calculations, Availability Analysis of Engine Processes – Availability Relationships – Entropy changes in Ideal Cycles – Availability Analysis of Ideal Cycles.

UNIT – V	**THERMO CHEMISTRY**	**12**

Ideal gas laws and properties of Mixtures, Combustion Stoichiometry, Application of First Law of Thermodynamics – Heat of Reaction – Enthalpy of Formation – Adiabatic flame temperature. Second law of Thermodynamics applied to combustion – entropy, maximum work and efficiency Chemical equilibrium: - Equilibrium constant evaluation Kp&Kf, Equilibrium composition evaluation of ideal gas and real gas mixtures.

Total Contact Hours : 60

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Apply the law of thermodynamics to thermal systems.
CO2	Analyse the actual thermodynamic cycles.
CO3	Design and analyse a multi component thermodynamic system.
CO4	Apply the thermodynamics concepts in automotive systems.
CO5	Understand and analyse the combustion of different fuels.

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Textbooks:	
1.	Kenneth Wark., J.R, Advanced Thermodynamics for Engineers, McGraw-Hill Inc., 1995.
2.	K.Annamalai, I.K.Puri, M.A.Jog, Advanced Thermodynamics Engineering, Second Edition, CRC Press, 2011.
3.	3. Advanced Thermodynamics, S.S. Thipse, Narosa Publishing Home Pvt. Ltd., 2013

Reference books/other materials/web resources:	
1.	Yunus A. Cengel and Michael A. Boles, Thermodynamics, McGraw-Hill Inc., 2006.
2.	B.P. Pundir, I.C. engine combustion and emissions. Bejan, A., Advanced Engineering Thermodynamics, John Wiley and Sons, 1988.
3.	Holman,J.P., Thermodynamics, Fourth Edition, McGraw-Hill Inc., 1988.

	CO-PO Mapping						CO-PSO Mapping		
PO & PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	2		3				3	2	1
CO2	2	1	3				3	3	2
CO3	2		3				3	2	3
CO4	2	1	3				3	3	2
CO5	2	1	3				3	2	3
Average:	2	0.6	3				3	2.4	2.2

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Subject Code	Subject Name	Category	L	T	P	C
TE24103	ADVANCED FLUID MECHANICS	PCC	3	0	0	3

Course Objectives:

- To understand the laws of fluid flow for ideal and viscous fluids.
- To represent the real solid shapes by suitable flow patterns and to analyze the same for aerodynamics performances.
- To understand the changes in properties in compressible flow and shock expansion.
- To introduce boundary layer concepts and velocity distributions
- To analyze compressible flow phenomena

UNIT – I	**BASIC EQUATIONS OF FLOW**	**9**

Three dimensional continuity equation - differential and integral forms – equations of motion momentum and energy - Reynolds transport theorem – Navier – Stokes equation – Engineering Applications.

UNIT – II	**POTENTIAL FLOW THEORY**	**9**

Rotational and irrational flows - circulation – vorticity - stream and potential functions forstandard flows and combined flows – representation of solid bodies by flow patters. Pressurdistribution over stationery and rotating cylinders in a uniform flow - magnus effect - Kutta –Zhukovsky theorem. Complex potential functions. Conformal transformation to analyze the flowover flat plate, cylinder, oval body and airfoils. Thin airfoil theory – generalized airfoil theory forcambered and flapped airfoils.

UNIT – III	**VISCOUS FLOW THEORY**	**9**

Laminar and turbulent flow - laminar flow between parallel plates - Poiseuille's equation for flowthrough circular pipes. Turbulent flow - Darcy Weisbach equation for flow through circular pipe -friction factor - smooth and rough pipes - Moody diagram – losses during flow through pipes.Pipes in series and parallel – transmission of power through pipes.

UNIT – IV	**BOUNDARY LAYER CONCEPT**	**9**

Boundary Layer - displacement and momentum thickness - laminar and turbulent boundary layers in flat plates - velocity distribution in turbulent flows in smooth and rough boundaries - laminar sub layer.

UNIT – V	**COMPRESSIBLE FLUID FLOW**	**9**

One dimensional compressible fluid flow – flow through variable area passage – nozzles and diffusers – fundamentals of supersonics – normal and oblique shock waves and calculation of flow and fluid properties over solid bodies (like flat plate, wedge, diamond) using gas tables.

Total Contact Hours : 45

Course Outcomes:	Upon completion of the course students should be able to:
CO1	After the completion of the syllabus students able to familiarized about the ideal and viscous fluid flow, boundary layer concepts and changes in properties in compressible flow and shock expansion.
CO2	Analyze potential flows using stream and potential functions, and apply conformal mapping to solve flow problems around basic geometries.
CO3	Solve laminar and turbulent flow problems in pipes and channels using analytical and empirical relations including friction factor and losses.
CO4	Evaluate boundary layer properties and velocity profiles over smooth and rough surfaces under laminar and turbulent conditions.
CO5	Analyze compressible fluid flows and apply shock wave theory and gas tables to compute fluid properties in nozzles and around solid bodies.

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Textbooks:	
1.	Anderson J.D., Fundamentals of Aerodynamics, McGraw Hill, Boston, 2001.
2.	Bansal R.K., Fluid Mechanics, Saurabh and Co., New Delhi, 1985.
3.	Houghten E.L. and Carruthers N.B., Aerodynamics for Engineering Students, Arnold Publishers, 1993.

Reference books/other materials/web resources:	
1.	Kumar K.L., Engineering Fluid Mechanics, Eurasia Publishing House, New Delhi, 2002.
2.	Munson B.R., Young D.F. and Okiisi, T.H., Fundamentals of Fluid Mechanics, John Wiley and Sons Inc., NewYork, 1990.
3.	Schlichting H., Boundary layer theory, Mc Graw Hill Book Company, 1979.

	CO-PO Mapping						CO-PSO Mapping		
PO & PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3		3		2	2	3	2	1
CO2	3		3		2	2	2	3	2
CO3	2		3		2	2	3	3	1
CO4	3		2		3	1	3	2	1
CO5	2		3		2	2	2	2	3
Average:	2.6		2.8		2.2	1.8	2.6	2.4	1.6

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Subject Code	Subject Name	Category	L	T	P	C
RM24101	RESEARCH METHODOLOGY AND IPR	RMC	2	0	0	2

Course Objectives:

- To introduce the fundamentals of research design and methodologies
- To develop skills in data collection and preparation
- To apply data analysis methods and effectively communicate research findings
- To provide foundational knowledge on Intellectual Property Rights
- To explain the patenting process and its practical applications

UNIT – I	**RESEARCH DESIGN**	**6**
Overview of research process and design, Use of Secondary and exploratory data to answer the research question, Qualitative research, Observation studies, Experiments and Surveys.		
UNIT – II	**DATA COLLECTION AND SOURCES**	**6**
Measurements, Measurement Scales, Questionnaires and Instruments, Sampling and methods. Data - Preparing, Exploring, examining and displaying.		
UNIT – III	**DATA ANALYSIS AND REPORTING**	**6**
Overview of Multivariate analysis, Hypotheses testing and Measures of Association. Presenting Insights and findings using written reports and oral presentation.		
UNIT – IV	**INTELLECTUAL PROPERTY RIGHTS**	**6**
Intellectual Property – The concept of IPR, Evolution and development of concept of IPR, IPR development process, Trade secrets, utility Models, IPR & Bio diversity, Role of WIPO and WTO in IPR establishments, Right of Property, Common rules of IPR practices, Types and Features of IPR Agreement, Trademark, Functions of UNESCO in IPR maintenance.		
UNIT – V	**PATENTS**	**6**
Patents – objectives and benefits of patent, Concept, features of patent, Inventive step, Specification, Types of patent application, process E-filling, Examination of patent, Grant of patent, Revocation, Equitable Assignments, Licences, Licensing of related patents, patent agents, Registration of patent agents.		
		Total Contact Hours : 30

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Understand and apply different types of research designs and qualitative research methods.
CO2	Develop and implement effective data collection instruments and sampling methods for various research scenarios.
CO3	Analyze data using appropriate methods and present research findings clearly in written and oral formats.
CO4	Demonstrate understanding of Intellectual Property Rights and their global implications in research and innovation.
CO5	Apply knowledge of patent systems, procedures, and legal frameworks relevant to innovation and research protection.

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Textbooks:	
1.	Cooper Donald R, Schindler Pamela S and Sharma JK, "Business Research Methods", Tata McGraw Hill Education, 11e (2012).
2.	Catherine J. Holland, "Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets", Entrepreneur Press, 2007.
3.	David Hunt, Long Nguyen, Matthew Rodgers, "Patent searching: tools & techniques",Wiley,2007.

Reference books/other materials/web resources:	
1.	The Institute of Company Secretaries of India, Statutory body under an Act of parliament, "Professional Programme Intellectual Property Rights, Law and practice" September 2013.
2.	C.R. Kothari, Research Methodology: Methods and Techniques New Age International, 2019
3.	Uma Sekaran, Roger Bougie, Research Methods for Business: A Skill-Building Approach Wiley, 2016.

	CO-PO Mapping						CO-PSO Mapping		
PO & PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3		3		2	2	3	2	1
CO2	3		3		2	2	3	2	1
CO3	2		3		2	2	3	2	2
CO4	3		2		3	1	2	3	3
CO5	2		3		2	2	1	3	3
Average:	2.6		2.8		2.2	1.8	2.4	2.4	1.8

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SUBJECT CODE	SUBJECT NAME	Category	L	T	P	C
TE24111	THERMAL ENGINEERING LABORATORY	PCC	0	0	4	2

COURSE OBJECTIVES:

- To conduct experiments on various Thermal Engineering devices to study the Performance and its applications.

LIST OF EXPERIMENTS	60

1. Performance and emission characteristics of multi cylinder Spark Ignition and Compression Ignition engines using alternate fuels.
2. Thermal performance of variable compression ratio engines.
3. Thermal analysis of natural / forced draught cooling towers.
4. Thermal analysis of heat pumps systems.
5. Experimental studies on vapour compression refrigeration systems using natural refrigerants
6. Overall performance of solar water heating system.
7. Physical, Chemical and thermal Properties of any liquid and gas fuels.
8. Experimental analysis of a Boiler.
9. Calibration of Temperature sensors (RTD / any thermocouple)
10. Calibration of Pressure sensors
11. Experimental studies on axial / centrifugal fan characteristics

TOTAL: 60 PERIODS

LEARNING OUTCOMES:
At the end of the course, learners will be able
CO1:Know the various alternate fuels are available for IC engines
CO2: Understand the thermodynamic relations for thermal engineering devices.
CO3: Understand the working principle of different renewable energy sources.
CO4: Measure the properties of different fuels

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:		QTY
1	Single cylinder / multi cylinder Automotive Engine with data acquisition system	1
2	Flue gas analyzer	1
3	Smoke meter	1
4	Single cylinder variable Compression ratio petrol engine	1
5	Single cylinder variable Compression ratio Diesel engine	1
6	Cooling tower test rig	1
7	Refrigeration cum Heat Pump test rig	1
8	100 LPD Solar flat plate water heater test rig	1
9	Pyrometer	1
10	Redwood / Saybolt viscometer	1
11	Bomb calorimeter apparatus	1
12	Gas calorimeter	1
13	Cloud & Pour point apparatus	1
14	IBR / Non-IBR Boiler test rig	1

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15	Fan test rig	1
16	Pressure Calibrator	1
17	Temperature Calibrator	1

	CO-PO Mapping						CO-PSO Mapping		
PO & PSO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**
CO1	3		3	3	2	2	3	2	2
CO2	3		2	3	2	3	3	3	2
CO3	3		2	2	2	2	3	3	2
CO4	2		2	2	2	1	2	3	3
CO5	2		3	2	2	2	3	2	3
Average:	2.6		2.4	2.4	2.2	2	2.8	2.6	2.4

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Subject Code	Subject Name	Category	L	T	P	C
TE24201	INSTRUMENTATION FOR THERMAL ENGINEERING	PCC	3	0	0	3

Course Objectives:

- To classify various measuring instruments.
- To categories temperature sensors and their applications in measurement.
- To outline the advancements in pressure and volume measurements.
- To explore the various measurement techniques for thermos physical properties.
- To compare the different data acquisition systems.

UNIT – I	**MEASUREMENT CHARACTERISTICS**	**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	**TEMPERATURE MEASUREMENT**	**9**

Temperature, Types, materials, Accuracy - Selection of Temperature sensors - Effect of length of sensor on temperature measurements- calibration of thermocouple, RTD's & Thermistors- Standards for temperature measurement - Cryogenic & High Temperature measurement techniques.

UNIT – III	**PRESSURE FLOW & VOLUME MEASUREMENTS**	**9**

Pressure Sensors: Types & materials - piezoelectric transducers- calibration of pressure sensors-selection of pipes & fittings for pressure sensors. Volume sensors: Standard volumetric flask- Types, Density measurement instruments for liquids & gases. Flow Sensors: Caroli's mass flow measurements - flow measurements for water, gases, other oils & other chemicals.

UNIT – IV	**MEASUREMENT OF THERMO PHYSICAL PROPERTIES**	**9**

Thermal Conductivity measurement of solids - liquids & gases- Sensors & calibration methods- Thermal conductivity of microbar nano composites - Specific heat of liquids, solids through DSC Analysis - viscosity measurement of Newtonian & non-Newtonian fluids through rheological analysis.

UNIT – V	**DATA ACQUISITION SYSTEM**	**9**

Data acquisition systems, Evolution of SCADA, Communication technologies, Monitoring and supervisory functions, SCADA applications in Utility Automation, Industries - SCADA System Components: Schemes- Remote Terminal Unit (RTU), Intelligent Electronic Devices (IED), Communication Network, SCADA Server, SCADA/HMI Systems Various SCADA architectures.

Total Contact Hours : 45

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Infer the role of uncertainty analysis in measuring instruments.
CO2	Select the appropriate temperature sensors based on specific applications.
CO3	Identify the suitable sensors for pressure and volume measurements.
CO4	Evaluate thermos physical properties of media.
CO5	Appraise the advantages of data acquisition systems.

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Subject Code	Subject Name	Category	L	T	P	C
IC24201	COMPUTATIONAL FLUID DYNAMICS	PCC	3	0	0	3

Course Objectives:

- This course aims to introduce numerical modeling and its role in the field of heat, fluid flow and combustion. It will enable the students to understand the various Discretization methods and solving methodologies and to create confidence to solve complex problems in the field of heat transfer and fluid dynamics.
- To develop finite volume discretised forms of the governing equations for diffusion processes.
- To develop finite volume discretised forms of the convection-diffusion processes.
- To develop pressure-based algorithms for flow processes.
- To introduce various turbulence models, Large Eddy Simulation and Direct Numerical Simulation.

UNIT – I	**GOVERNING DIFFERENTIAL EQUATIONS AND DISCRETISATION TECHNIQUES**	**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**

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**

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**

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

UNIT – V	**TURBULENCE MODELS**	**9**

Turbulence – RANS equation - Algebraic Models, One equation model, Two equation models – k & standard k – ϵ model, Low Reynold number models of k- ϵ, Large Eddy Simulation (LES), Direct Numerical Simulation (DNS) - Introduction. Solving simple cases using standard CFD codes.

Total Contact Hours : 45

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Infer the role of uncertainty analysis in measuring instruments.
CO2	Select the appropriate temperature sensors based on specific applications.
CO3	Identify the suitable sensors for pressure and volume measurements.
CO4	Evaluate thermos physical properties of media.
CO5	Appraise the advantages of data acquisition systems.

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Textbooks:	
1.	Holman J.P., Experimental methods for engineers, McGraw-Hill, 2012.
2.	Barnery, Intelligent Instrumentation, Prentice Hall of India, 2010.
3.	Bolton.W, Industrial Control & Instrumentation, Universities Press, Second Edition, 2001.

Reference books/other materials/web resources:	
1.	John G Webster, The measurement, Instrumentation and sensors Handbook, CRC and IEE Press, 2014.
2.	Morris A.S, Principles of Measurements and Instrumentation Prentice Hall of India, 2004.
3.	Nakra, B.C., Choudhry K.K., Instrumentation, Measurements and Analysis Tata McGraw Hill,New Delhi, 2nd Edition 2003.

	CO-PO Mapping						CO-PSO Mapping		
PO & PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	1	1		1			3	3	1
CO2	2		2	1	2	1	3	3	1
CO3	2		2	1	2	1	3	2	2
CO4	2		2	2	2	1	3	3	1
CO5	2		1	1	2		2	2	3
Average:	1.8	1	1.4	1.2	1.6	0.6	2.8	2.6	1.6

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Textbooks:	
1.	Holman J.P., Experimental methods for engineers, McGraw-Hill, 2012.
2.	Barnery, Intelligent Instrumentation, Prentice Hall of India, 2010.
3.	Bolton.W, Industrial Control & Instrumentation, Universities Press, Second Edition, 2001.

Reference books/other materials/web resources:	
1.	John G Webster, The measurement, Instrumentation and sensors Handbook, CRC and IEE Press, 2014.
2.	Morris A.S, Principles of Measurements and Instrumentation Prentice Hall of India, 2004.
3.	Nakra, B.C., Choudhry K.K., Instrumentation, Measurements and Analysis Tata McGraw Hill,New Delhi, 2nd Edition 2003.

	CO-PO Mapping						CO-PSO Mapping		
PO & PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	1	1		1			3	3	1
CO2	2		2	1	2	1	3	3	2
CO3	2		2	1	2	1	3	3	2
CO4	2		2	2	2	1	3	3	3
CO5	2		1	1	2		2	3	3
Average:	1.8	1	1.4	1.2	1.6	0.6	2.8	3	2.2

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Subject Code	Subject Name	Category	L	T	P	C
TE24202	FUELS, COMBUSTION AND EMISSION CONTROL	PCC	4	0	0	4

Course Objectives:

- To understand the types of fuels.
- To compare the fuels in specific point
- To understand the principles of combustion and combustion equipment's.
- To understand the thermodynamic process behind the combustion.
- To Identify the level of emission standards

UNIT – I	**SOLID FUELS**	**9**

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

UNIT – II	**LIQUID AND GASEOUS FUELS**	**9**

Liquid Fuel Types - Sources - Petroleum Fractions - Classification - Refining - Properties of Liquid Fuels - Calorific Value, Specific Gravity, Flash & Fire Point, Octane Number, Cetane Number etc., - Alcohols - Tar Sand Oil - Liquefaction of Solid Fuels. Gaseous Fuel Classification - Composition & Properties - Estimation of Calorific Value – Gas Calorimeter. Rich & Lean Gas - Wobbe Index - Natural Gas - Dry & Wet Natural Gas - Stripped NG - Foul & Sweet NG - LPG - LNG - CNG - Methane - Producer Gas - Gasifier - Water Gas – Town Gas - Coal Gasification - Gasification Efficiency - Non - Thermal Route - Biogas - Digesters - Reactions - Viability - Economics.

UNIT – III	**COMBUSTION: STOICHIOMETRY & KINETICS**	**9**

Stoichiometry – Mass Basis & Volume Basis – Excess Air Calculation – Fuel & Flue Gas Compositions - Calculations – Rapid Methods – Combustion Processes – Stationary Flame – Surface or Flameless Combustion – Submerged Combustion – Pulsating & Slow Combustion Explosive Combustion. Mechanism of Combustion – Ignition & Ignition Energy – Spontaneous Combustion – Flame Propagation – Solid, Liquid & Gaseous Fuels Combustion – Flame Temperature – Theoretical, Adiabatic & Actual – Ignition Limits – Limits of Inflammability. Thermo Chemistry - Equilibrium combustion products. Low temperature combustion products – High temperature combustion products.

UNIT – IV	**COMBUSTION EQUIPMENTS**	**9**

Coal Burning Equipments – Types – Pulverized Coal Firing – Fluidized Bed Firing – Fixed Bed & Recycled Bed – Cyclone Firing – Spreader Stokers – Vibrating Grate Stokers – Sprinkler Stokers, Traveling Grate Stokers. Oil Burners – Vaporizing Burners, Atomizing Burners – Design of Burners. Gas Burners – Atmospheric Gas Burners – Air Aspiration Gas Burners – Burners Classification according to Flame Structures – Factors Affecting Burners & Combustion.

UNIT – V	**EMISSION CONTROL METHODS**	**9**

Emissions - Emission index - Corrected concentrations - Control of emissions for premixed and non-prefixed combustion. Flue gas Desulphurization, Coal Beneficiation, Coal Blending, Efficiency Improvement Methods (CO_2 reduction)– Super critical boilers, Integrated Gasification Combined Cycle Power Plant, Carbon Capture & Storage (CCS)

Total Contact Hours : 45

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Course Outcomes:	Upon completion of the course students should be able to:
CO1	Identify to enable the fuels used for different purposes.
CO2	Examine the fuels at different conditions.
CO3	Summarize the fuels and its combustion levels.
CO4	Select the correct Equipments on combustion techniques.
CO5	Illustrate the emission control at a standard rate.

Textbooks:	
1.	B.I. Bhatt and S.M. Vora, Stoichiometry, 2nd Edition, Tata Mcgraw Hill, 2010.
2.	Blokh A.G., Heat Transfer in Steam Boiler Furnace, Hemisphere Publishing Corpn, 1988.
3.	Civil Davies, Calculations in Furnace Technology, Pergamon Press, Oxford, 1966.

Reference books/other materials/web resources:	
1.	Holman J.P., Thermodynamics, Fourth Edition, McGraw-Hill Inc., 1988.
2.	Samir Sarkar, Fuels & Combustion, 2nd Edition, Orient Longman, 1990.
3.	Sharma SP., Mohan Chander, Fuels & Combustion, Tata Mcgraw Hill, 1984.

	CO-PO Mapping						CO-PSO Mapping		
PO & PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	1		2	1		3	3	2	1
CO2	1		2	2		1	3	3	2
CO3	1		2	1		1	3	3	2
CO4			2	1		1	2	3	3
CO5				-			2	2	3
Average:	1		1.6	1		1.2	2.6	2.6	2.2

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SUBJECT CODE	SUBJECT NAME	Category	L	T	P	C
TE24211	THERMAL SYSTEMS SIMULATION LABORATORY	PCC	0	0	4	2

COURSE OBJECTIVES:

- To learn the modeling and simulation analysis of various thermal engineering application using analysis software.
- To educate the students about calibration and its essentiality in thermal systems.

LIST OF EXPERIMENTS	60

1. Heat exchanger analysis – NTU method
2. Heat exchanger analysis – LMTD method
3. Convection heat transfer analysis – Velocity boundary layer.
4. Convection heat transfer analysis – Internal flow
5. Radiation heat transfer analysis – Emissivity
6. Critical radius of insulation
7. Lumped heat transfer analysis
8. Conduction heat transfer analysis
9. Condensation heat transfer analysis

TOTAL: 60 PERIODS

LEARNING OUTCOMES:

At the end of the course, learners will be able

CO1: Knowledge in various heat transfer simulation study on different thermal engineering applications by using analysis software.

CO2: Analyze the critical/influential properties of thermal systems

DYNAMIC LINKING OF MAT LAB AND REF PROP SOFTWARE SIMPLE CFD PROBLEMS FOR PRACTICE

NOTE: The above exercises are only guidelines to maintain the standard for teaching and Conduct of examination.

SIMULATION LAB – REQUIREMENT:	
1	Software - Modeling software like ProE, Gambit, Ansys, etc Analysis software like Ansys, fluent, CFX, etc Equation solving software like Matlab, Engg equation solver
2	Every students in a batch must be provided with a terminal
3	Hardware are compatible with the requirement of the above software.

	CO-PO Mapping						CO-PSO Mapping		
PO & PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	1	2	2	3	2	1	3	2	2
CO2	1	2	2	3	2	1	3	3	2
Average:	1	2	2	3	2	1	3	2.5	2

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Subject Code	Subject Name	Category	L	T	P	C
TE24212	TECHNICAL SEMINAR - I	EEC	0	0	2	1

COURSE OBJECTIVES:

- To Enhance the ability of self-study
- To Improve presentation and communication skills
- 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 three 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: 30 PERIODS

LEARNING OUTCOMES:

At the end of the course, learners will be able

CO1: Identify and choose appropriate topic of relevance.

CO2: Assimilate literature on technical articles of specified topic and develop Comprehension.

CO3: Prepare technical report.

CO4 : Design, develop and deliver presentation on specified technical topic

EVALUATION

Technical Seminar I evaluation is based on Regulations of Post graduate programmes of Anna University.

	CO-PO Mapping						CO-PSO Mapping		
PO & PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	1			1	2	1	3	2	2
CO2	1	1		1	1		3	3	2
CO3	1	1		1			2	3	2
CO4	1	2			3	3	2	2	2
Average:	0.8	0.8		0.6	1.2	0.8	2.5	2.5	2

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Subject Code	Subject Name	Category	L	T	P	C
TE24301	DESIGN AND OPTIMIZATION OF THERMAL ENERGY SYSTEMS	PCC	3	0	0	3

Course Objectives:

- To learn basic principles underlying pumping, heat exchangers; modeling and optimization in design of thermal systems.
- To develop representational modes of real processes and systems.
- To optimization concerning design of thermal systems.
- To analyze dynamic behavior and stability of thermal systems using control theory and Laplace transforms.
- To apply simulation and optimization methods in real-world thermal system case studies including uncertainty and trade-off analysis.

UNIT – I	**DESIGN CONCEPTS**	**9**
Design Principles, Workable Systems, Optimal Systems, Matching of System Components, Economic Analysis, Depreciation, Gradient Present Worth factor, modelling overview – levels and steps in model development - Examples of models – curve fitting and regression analysis		
UNIT – II	**MODELLING AND SYSTEMS SIMULATION**	**10**
Modelling of thermal energy systems – heat exchanger - solar collectors – distillation - rectification turbo machinery components - refrigeration systems - information flow diagram - solution of set of nonlinear algebraic equations - successive substitution - Newton Raphson method- examples of thermal systems simulation		
UNIT – III	**OPTIMIZATION**	**10**
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 – examples.		
UNIT – IV	**DYNAMIC BEHAVIOUR**	**8**
Steady state Simulation, Laplace Transformation, Feedback Control Loops, Stability Analysis, Non-Linearities.		
UNIT – V	**APPLICATIONS AND CASE STUDIES**	**8**
Case studies of optimization in thermal systems problems- Dealing with uncertainty-probabilistic techniques – Trade-offs between capital and energy using Pinch analysis		
	Total Contact Hours : 45	

Course Outcomes:	Upon completion of the course students should be able to:
CO1	On successful Completion of this course the student will be understand modeling and optimization of Thermal systems.
CO2	Develop mathematical models and perform simulations for heat exchangers, solar collectors, distillation, and refrigeration systems.
CO3	Formulate and solve constrained and unconstrained optimization problems using classical and modern optimization methods.
CO4	Analyze dynamic behavior and stability of thermal systems through Laplace transforms and feedback control concepts.
CO5	Evaluate case studies to apply optimization and simulation techniques considering uncertainty and trade-offs in thermal systems.

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Textbooks:	
1.	B.K.Hodge, Analysis and Design of Thermal Systems, Prentice Hall Inc., 1990.
2.	Bejan A., George Tsatsaronis , Michael J. Moran , Thermal Design and Optimization, Wiley ,1996.
3.	D.J. Wide, Globally Optimal Design, Wiley- Interscience, 1978.

Reference books/other materials/web resources:	
1.	Kapur J. N., Mathematical Modelling , Wiley Eastern Ltd , New York , 1989.
2.	Rao S. S., Engineering Optimization Theory and Practice, New Age Publishers, 2000.
3.	Stoecker W. F., Design of Thermal Systems, McGraw Hill Edition, 1989.

	CO-PO Mapping						CO-PSO Mapping		
PO & PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	1		2	1		3	3	1	2
CO2	1		2	2		1	3	2	1
CO3	1		2	1		1	2	3	2
CO4			2	1		1	1	3	1
CO5							2	2	3
Average:	1		1.6	1		1.2	2.2	2.2	1.8

HoD/BOS Chairman

Principal

Subject Code	Subject Name	Category	L	T	P	C
TE24311	TECHNICAL SEMINAR - II	EEC	0	0	2	1

COURSE OBJECTIVES:

- To enhance the reading ability required for identification of his/her field of interest.
- To develop skills regarding professional communication and technical report writing.
- To establish the fact that student is not a mere recipient of ideas, but a participant in discovery and inquiry.
- 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 seminar shall be of 30 minutes 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 ofKnowledge and the overall quality.
4. A faculty guide is to be allotted and he / she will guide and monitor the progress ofthe 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 three periods per week, 4 students are expected to present theSeminar.
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 may be in the form of a technical paper which is suitable for publishing in Conferences / Journals as a review paper.

TOTAL: 30 PERIODS

LEARNING OUTCOMES:

At the end of the course, learners will be able

CO1: Develop the capacity to observe intelligently and propose and defend opinions and ideas with tact and conviction.

CO2: Develop skills regarding professional communication and technical report writing.

CO3: Learn the methodology of publishing technical papers.

EVALUATION

Technical Seminar II evaluation is based on Regulations of Post graduate programmes of Anna University.

	CO-PO Mapping						CO-PSO Mapping		
PO & PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	1	1		1	2	1	2	2	2
CO2	1	1		1	1		2	3	2
CO3	1	2		1			2	3	2
Average:	1	0.8		0.6	1.2	0.8	2	2.5	2

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Principal

Subject Code	Subject Name	Category	L	T	P	C
TE24312	PROJECT WORK – I	EEC	0	0	12	6

COURSE OBJECTIVES:

- To improve the skills in reading technical magazines, conference proceedings and Journals.
- To develop the skill of identifying research problems/projects in the field of Thermal Engineering.
- To familiarize with the design and analysis tools required for the project work and plan the experimental platform, if any, required for project work.

GUIDELINES

1. Each student has to identify the topic of project related to the field of Thermal Engineering.
2. The candidate has to be in regular contact with his guide and the topic of dissertation must be mutually decided by the guide and student
3. The topic has to be approved by a review committee constituted by the department.
4. The work has to be presented periodically in front of the review committee.
5. The preparation of report consisting of a detailed problem statement and a literature review.
6. The preliminary results (if available) of the problem may also be discussed in the report.
7. The project report should be presented in standard format as provided by the Anna University.

TOTAL: 90 PERIODS

LEARNING OUTCOMES:

At the end of the course, learners will be able

The students would apply the knowledge gained from theoretical and practical courses in solving problems, so as to give confidence to the students to be creative, well planned, organized, coordinated in their project work phase – II.

EVALUATION

Project Work Phase - I evaluation is based on Regulations of Post graduate programmes of Anna University.

	CO-PO Mapping						CO-PSO Mapping		
PO & PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	1			1	2	3	2	2	2
CO2	1				1	3	2	3	2
CO3	1				2	3	2	3	2
CO4	1				2	3	2	3	2
CO5	1			.3	2		2	3	2
Average:	1			0.8	1.8	2.4	2	2.75	2

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Subject Code	SUBJECT NAME	Category	L	T	P	C
TE24411	PROJECT WORK – II	EEC	0	0	24	12

COURSE OBJECTIVES:

- To improve the skills in publishing technical papers in conference proceedings and journals.
- To produce factual results of their applied research idea in the Thermal engineering, from phase – I.

GUIDELINES

1. Each student has to complete project (phase II) under the guidance of a faculty member, as Specified in Phase I.
2. The candidate has to be in regular contact with his guide and the topic of dissertation must be mutually decided by the guide and student
3. The topic has to be approved by a review committee constituted by the department.
4. The work has to be presented periodically in front of the review committee.
5. The candidate has to prepare a detailed project report consisting of introduction of the problem, problem statement, literature review, objectives of the work, methodology (experimental set up or numerical details as the case may be) of solution and results and discussion.
6. The report must bring out the conclusions of the work and future scope for the study.
7. The project report should be presented in standard format as provided by the Anna University.

TOTAL: 180 PERIODS

LEARNING OUTCOMES:

At the end of the course, learners will be able

The students' would apply the knowledge gained from theoretical and practical courses in solving problems, so as to give confidence to the students to be creative, well planned, organized, coordinated project outcome of the aimed work.

EVALUATION

Project Work Phase - II evaluation is based on Regulations of Post graduate programmes of Anna University.

	CO-PO Mapping						CO-PSO Mapping		
PO & PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	1	1		1	2	3	2	2	2
CO2	1	1			1	3	2	3	2
CO3	1	2			2	3	2	3	2
CO4	1				2	3			
CO5	1			3	2				
Average:	1	0.8		0.8	1.8	2.4	2	2.5	2

HoD/BOS Chairman

Principal

Subject Code	Subject Name	Category	L	T	P	C
TE24001	AIRCRAFT AND JET PROPULSION	PEC	3	0	0	3

Course Objectives:

- To gain insight on the working principle of rocket engines, different feed systems, propellants and their properties and dynamics of rockets.
- To study the thermodynamics and working principles of various aircraft propulsion systems.
- To analyze performance characteristics and design aspects of aircraft engines including inlets and nozzles.
- To learn the fundamentals of rocket propulsion, rocket equations, and multi-stage rocket systems.
- To understand combustion processes, propellant systems, and heat transfer in rocket thrust chambers.

UNIT – I	**GAS DYNAMICS**	**9**
Wave motion - Compressible fluid flow through variable area devices – Stagnation state Mach Number and its influence and properties, Isentropic Flow, Rayleigh and Fanno Flow. Deflagration and Detonation – Normal shock and oblique shock waves.		
UNIT – II	**THERMODYNAMICS OF AIRCRAFT ENGINES**	**10**
Theory of Aircraft propulsion – Thrust – Various efficiencies – Different propulsion systems –Turboprop – Ram Jet – Turbojet, Turbojet with after burner, Turbo fan and Turbo shaft Variable thrust- nozzles – vector control.		
UNIT – III	**PERFORMANCE CHARACTERISTICS OF AIRCRAFT ENGINES**	**10**
Engine - Aircraft matching – Design of inlets and nozzles – Performance characteristics of Ramjet, Turbojet, Scramjet and Turbofan engines.		
UNIT – IV	**ROCKET PROPULSION**	**8**
Theory of rocket propulsion – Rocket equations – Escape and Orbital velocity – Multi-staging of Rockets – Space missions – Performance characteristics – Losses and efficiencies.		
UNIT – V	**ROCKET THRUST CHAMBER**	**8**
Combustion in solid and liquid propellant classification – rockets of propellants and Propellant Injection systems – Non-equilibrium expansion and supersonic combustion – Propellant feed Systems – Reaction Control Systems - Rocket heat transfer.		
		Total Contact Hours : 45

Course Outcomes:	Upon completion of the course students should be able to:
CO1	On successful completion of this course the student will be able to understand the working of different types of Aircraft and Jet propulsion systems and their performance characteristics.
CO2	Describe thermodynamics and operational principles of various aircraft propulsion systems.
CO3	Analyze engine-aircraft matching and evaluate performance characteristics of aircraft engines.
CO4	Calculate rocket propulsion parameters including thrust, escape velocity, and staging efficiencies.
CO5	Understand combustion, propellant feed systems, and thermal aspects in rocket thrust chambers.

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Textbooks:	
1.	Bonney E.A., Zucrow N.J,. Principles of Guided Missile Design, Van Nostranc Co., 1956.
2.	Khajuria P.R. and Dubey S.P., Gas Turbines and Propulsive Systems, Dhanpat Rai Publications, 2003.
3.	Mattingly J.D., Elements of Gas turbine Propulsion, McGraw Hill, 1st Edition, 1997.

Reference books/other materials/web resources:	
1.	Philip G. Hill and Carl R. Peterson, Mechanics and Thermodynamics of Propulsion, Second Edition, Addition – Wesley Publishing Company, New York, 2009.
2.	S.M.Yahya, Fundamentals of Compressible Flow, Third edition, New Age International Pvt Ltd, 2003.
3.	Zucrow N.J., Principles of Jet Propulsion and Gas Turbines, John Wiley and Sons, New York, 1970.

	CO-PO Mapping						CO-PSO Mapping		
PO & PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	1		2	1		3	3	2	1
CO2	1		2	2		1	2	3	1
CO3	1		2	1		1	2	3	2
CO4			2	1		1	3	2	1
CO5				-			1	2	3
Average:	1		1.6	1		1.2	2.2	2.4	1.6

HoD/BOS Chairman

Principal

Subject Code	Subject Name	Category	L	T	P	C
TE24002	HYDROGEN AND FUEL CELL TECHNOLOGIES	PEC	3	0	0	3

Course Objectives:

- To study in detail on the hydrogen production methodologies, possible applications and various storage options.
- To understand the working principle of a typical fuel cell, its types and to elaborate on its Thermodynamics and kinetics.
- To study the cost effectiveness and eco-friendliness of Fuel Cells.
- To learn about different types of fuel cells and their comparative advantages and disadvantages.
- To analyze the applications, economic viability, and environmental impact of fuel cells and hydrogen energy systems.

UNIT – I	**HYDROGEN – BASICS AND PRODUCTION TECHNIQUES**	**9**
Hydrogen – physical and chemical properties, salient characteristics. Production of hydrogen – steam reforming – water electrolysis – gasification and woody biomass conversion – logical hydrogen production – photo dissociation – direct thermal or catalytic splitting of water.		
UNIT – II	**HYDROGEN STORAGE AND APPLICATIONS**	**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**
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**
Types of fuel cells – AFC, PAFC, SOFC, MCFC, DMFC, PEMFC – relative merits and demerits.		
UNIT – V	**APPLICATION OF FUEL CELL AND ECONOMICS**	**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 Contact Hours : 45	

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Know the working of various fuel cells, their relative advantages / disadvantages and hydrogen generation/storage technologies.
CO2	Evaluate hydrogen storage technologies and safety management for various applications.
CO3	Understand the principles and performance characteristics of fuel cells.
CO4	Differentiate between types of fuel cells and assess their suitability for different applications.
CO5	Assess the economic and environmental aspects of fuel cells and hydrogen usage, and predict future trends.

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Textbooks:	
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.

Reference books/other materials/web resources:	
1.	Kordesch K. and G.Simader, Fuel Cell and Their Applications, Wiley-Vch, Germany 1996.
2.	Hart A.B. and G.J.Womack, Fuel Cells: Theory and Application, Prentice Hall, New York Ltd., London 1989.
3.	Jeremy Rifkin, The Hydrogen Economy, Penguin Group, USA 2002.

	CO-PO Mapping						CO-PSO Mapping		
PO & PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3		3	1	1	2	3	1	1
CO2	3		3	1	1	2	3	2	1
CO3	2		2	2		1	2	3	1
CO4	2		2	1		2	1	3	1
CO5	2		2	1	3	2	1	2	3
Average:	2.4		2.4	1.2	1	1.8	2	2.2	1.4

HoD/BOS Chairman

Principal

Subject Code	Subject Name	Category	L	T	P	C
TE24003	ENERGY RESOURCES	PEC	3	0	0	3

Course Objectives:

- To explain concept of various forms of Non-renewable and renewable energy.
- To outline division aspects and utilization of renewable energy sources for both domestics and industrial applications.
- To study the environmental and cost economics of using renewable energy sources compared to fossil fuels.
- To explore biomass resources, conversion technologies, and bio energy applications with emphasis on Indian energy programs.
- To gain knowledge on ocean, geothermal, and emerging energy sources including hydrogen and fuel cells.

UNIT – I	**COMMERCIAL ENERGY**	**9**

Coal, Oil, Natural gas, Nuclear power and Hydro - their utilization pattern in the past, present and future projections of consumption pattern - Sector-wise energy consumption –environmental impact of fossil fuels – Energy scenario in India – Growth of energy sector and its planning in India.

UNIT – II	**SOLAR ENERGY**	**9**

Solar radiation at the earth's surface – solar radiation measurements – estimation of average solar radiation - solar thermal flat plate collectors - concentrating collectors – solar thermal applications - heating, cooling, desalination, drying, cooking, etc – solar thermal electric power plant - principle of photovoltaic conversion of solar energy, types of solar cells – Photovoltaic applications: battery charger, domestic lighting, street lighting, water pumping etc - solar PV power plant – Net metering concept.

UNIT – III	**WIND ENERGY**	**9**

Nature of the wind – power in the wind – factors influencing wind – wind data and energyestimation - wind speed monitoring - wind resource assessment - Betz limit - site selection - wind energy conversion devices - classification, characteristics, applications – offshore wind energy - Hybrid systems - safety and environmental aspects – wind energy potential and installation in India - Repowering concept.

UNIT – IV	**BIO-ENERGY**	**9**

Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - direct combustion – biomass gasification - pyrolysis and liquefaction – biochemical conversion - anaerobic digestion - types of biogas Plant - applications - alcohol production from biomass – bio diesel production – Urban waste to energy conversion - Biomass energy programme in India.

UNIT – V	**OTHER TYPES OF ENERGY**	**9**

Ocean energy resources - principle of ocean thermal energy conversion (OTEC) - ocean thermal power plant - ocean wave energy conversion - tidal energy conversion – small hydro - geothermal energy - geothermal power plant – hydrogen production and storage - Fuel cell – principle of working - various types - construction and applications.

Total Contact Hours : 45

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Understand the commercial energy and renewable energy sources.
CO2	Know the working principle of various energy systems.
CO3	Evaluate wind energy potential, design wind energy conversion systems, and understand offshore and hybrid configurations.
CO4	Identify biomass types, conversion methods, and applications of bioenergy including biofuels and waste-to-energy.
CO5	Describe ocean, geothermal, hydrogen energy, and fuel cell technologies and their applications.

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Textbooks:	
1.	Sukhatme S.P., "Solar Energy", Tata McGraw Hill, 1984.
2.	Twidell J.W. and Weir A., "Renewable Energy Sources", EFN Spon Ltd., 1986.
3.	Kishore V.V.N., "Renewable Energy Engineering and Technology", Teri Press, New Delhi, 2012.

Reference books/other materials/web resources:	
1.	Peter Gevorkian, "Sustainable Energy Systems Engineering," McGraw Hill,2007.
2.	reith F. and Kreider J.F., "Principles of Solar Engineering", McGraw-Hill, 1978.
3.	Godfrey Boyle, "Renewable Energy Power for a Sustainable Future", Oxford University Press,U.K, 1996.

	CO-PO Mapping						CO-PSO Mapping		
PO & PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	1		2	1		3	1	3	3
CO2	1		2	2		1	3	2	1
CO3	1		2	1		1	3	2	1
CO4			2	1		1	3	2	1
CO5				-			2	2	2
Average:	1		1.6	1		1.2	2.4	2.2	1.6

HoD/BOS Chairman

Principal

Subject Code	Subject Name	Category	L	T	P	C
TE24004	ADVANCED INTERNAL COMBUSTION ENGINES	PEC	3	0	0	3

Course Objectives:

- To gain insight on the working principle of spark ignition engines and compression ignition engines.
- To study the pollutant formation and its control in IC engines.
- To study the recent technologies adopted in IC engine applications.
- To analyze the properties and applicability of alternative fuels in IC engines.
- To explore advanced IC engine technologies including lean burn, HCCI, stratified charge engines, and diagnostic tools.

UNIT – I	**SPARK IGNITION ENGINES**	**9**
Spark ignition Engine mixture requirements – Fuel – Injection systems – Monopoint, Multipoint injection, Direct injection – Stages of combustion – Normal and abnormal combustion – factors affecting knock – Combustion chambers.		
UNIT – II	**COMPRESSION IGNITION ENGINES**	**9**
States of combustion in C.I. Engine – Direct and indirect injection systems – Combustion chambers – Fuel spray behavior – spray structure, spray penetration and evaporation – air motion – Introduction to Turbo charging.		
UNIT – III	**POLLUTANT FORMATION AND CONTROL**	**9**
Pollutant – Sources – Formation of carbon monoxide, Unburnt hydrocarbon, NOx, Smoke and Particulate matter – Methods of controlling Emissions – Catalytic converters and Particulate Traps – Methods of measurements and Introduction to emission norms and Driving cycles.		
UNIT – IV	**ALTERNATIVE FUELS**	**9**
Alcohol, Hydrogen, Natural Gas and Liquefied Petroleum Gas- Properties, Suitability, Merits and Demerits as fuels, Engine Modifications.		
UNIT – V	**ROCKET THRUST CHAMBER**	**9**
Lean Burn Engines – Stratified charge Engines – homogeneous charge compression ignition engines – Plasma Ignition – Measurement techniques – laser Doppler, Anemometry. Use of nano technology in IC Engines.		
		Total Contact Hours : 45

Course Outcomes:	Upon completion of the course students should be able to:
CO1	On successful completion of this course the student will be able to understand the working principle of IC engines, source of pollution formation and its control and recent trends in IC engines.
CO2	Explain combustion characteristics, fuel spray behavior, and turbocharging in CI engines.
CO3	Identify and control various pollutants formed in IC engines and interpret emission standards.
CO4	Evaluate alternative fuels and suggest appropriate engine modifications.
CO5	Apply knowledge of advanced combustion techniques and measurement tools used in IC engine research.

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Textbooks:	
1.	Duffy Smith, Auto fuel Systems, The Good Heart Willox Company, Inc., 1989.
2.	Heywood, J.B., Internal Combustion Engine Fundamentals, McGraw-Hill, 1988.
3.	K.K. Ramalingam, Internal Combustion Engine fundamentals, Scitech Publications, 2002.

Reference books/other materials/web resources:	
1.	Kirpal Singh, Automobile Engineering Vol - I, Standard Publishers, Delhi 2013.
2.	R.B. Mathur and R.P.Sharma, Internal Combustion Engines, Dhanapat Rai Publications,1993.
3.	V. Ganesan, Internal Combustion Engines, II Edition, Tata McGraw-Hill Education, 2002.

	CO-PO Mapping						CO-PSO Mapping		
PO & PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	1		2	1		3	3	2	1
CO2	1		2	2		1	3	2	2
CO3	1		2	1		1	2	3	2
CO4			2	1		1	2	3	1
CO5				-			1	2	3
Average:	1		1.6	1		1.2	2.2	2.4	1.8

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Principal

Subject Code	Subject Name	Category	L	T	P	C
TE24005	CRYOGENIC ENGINEERING	PEC	3	0	0	3

Course Objectives:

- To give introductory knowledge of cryogenic Engineering.
- To impart knowledge in liquefaction, separation of cryogenics gases and working of cryocoolers.
- To embark on a research career in Cryogenic Engineering.
- To understand the working of cryogenic refrigeration systems.
- To equip students with knowledge on safe handling and instrumentation for cryogens.

UNIT – I	**INTRODUCTION**	**9**
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**	**9**
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**
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**	**9**
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**	**9**
Cryogenic Dewar, Cryogenic Transfer Lines. Insulations used in Cryogenic Systems, Instrumentation to measure Flow, Level and Temperature.		
	Total Contact Hours : 45	

Course Outcomes:	Upon completion of the course students should be able to:
CO1	On successful completion of this course the student will be able to understand Concepts of cryogenic, cryogenic refrigeration and handling of the cryogens.
CO2	Analyze different cryogenic liquefaction cycles and their performance.
CO3	Describe gas separation techniques using cryogenic rectification and adsorption.
CO4	Understand and compare various types of cryogenic refrigeration systems.
CO5	Apply safety protocols and measurement techniques for handling cryogens.

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Textbooks:	
1.	Klaus D. Timmerhaus and Thomas M. Flynn, Cryogenic Process Engineering, Plenum Press, New York, 1989.
2.	Randall F. Barron, Cryogenic Systems, McGraw-Hill, 1985.
3.	Scott R.B., Cryogenic Engineering, Van Nostrand and Co., 1962.

Reference books/other materials/web resources:	
1.	Herald Weinstock, Cryogenic Technology, Boston Technical Publishers, inc., 1969.
2.	Robert W. Vance, Cryogenic Technology, John wiley & Sons, Inc., New York, London.
3.	G.Venkatarathnam, Cryogenic Mixed Refrigerant Processes, Springer Publication, 2010.

	CO-PO Mapping						CO-PSO Mapping		
PO & PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	1		2	1		3	2	2	2
CO2	1		2	2		1	3	3	2
CO3	1		2	1		1	2	3	2
CO4			2	1		1	3	3	2
CO5				-			2	2	3
Average:	1		1.6	1		1.2	2.8	2.6	2.2

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Subject Code	Subject Name	Category	L	T	P	C
TE24006	REFRIGERATION SYSTEMS	PEC	3	0	0	3

Course Objectives:

To study the cycle analysis pertaining to Refrigeration systems.

- To study the performance of system components and their balancing in cycles.
- To study the significance of Refrigerants and their impact on the environment.
- To learn about the various components used in refrigeration systems and their operational characteristics.
- To apply system balancing and performance analysis techniques to refrigeration systems.
- To explore electrical drives, control systems, and noise management in refrigeration applications.

UNIT – I	**INTRODUCTION AND REFRIGERANTS**	**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 – ANALYSIS**	**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 Thermo Electric Refrigeration, Air Refrigeration cycles, Heat pumps.		
UNIT – III	**REFRIGERATION SYSTEM COMPONENTS**	**9**
Compressor- Types, performance, Characteristics, Types of Evaporators & Condensers and their functional aspects, Expansion Devices and their Behaviour 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**
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**
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 Contact Hours : 45

Course Outcomes:	Upon completion of the course students should be able to:
CO1	The student will be able to understand different refrigeration systems and do the design of the same for a particular applications.
CO2	Analyze various refrigeration cycles including vapor compression and absorption systems.
CO3	Evaluate the performance and function of key refrigeration components.
CO4	Conduct system simulation and balancing through graphical and mathematical methods
CO5	Apply knowledge of electrical drives, controls, and acoustic considerations in refrigeration systems.

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Textbooks:	
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.

Reference books/other materials/web resources:	
1.	Kuehn T.H., Ramsey J.W. and Threlkeld J.L., Thermal Environmental Engineering, 3rd Edition, Prentice Hall, 1998.
2.	Langley Billy C., 'Solid state electronic controls for HVACR, Prentice-Hall 1986.
3.	Rex Milter, Mark R.Miller., Air conditioning and Refrigeration, McGraw Hill, 2006.

	CO-PO Mapping						CO-PSO Mapping		
PO & PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	1		2	1		3	2	2	3
CO2	1		2	2		1	3	3	2
CO3	1		2	1		1	3	3	2
CO4			2	1		1	2	3	2
CO5				-			2	2	3
Average:	0.6		1.6	1		1.2	2.4	2.6	2.4

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Principal

Subject Code	Subject Name	Category	L	T	P	C
IC24001	ELECTRONIC ENGINE MANAGEMENT SYSTEMS	PEC	3	0	0	3

Course Objectives:

- To provide basic grounding on electronics
- To learn the various sensors used in engine management systems
- Give an overview of different types of ignition systems
- To understand the significance of gasoline injection systems
- To know the latest advancements in Diesel injection systems

UNIT – I	**FUNDAMENTALS OF AUTOMOTIVE ELECTRONICS**	**9**
Components for Electronic Engine Management System- Open and Closed Loop Control Strategies- PID Control- Look Up Tables- Introduction to Modern Control Strategies Like Fuzzy Logic and Adaptive Control. Switches- Active Resistors- Transistors- Current Mirrors/Amplifiers- Voltage and Current References- Comparator- Multiplier. Amplifier- Filters- A/D and D/A Converter.		
UNIT – II	**SENSORS AND ACTUATORS**	**9**
Inductive- Hall Effect- Thermistor- Piezo Electric- Piezoresistive- Based Sensors. Throttle Position- Mass Air Flow- Crank Shaft Position- Cam Position- Engine Speed Sensor- Exhaust Oxygen Level (Two Step- Linear Lambda and Wideband)- Knock- Manifold Temperature and Pressure Sensors. Solenoid- Relay (Four and Five Pin)- Stepper Motor		
UNIT – III	**SI ENGINE MANAGEMENT**	**9**
Layout and Working of SI Engine Management Systems. Group and Sequential Injection Techniques. MPFI- GDI- Advantages of Electronic Ignition Systems. Types of Solid State Ignition Systems and Their Principle of Operation- Contactless (BREAKERLESS) Electronic Ignition System- Electronic Spark Timing Control		
UNIT – IV	**CI ENGINE MANAGEMENT**	**9**
Fuel Injection System Parameters Affecting Combustion- Noise and Emissions in CI Engines. Electronically Controlled Unit Injection System. Common Rail Fuel Injection System. Working of Components Like Fuel Injector- Fuel Pump- Rail Pressure Limiter- Flow Limiter- EGR Valve.		
UNIT – V	**DIGITAL ENGINE CONTROL SYSTEM**	**9**
Cold Start and Warm Up Phases- Idle Speed Control- Acceleration and Full Load Enrichment- Deceleration Fuel Cut-off. Fuel Control Maps- Open Loop and Closed Loop Control – Integrated Engine Control System- Electromagnetic Compatibility – EMI Suppression Techniques – Electronic Dash Board Instruments – Onboard Diagnosis System.		
		Total Contact Hours : 45

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Understand the basic electronic components and controls used in Sensors
CO2	Explain the different types of sensors used in an automobile engine
CO3	Describe the ignition and injection methods used in an SI engine
CO4	Describe the fuel injection systems in a diesel engine and the emission control systems
CO5	Explain the electronic systems used in the fuel control system and the dash board unit.

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Textbooks:	
1.	Understanding Automotive Electronics William B Ribbens, SAE 1998
2.	Automobile Electronics by Eric Chowanietz SAE

Reference books/other materials/web resources:	
1.	Diesel Engine Management by Robert Bosch, SAE Publications, 3rd Edition, 2004
2.	Gasoline Engine Management by Robert Bosch, SAE Publications, 2nd Edition, 2004

	CO-PO Mapping						CO-PSO Mapping		
PO & PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	2		2	3		2	3	2	2
CO2	3		2	3		3	2	3	2
CO3	3		2	3		3	3	2	2
CO4	3		2	3		3	3	3	2
CO5	3			3		2	2	2	3
Average:	2.8		1.6	3		2.6	2.6	2.4	2.2

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Principal

Subject Code	Subject Name	Category	L	T	P	C
TE24007	COGENERATION AND WASTE HEAT RECOVERY SYSTEMS	PEC	3	0	0	3

Course Objectives:

- To analyze the basic energy generation cycles.
- To detail about the concept of cogeneration, its types and probable areas of applications.
- To study the significance of waste heat recovery systems and carry out its economic analysis.
- To explore different waste heat recovery systems and design considerations.
- To perform economic analysis for optimized selection, design, and implementation of cogeneration and waste heat recovery systems.

UNIT – I	**INTRODUCTION**	**9**
Introduction – principles of thermodynamics – cycles – topping – bottoming – combined cycle – Organic rankine cycles – performance indices of cogeneration systems – waste heat recovery – sources and types – concept of tri and quad generation.		
UNIT – II	**COGENERATION TECHNOLOGIES**	**9**
Configuration and thermodynamic performance – steam turbine congeneration systems – gas turbine cogeneration systems – reciprocating IC engines cogeneration systems – combined cycles cogeneration systems – advanced cogeneration systems: fuel cell, Stirling engines etc.,		
UNIT – III	**ISSUES AND APPLICATIONS OF COGENERATION TECHNOLOGIES**	**9**
Cogeneration plants electrical interconnection issues – utility and cogeneration plant interconnection issues – applications of cogeneration in utility sector – industrial sector – building sector – rural sector – impacts of cogeneration plants – fuel, electricity and Environment.		
UNIT – IV	**WASTE HEAT RECOVERY SYSTEMS**	**9**
Selection criteria for waste heat recovery technologies – recuperators – Regenerators – economizers – plate heat exchangers – thermic fluid heaters – Waste heat boilers – classification, location, service conditions, design Considerations – fluidized bed heat Exchangers – heat pipe exchangers – heat pumps – sorption systems.		
UNIT – V	**ECONOMIC ANALYSIS**	**9**
Investment cost – economic concepts – measures of economic performance – procedure for economic analysis – examples – procedure for optimized system selection and design – load curves – sensitivity analysis – regulatory and financial frame work for cogeneration and waste heat recovery systems.		
		Total Contact Hours : 45

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Course Outcomes:	Upon completion of the course students should be able to:
CO1	On completing of the syllabus students can able understand the principles of cogeneration systems, waste heat recovery systems, applications of cogeneration and economic analysis of waste heat recovery systems.
CO2	Analyze various cogeneration technologies and their configurations.
CO3	Evaluate the sector-specific applications and interconnection issues of cogeneration plants.
CO4	Select appropriate waste heat recovery devices based on criteria and design considerations.
CO5	Perform economic and sensitivity analysis to aid in the selection and optimization of cogeneration and recovery systems.

Textbooks:	
1.	Charles H. Butler, Cogeneration, McGraw Hill Book Co., 1984.
2.	De Nevers, Noel, Air Pollution Control Engineering, McGraw Hill, New York,1995.
3.	EDUCOGEN – The European Educational tool for cogeneration, Second Edition, 2001.

Reference books/other materials/web resources:	
1.	Energy Cogeneration Hand book, George Polimveros, Industrial Press Inc, Newyark 1982.
2.	Horlock JH., Cogeneration - Heat and Power, Thermodynamics and Economics, Oxford,1987.
3.	Institute of Fuel, London, Waste Heat Recovery, Chapman & Hall Publishers, London, 1963.

	CO-PO Mapping						CO-PSO Mapping		
PO & PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	2		2	3		2	3	2	2
CO2	3		2	3		3	3	3	2
CO3	3		2	3		3	2	3	3
CO4	3		2	3		3	2	3	2
CO5	3			3		2	2	2	3
Average:	2.8		1.6	3		2.6	2.4	2.6	2.4

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Subject Code	Subject Name	Category	L	T	P	C
TE24008	DESIGN OF TURBO MACHINES	PEC	3	0	0	3

Course Objectives:

- To elucidate the energy transfer process, Fans laws in Turbo machines.
- To illustrate the selection and working of Centrifugal Blowers.
- To classify different types of axial fans and rotor design.
- To outline the working different compressors and its performance characteristics.
- To select different fans / blowers / compressors for specific applications.

UNIT – I	**INTRODUCTION**	**9**
Energy transfer between fluid and rotor velocity triangles for a generalized turbo machines – velocity triangle. Euler's equation for turbo machines and its different forms. Degree of reaction in turbo machines various efficiencies – isentropic, mechanical, thermal, overall And polytrophic – fan laws – Dimensionless parameters – Specific speed – Cordier Diagram.		
UNIT – II	**CENTRIFUGAL BLOWERS**	**9**
Centrifugal Blowers: Theoretical characteristic curves, velocity triangles, losses and hydraulic efficiency, flow through impeller casing, inlet, nozzle, volute, diffusers. Leakage losses, mechanical losses, multi-vane impellers, cross flow fans. Selection of Centrifugal blower for duct flow.		
UNIT – III	**AXIAL FLOW FANS**	**9**
Rotor design using airfoil theory, vortex theory, cascade effects, degree of reaction, blade twist, stage design, surge and stall, stator and casing, mixed flow impellers. Selection of axial fans / blower for duct flow.		
UNIT – IV	**COMPRESSORS**	**9**
Reciprocating compressors, Construction Type – open, hermetic and semi sealed effect of cylinder cooling, heating and friction. Dynamic compressor - centrifugal compressor, velocity triangles, performance characteristics, part load operation, Capacity control. Selection of compressor for different applications.		
UNIT – V	**DESIGN AND APPLICATIONS**	**9**
Special design and applications of blowers / compressors for air conditioning plants, cooling towers, ventilation systems, booster systems - turbocharger.		
		Total Contact Hours : 45

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Analyze the fundamentals of Turbo machinery and solve the problems on Energy Transfer.
CO2	Categorize the Centrifugal Blowers and Fans for various applications.
CO3	Summarize the different types of axial fan design and performance.
CO4	Analyze various compressors based on its performance.
CO5	Select fans / blowers /compressors for the given applications.

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Textbooks:	
1.	Austin H. Church, Centrifugal pumps and blowers, John Wiley and Sons, 2017
2.	Dixon, Fluid Mechanics, Thermodynamics of turbo machinery Pergamon Press, 1984.
3.	Fans & Ventilation A practical guide (Bill) cory WTW, Elsevier, 2005.

Reference books/other materials/web resources:	
1.	Jay Matley., Fluid Movers: Pumps, Compressors, Fans and Blowers, McGraw-Hill Publications, 1990.
2.	Royce N. Brown, Compressors: Selection and Sizing, Elsevier, 2005.
3.	Tony Giampaolo, Compressor Hand Book Principles and Practice, The Fairmont Press, 2010.

	CO-PO Mapping						CO-PSO Mapping		
PO & PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	1	1	1			1	3	2	2
CO2	1						3	3	2
CO3		2	1				3	3	2
CO4	1	1	1				3	2	3
CO5		1				2	2	3	3
Average:	0.6	1	0.6			0.6	2.8	2.6	2.4

HoD/BOS Chairman

Principal

Subject Code	Subject Name	Category	L	T	P	C
TE24009	ELECTRONICS COOLING AND PACKAGING	PEC	3	0	0	3

Course Objectives:

- To provide a basic knowledge of the technologies and processes required for the packaging.
- To expose the students to all aspects of electronic equipment and components including electrical, thermal, fluid dynamics and reliability issues
- To illustrate Radiation on the surface through electronic components
- To analyze the effect of electronics equipment at different modes
- To provide a vision for cooling systems and its packaging devices

UNIT – I	**INTRODUCTION**	**9**

Electronic Equipment, Components of Electronic Systems, Thermal management in electronic devices - Packaging Trends. Electronic packaging and interconnection technology. Conduction in Electronic Equipment: Thermal Conductivity, Thermal Resistances, Conductivity in Solids, Conductivity in Fluids, Conduction—Steady State, Conduction in Simple Geometries, Conduction through a Plane Wall, Conduction through Cylinders and Spheres.

UNIT – II	**ELECTRONICS ASSISTED IN THERMAL COMPONENTS**	**9**

Conduction—Transient, Lumped Capacitance Method, Conduction in Extended Surfaces. Fin Efficiency, Fin Optimization, Fin Surface Efficiency, Thermal Contact Resistance in Electronic Equipment, Discrete Heat Sources and Thermal Spreading. Fluid Dynamics for Electronic Equipment-Boundary Layer Theory, Turbulent Flow, Loss Coefficients and Dynamic Drag, Fans and Pumps, Electronic Chassis Flow.

UNIT – III	**IMPACT OF RADIATION ON SURFACE**	**9**

Radiation Heat Transfer in Electronic Equipment, The Electromagnetic Spectrum, Radiation Equations, Stefan-Boltzmann Law, Surface Characteristics, Emittance, Emittance Factor Emittance from Extended Surface, Absorptance, Reflectance, Specular Reflectance, Heat Transfer with Phase Change. Combined Modes of Heat Transfer for Electronic Equipment, Radiation and Convection in Parallel.

UNIT – IV	**ANALYSIS OF ELECTRONIC EQUIPMENT**	**9**

Introduction to Thermal Design of Electronic Equipment. Analysis of Thermal Failure of Electronic Components. Analysis of Thermal Stresses and Strain, Effect of PCB Bending Stiffness on Wire Stresses, Vibration Fatigue in Lead Wires and Solder Joints. Electronics Cooling Methods in Industry. Heat Sinks, Heat Pipes, Heat Pipes in Electronics Cooling, Thermoelectric Cooling, Immersion Cooling, Cooling Techniques for High Density Electronics.

UNIT – V	**COOLING SYSTEMS FOR ELECTRONIC PACKAGES**	**9**

Cooling systems for electronics packages – heat sinks, heat spreaders, heat pipes, micro channels, actuators, fans, cold plates; Thermo-mechanical issues in electronic packages Effects of Vibration – vibrating systems, vibration of axially loaded components, circuit boards, Theorem of Castigliano; Reliability Metrology and Analysis, Environmental Stress Screening.

Total Contact Hours : 45

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Identify the basic knowledge about the packaging of electronics
CO2	Utilize the ability of electronic cooling system.
CO3	Analyse the radiation through multi electronic devices
CO4	Evaluate the performance calculation of Electronics Equipment.
CO5	Applying cooling systems for different thermal sourcing agents

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Textbooks:	
1.	Rao R. Tummala : Fundamentals of Microsystem Packaging, McGraw Hill, 2001.
2.	Richard K. Ulrich &William D. Brown Advanced Electronic Packaging - 2nd Edition : IEEE Press,2006.
3.	Yunus A. Cengel : Heat Transfer – A Practical Approach, McGraw Hill, 2003. 4. The Electronic Packaging Handbook- Glenn R. Blackwell, 1st Edition, 2000

Reference books/other materials/web resources:	
1.	Kraus, A.D., & Bar-Cohen, A. "Thermal Analysis and Control of Electronic Equipment" McGraw-Hill, 1983.
2.	Yeh, R. T., & Chu, R. C."Thermal Management of Electronic Systems" ASME Press, 2002.
3.	Lasance, C. J. M., & Poppe, A."Thermal Management for LED Applications" Springer, 2014.

	CO-PO Mapping						CO-PSO Mapping		
PO & PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	1	3		2	2		3	2	1
CO2	1	3		3	2		3	3	2
CO3	1	1		2	2		3	3	2
CO4	2	2		1	2		2	2	3
CO5	1	1		3	1		2	3	3
Average:	1.2	2		2.2	1.8		2.6	2.6	2.2

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Principal

Subject Code	Subject Name	Category	L	T	P	C
TE24010	AIR CONDITIONING SYSTEMS	PEC	3	0	0	3

Course Objectives:

- To learn the psychometric concepts underlying Air conditioning process.
- To learn the design features and load estimation principles of specific Air conditioning system.
- To learn about the critical auxiliary systems
- To learn about the air distribution circuits, water distribution circuits etc.
- To learn about the HVAC systems in air conditioning systems

UNIT – I	**PSYCHROMETRY AND AIR CONDITIONING PROCESSES**	**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**
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**
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**
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**
Automotive System layout and Components- Commonly used Refrigerants- Safety devices – Climate control – Fuel efficiency aspects.		
	Total Contact Hours : 45	

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Analyse psychometrically the Air conditioning processes.
CO2	Estimate the heat load for summer and winter Air conditioning applications.
CO3	Understand and appreciate the utility of different Air conditioning systems for different applications.
CO4	Design a fan-duct system for Air conditioning application.
CO5	Understand and appreciate the individual components of an automobile Air conditioning system. Various HVAC system components for various applications in the building requirements.

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Textbooks:	
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.

Reference books/other materials/web resources:	
1.	Carrier Air Conditioning Co., Handbook of Air Conditioning Systems design, McGraw Hill, 1985.
2.	Jones, Air Conditioning Engineering, Edward Amold pub. 2001.
3.	Kuehn T.H., Ramsey, J.W. and Threlkeld, J.L., Thermal Environmental Engineering 3rd Edition, Prentice Hall, 1998

	CO-PO Mapping						CO-PSO Mapping		
PO & PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	1	1		1	1		3	2	1
CO2	2	2		1	2		3	3	2
CO3	1	2		1	2		2	3	2
CO4	1	1		1	1		2	2	3
CO5	1	2		1	2		2	1	3
Average:	1.2	1.6		1	1.6		2.4	2.2	2.2

HoD/BOS Chairman

Principal

Subject Code	Subject Name	Category	L	T	P	C
IC24002	ALTERNATE FUELS FOR IC ENGINES	PEC	3	0	0	3

Course Objectives:

- To expose potential alternate fuels and their characteristics
- To use appropriate synthetic fuels and fuel additives for better combustion characteristics
- To utilize alcohol fuels effectively for lower emissions
- To elaborate on the utilization of Bio-Diesel and its types as a suitable fuel in CI engines
- To utilize different gaseous fuels and predict their performance and combustion characteristics

UNIT – I	**INTRODUCTION**	**9**
Availability, Suitability, Properties, Merits and Demerits of Potential Alternative Fuels – Alcohols, Biodiesel, Hydrogen, Liquefied Petroleum Gas, Natural Gas, Biogas, Fuel standards – ASTM & EN.		
UNIT – II	**SPECIAL AND SYNTHETIC FUELS**	**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**
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**
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**
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 Contact Hours : 45	

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Expose potential alternate fuels and their characteristics
CO2	Use appropriate synthetic fuels and fuel additives for better combustion characteristics
CO3	Utilize alcohol fuels effectively for lower emissions
CO4	Elaborate on the utilization of Bio-Diesel and its types as a suitable fuel in CI engines
CO5	Utilize different gaseous fuels and predict their performance and combustion characteristics.

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Textbooks:	
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

Reference books/other materials/web resources:	
1.	Richard L. Bechtold, Automotive Fuels Guide Book, SAE Publications, 1997

	CO-PO Mapping						CO-PSO Mapping		
PO & PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	1	-	2		1		3	2	2
CO2	2	2	2		2		2	3	2
CO3	2	2	2		1		2	3	3
CO4	2	3	3		2	2	3	3	2
CO5	2	3	2		2	2	3	2	3
Average:	1.8	2.5	2.2		1.6	0.8	2.6	2.6	2.4

HoD/BOS Chairman

Principal

Subject Code	Subject Name	Category	L	T	P	C
TE24011	DESIGN OF HEAT EXCHANGERS	PEC	3	0	0	3

Course Objectives:

- To make students familiarize with the various types of heat exchangers
- To explain the importance of thermal and stress analysis of heat exchangers
- To inculcate the thermal design aspects of tubular heat exchangers
- To provide the details of design aspects of compact heat exchangers
- To explain the function and design aspects of condensers and cooling towers

UNIT – I	**FUNDAMENTALS OF HEAT EXCHANGER**	**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	**STRESS ANALYSIS**	**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**
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**
Types–merits and demerits–design of compact heat exchangers, plate heat exchangers performance influencing parameters– limitations.		
UNIT – V	**CONDENSERS AND COOLING TOWERS**	**9**
Design of surface and evaporative condensers–cooling tower –performance characteristics		
	Total Contact Hours : 45	

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Classify heat exchangers and illustrate the applications of various types of heat exchangers
CO2	Interpret the significance of stress analysis of heat exchangers
CO3	Analyse the design of tubular heat exchangers for various applications
CO4	Appraise the design of compact heat exchangers for industrial requirements
CO5	Evaluate the performance calculation of condensers and cooling towers

Textbooks:

1. SadikKakac, Hongtan Liu, Anchasa Pramuanjaroenkij, "Heat Exchangers Selection, Rating and Thermal Design", CRC Press,Third Edition,2012.
2. Ramesh K.Shah, Dušan P.Sekulic, "Fundamentals of heat exchanger design", John Wiley & Sons, 2003.
3. Robert W. Serth, "Process heat transfer principles and applications", Academic press, Elesevier, 2010.

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Reference books/other materials/web resources:	
1.	T. Kuppan, "Heat exchanger design hand book",New York: Marcel Dekker,2009.
2.	Arthur.P Frass, "Heat Exchanger Design", John Wiley & Sons,1989.

	CO-PO Mapping						CO-PSO Mapping		
PO & PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3		1	3	1		3	2	2
CO2	3		1	3	1		2	3	2
CO3	3		3	2	1		3	3	2
CO4	3		2	2	1		3	2	3
CO5	3		3	1	1		2	3	3
Average:	3		2	2.2	1		2.6	2.6	2.4

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Subject Code	Subject Name	Category	L	T	P	C
TE24012	BATTERY THERMAL MANAGEMENT SYSTEM	PEC	3	0	0	3

Course Objectives:

- The objective of this course is to introduce learner to batteries, its parameters, modelling and charging requirements.
- The course will help learner to develop battery management algorithms for batteries
- To analyse the battery state of charge and its functions
- To evaluate models using the range of simulation.
- To examine the design standards of a battery.

UNIT – I	**INTRODUCTION**	**9**
Introduction and BMS functionality, Battery pack topology, BMS Functionality, Voltage Sensing, Temperature Sensing, Current Sensing, BMS Functionality, High-voltage contactor control, Isolation sensing, Thermal control, Protection, Communication Interface, Range estimation, State-of- charge estimation, Cell total energy and cell total power.		
UNIT – II	**BATTERY MANAGEMENT SYSTEM REQUIREMENT**	**9**
Introduction and BMS functionality, Battery pack topology, BMS Functionality, Voltage Sensing, Temperature Sensing, Current Sensing, BMS Functionality, High-voltage contactor control, Isolation sensing, Thermal control, Protection, Communication Interface, Range estimation, State-of- charge estimation, Cell total energy and cell total power.		
UNIT – III	**BATTERY STATE OF CHARGE AND STATE OF HEALTH ESTIMATION, CELL BALANCING**	**9**
Battery state of charge estimation (SOC), voltage-based methods to estimate SOC, Model-based state estimation, Battery Health Estimation, Lithium-ion aging: Negative electrode, Lithium-ion aging: Positive electrode, Cell Balancing, Causes of imbalance, Circuits for Balancing.		
UNIT – IV	**MODELLING AND SIMULATION**	**9**
Equivalent-circuit models (ECMs), Physics-based models (PBMs), Empirical modelling approach, Physics-based modelling approach, simulating an electric vehicle, Vehicle range calculations, simulating constant power and voltage, Simulating battery packs.		
UNIT – V	**DESIGN OF BATTERY BMS:**	**9**
Design principles of battery BMS, Effect of distance, load, and force on battery life and BMS, energy balancing with multi-battery system		
		Total Contact Hours : 45

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Interpret the role of battery management system
CO2	Identify the requirements of Battery Management System
CO3	Interpret the concept associated with battery charging / discharging process
CO4	Calculate the various parameters of battery and battery pack
CO5	Design the model of battery pack

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Textbooks:	
1.	Plett, Gregory L. Battery management systems, Volume I: Battery modeling. Artech House, 2015.
2.	Plett, Gregory L. Battery management systems, Volume II: Equivalent-circuit methods, Artech House, 2015.
3.	Bergveld, H.J., Kruijt, W.S., Notten, P.H.L "Battery Management Systems -Design by Modelling" Philips Research Book Series 2002.

Reference books/other materials/web resources:	
1.	Davide Andrea," Battery Management Systems for Large Lithium-ion Battery Packs" Artech House, 2010
2.	Pop, Valer, et al. Battery management systems: Accurate state-of-charge indication for Battery powered applications. Vol. 9. Springer Science & Business Media, 2008.

	CO-PO Mapping						CO-PSO Mapping		
PO & PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	1	1	2		3		3	2	2
CO2					2		3	3	2
CO3	2	3	1				3	3	2
CO4	1						2	3	3
CO5	1	1			1		3	2	3
Average:	1	1	0.6		1.2		2.8	2.6	2.4

HoD/BOS Chairman

Principal

Subject Code	Subject Name	Category	L	T	P	C
EY24001	ADVANCED ENERGY STORAGE TECHNOLOGIES	PEC	3	0	0	3

Course Objectives:

- To understand the various types of energy storage technologies and its applications
- To study the various modelling techniques of energy storage systems using TRNSYS
- To learn working concepts and types of batteries
- To make the students to get understand the concepts of Hydrogen and Biogas storage
- To provide the insights on super capacitor, Fly wheel and compressed energy storage system

UNIT – I	**INTRODUCTION**	**9**
Necessity of energy storage–types of energy storage–comparison of energy storage technologies– Applications		
UNIT – II	**THERMAL STORAGE SYSTEM**	**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**
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 di oxide and modern batteries for example(i)zinc-Air(ii)Nickel Hydride,(iii)Lithium Battery		
UNIT – IV	**HYDROGEN AND BIOGAS STORAGE**	**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**
Flywheel, Super capacitors, Principles & Methods–Applications, Compressed air Energy storage, Concept of Hybrid Storage – Applications		
	Total Contact Hours : 45	

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Identify the energy storage technologies for suitable applications.
CO2	Analyze the energy storage systems using TRNSYS.
CO3	Summarise the concepts and types of batteries.
CO4	Examine the principle of operation of Hydrogen and Biogas storage systems
CO5	Explain the working of super capacitor, Flywheel and compressed energy storage systems

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Principal

Text book:	
1.	Ibrahim Dincer and Mark A. Rosen, Thermal Energy Storage Systems and Applications, John Wiley & Sons 2010.
2.	Viswanathan, Fuel cell principle and applications university press,2006.

Reference books/other materials/web resources:	
1.	Luisa F.Cabeza, Advances in Thermal Energy Storage Sy stems: Methods and Applications, Elsevier Wood head Publishing, 2015
2.	Robert Huggins, Energy Storage: Fundamentals, Materials andApplications,2nd edition, Springer,2015.
3.	Ru-shiliu, Leizhang, Xueliang sun, Electrochemical technologies for energy storage and conversion,,Wileypublications,2012
4.	National Energy Technology Laboratory, U.S. Department of Energy, Fuel Cell Handbook (Seventh Edition).

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	2	-	1	2			3	2	2
CO2	2	-	1	3			3	3	2
CO3	2	-	1	2			3	3	3
CO4	2	-	1	2			2	3	2
CO5	2	-	1	2			3	2	3
Average:	2	-	1.4	2.2			2.8	2.6	2.4

HoD/BOS Chairman

Principal

Subject Code	Subject Name	Category	L	T	P	C
IC24003	HYBRID AND ELECTRIC VEHICLES	PEC	3	0	0	3

Course Objectives:

- To introduce the concept of hybrid and electric drive trains
- To elaborate on the types and utilisation of hybrid and electric drive trains
- To expose on different types of AC and DC drives for electric vehicles
- To understand and utilise different types of energy storage systems
- To introduce concept of energy management strategies and drive sizing

UNIT – I	**INTRODUCTION**	**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**
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**
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**
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**
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 Contact Hours : 45	

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Characterise and configure hybrid drive trains requirement for a vehicle
CO2	Design and apply appropriate hybrid and electric drive trains in a vehicle
CO3	Design and install suitable AC and DC drives for electric vehicles
CO4	Arrive at a suitable energy storage system for a hybrid / electric vehicle
CO5	Apply energy management strategies to ensure better economy and efficiency

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Principal

Text book:	
1.	Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
2.	James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003

Reference books/other materials/web resources:	
1.	MehrdadEhsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
2.	Rand D.A.J, Woods, R & Dell RM Batteries for Electric vehicles, John Wiley & Sons, 1998

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	-	2	3	-	2	-	3	2	2
CO2	3	2	3	-	2	2	3	3	2
CO3	3	2	3	-	2	2	3	3	3
CO4	2	2	3	-	2	3	2	3	3
CO5	2	2	3	-	2	3	3	3	2
Average:	2.5	2	3	-	2	2.5	2.8	2.8	2.4

HoD/BOS Chairman

Principal

Subject Code	Subject Name	Category	L	T	P	C
TE24013	ADVANCED POWER PLANT ENGINEERING	PEC	3	0	0	3

Course Objectives:

- Understand the thermodynamics associated with power plants
- Detail on the role of various utilities in coal based thermal power plants
- Acquire know-how on the working of gas turbine and diesel power plants
- Appreciate the concept of Poly generation for total energy recovery from a system
- Brief on the working of hydroelectric and nuclear power plants

UNIT – I	**INTRODUCTION**	**9**
Energy scenario: India Vs. World – Load curves and–thermodynamic analysis of Conventional Power Plants (Coal, Gas Turbine and Diesel)-Advanced Power Cycles-Kalina Cycle, IGCC.		
UNIT – II	**COAL BASED THERMAL POWER PLANTS**	**9**
Basics of typical power plant utilities – Boilers, Nozzles, Turbines, Condensers, Cooling Towers, Water Treatment and Piping system – steam rate and heat rate – mean temperature of heat addition-Rankine cycle improvements–Superheat, Reheat, Regeneration, Supercritical, AFBC/PFBC – computation of per unit cost of power generation from coal/biomass		
UNIT – III	**GAS TURBINE AND DIESEL POWER PLANTS**	**9**
Brayton cycle – Open and Closed – Improvements – Intercooler, Reheating and Regeneration. Diesel power plant – Layout – Performance analysis and improvement – Techniques for starting, cooling and lubrication of diesel engines-computation of per unit cost of power generation		
UNIT – IV	**CHP AND MHD POWER PLANTS**	**9**
Cogeneration systems–types-heat to power ratio-Thermodynamic performance of steam turbine gas turbine and IC engine-based cogeneration systems–Poly Generation-Binary CycleCombined cycle. MHD –Open cycle and closed cycle-Hybrid MHD & steam power plants		
UNIT – V	**HYDRO ELECTRIC & NUCLEAR POWER PLANTS**	**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-Computation of per Unit cost of power generation		
		Total Contact Hours : 45

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Evaluate appropriate power generation technologies for mitigating the energy gap
CO2	Appraise the steam rate, heat rate and cost for generating electricity from coal based thermal power plants
CO3	Analyse and suggest measures for improving the performance of gas turbine and diesel power plants
CO4	Assess the applicability and performance of a cogeneration system
CO5	Decide a suitable type of hydroelectric/nuclear power plant commensurate with the prevailing conditions

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Principal

Text Book:	
1.	Nag, P.K., Power Plant Engineering, Tata McGraw Hill Publishing Co Ltd, New Delhi,1998.
2.	Haywood, R.W., Analysis of Engineering Cycles,4th Edition, Pergamon Press,Oxford,1991.
3.	Wood, A.J., Wollen berg, B.F., Power Generation, operation and control, John Wiley, New York,1984

Reference books/other materials/web resources:	
1.	Gill, A.B., Power Plant Performance, Butter worths,1984.
2	Lamarsh, J.R., Introduction to Nuclear Engg. 2nd edition, Addison-Wesley, 1983.

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	2	-	2	-	-	-	3	2	2
CO2	2	-	2	2	-	1	3	3	3
CO3	2	-	2	2	-	1	3	3	2
CO4	2	-	2	2	-	1	2	3	3
CO5	2	-	2	1	2	-	3	2	2
Average:	2	-	2	1.4	0.4	0.6	2.8	2.6	2.4

HoD/BOS Chairman

Principal

Subject Code	Subject Name	Category	L	T	P	C
IC24004	BOUNDARY LAYER THEORY AND TURBULENCE	PEC	3	0	0	3

Course Objectives:

- To introduce the fundamental concepts of boundary layer in real flows
- To distinguish between turbulent and laminar boundary layers.
- To model turbulent flows using various approaches.
- To analyse various flow parameters using statistical principles.
- To introduce the types, characteristics of wall shear flows from free shear flows.

UNIT – I	**FUNDAMENTALS OF BOUNDARY LAYER THEORY**	**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**
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**
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**
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**
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 Contact Hours : 45	

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Analyse flow with the principles of boundary layer theory
CO2	Distinguish turbulent boundary layer for various types of flows
CO3	Select and use various turbulence models for the appropriate applications
CO4	Apply the statistical theory for averaging various flow parameters
CO5	Differentiate the characteristics of wall shear and free shear flows

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Principal

Text book:	
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.

Reference books/other materials/web resources:	
1.	S. M. Yahya, Fundamentals of Compressible Flow. Third edition, New Age International Pvt Ltd, 2003.
2.	George P. Sutton, Oscar Biblarz. Rocket Propulsion Elements, John Wiley & Sons, 8th Edition, 2010
3.	Ramamurthy, Rocket Propulsion, Pan Macmillan (India) Ltd, 2010.
4.	W.P.Gill, H.J.Smith& J.E. Ziurys, "Fundamentals of Internal Combustion Engines asapplied to Reciprocating, Gas turbine & Jet Propulsion Power Plants", Oxford & IBH Publishing Co., 1980.

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	-	-	1	-	2	-	2	2	2
CO2	2	2	2	1	2	-	3	2	2
CO3	2	2	2	2	2	-	3	3	2
CO4	2	2	2	2	2	-	3	3	2
CO5	2	2	2	2	2	-	2	3	2
Average:	1.6	1.6	1.8	1.7	2	-	2.6	2.6	2

HoD/BOS Chairman

Principal

Subject Code	Subject Name	Category	L	T	P	C
TE24014	STEAM GENERATOR TECHNOLOGY	PEC	3	0	0	3

Course Objectives:

- To educate the students on the types of boilers with their constructional and functional significance.
- To understand the working and design of fuel preparation units and boilers.
- To introduce the concept of boiler design, emission aspects
- To Classify the auxiliary Equipments in design
- To enumerate the technological design aspect in steam generator

UNIT – I	**BASICS**	**9**
Steam Cycle for Power Generation – Fuel Stoichiometry - Boiler Classification & Components – Specifications - Boiler Heat Balance – Efficiency Estimation (Direct & Indirect) – Sankey Diagram		
UNIT – II	**FUELS AND BOILER TYPES**	**9**
Solid Fuel: Coal Preparation – Pulverization – Fuel feeding arrangements, Fuel Oil: Design of oil firing system – components – Air regulators, Types of Boilers – Merits & Limitations – Specialty of Fluid Bed Boilers – Basic design principles (Stoker, Travelling Grate etc).		
UNIT – III	**COMPONENTS DESIGN**	**9**
Furnace– Water Wall – Steam Drum – Attemperator – Super heaters – Reheaters – Air Preheaters – Economisers - Steam Turbines: Design Aspects of all these		
UNIT – IV	**AUXILIARY EQUIPMENTS – DESIGN & SIZING**	**9**
Forced Draft & Induced Draft Fans – PA / SA Fans – Water Pumps (Low Pressure & High Pressure) – Cooling Towers – Softener – DM Plant		
UNIT – V	**EMISSION ASPECTS**	**9**
Emission Control – Low NOx Burners– Boiler Blow Down - Control & Disposal: Feed Water Deaeration & Deoxygenation – Reverse Osmosis - Ash Handling Systems Design – Ash Disposal– Chimney Design to meet Pollution std – Cooling Water Treatment & Disposal		
		Total Contact Hours : 45

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Familiarization with Boiler cycles, components and will have specialized knowledge in steam boiler performance evaluation.
CO2	Emission related aspects in terms of CO_2 NOx emission, mitigation etc will make them to realize the impact of Coal / fuel burning in the society
CO3	Familiarization with Boiler cycles, components and in Design.
CO4	Apply the statistical theory for averaging various flow parameters
CO5	Emission related aspects in terms of CO_2 NOx emission, mitigation etc will make them to realize the impact of Coal / fuel burning in the society

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Text Book:	
1.	BlokhA.G.,Heat Transfer in Steam Boiler Furnace, Hemisphere Publishing Corporation, 2017
2.	Carl Schields, Boilers: Type, Characteristics and Functions, McGraw Hill Publishers, 1982.
3.	David Gunn and Robert Horton, Industrial Boilers, Longman Scientific and Technical Publication, 1986.

Reference books/other materials/web resources:	
1.	Ganapathy V., Industrial Boilers and Heat Recovery Steam Generators, Marcel Dekker Ink, 2003. 5. Howard J.R., Fluidized Bed Technology: Principles and Applications, Adam Hilger, New York, 1983
2.	Mosoon Kwauk, Fluidization Idealized and Bubbleless, with Applications, Science Press, 1992
3.	PrabirBasu, Cen Kefa and Louis Jestin, Boilers and Burners: Design and Theory, Springer, 2000

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	1	2	-	-	-	-	2	2	2
CO2	2	-	-	-	-	-	3	2	2
CO3	1	-	-	-	-	-	3	3	2
CO4	-	-	-	1	2	-	3	3	2
CO5	-	-	1	-	2	-	2	2	3
Average:	0.8	0.4	0.2	0.2	0.8	-	2.6	2.4	2.2

HoD/BOS Chairman

Principal

Subject Code	Subject Name	Category	L	T	P	C
EY24002	FLUIDIZED BED SYSTEMS	PEC	3	0	0	3

Course Objectives:

- To understand the behavior of fluidized beds
- To learn about the heat transfer process
- To differentiate the combustion and gasification, and appreciate the relative merits
- To design components of fluidized bed systems
- To understand the industrial applications of fluidized bed systems

UNIT – I	**FLUIDIZED BED BEHAVIOUR**	**9**

Characterization of bed particles–comparison of different methods of gas–solid contacts. Fluidization phenomena – regimes of fluidization – bed pressure drop curve. Two phase and wellmixed theory of fluidization. Particle entrainment and elutriation – unique features of circulating fluidized beds.

UNIT – II	**HEAT TRANSFER**	**9**

Different modes of heat transfer in fluidized bed– bed to wall heat transfer – gas to solid heat transfer – radiant heat transfer – heat transfer to immersed surfaces. Methods for improvement – external heat exchangers– heat transfer and part load operations.

UNIT – III	**COMBUSTION AND GASIFICATION**	**9**

Fluidized bed combustion and gasification–stages of combustion of particles–performance–start –up methods. Pressurized fluidized beds.

UNIT – IV	**DESIGN CONSIDERATIONS**	**9**

Design of distributors–stoichiometric calculations–heat and mass balance–furnace design–design of heating surfaces–gas solid separators.

UNIT – V	**INDUSTRIAL APPLICATIONS**	**9**

Physical operations like transportation, mixing of fine powders, heat exchange, coating, drying and sizing. Cracking and reforming of hydrocarbons, carbonization, combustion and gasification. Sulphur retention and oxides of nitrogen emission Control.

Total Contact Hours : 45

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Illustrate the behavior of fluidized bed particles and explain the theory of fluidization.
CO2	Analyze the heat transfer process in fluidized beds
CO3	Apply concepts of combustion and gasification in fluidized beds
CO4	Interpret the design consideration for components of fluidized bed system.
CO5	Evaluate fluidized bed systems for various industrial applications

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Text Book:	
1.	Howard,J.R.,FluidizedBedTechnology:PrinciplesandApplications,AdamHilger,NewYork,1983
2.	Geldart, D., Gas Fluidization Technology, John Willey and Sons, 1986
3.	Kunii,D and Levespiel,O., Fluidization Engineering, John Wiley and Son Inc, New York,1969

Reference books/other materials/web resources:	
4.	Howard,J.R.(Ed), Fluidized Beds: Combustion and Applications, Applied Science Publishers, New York, 1983
5.	Botteril,J.S.M., Fluid Bed Heat Transfer, Academic Press, London,1975.

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3		2	3			3	2	2
CO2	3		3	3			3	3	2
CO3	3		2	3	2		3	3	3
CO4	3		3	3	2		2	3	3
CO5	3		2	3	2		3	2	3
Average:	3		2.4	3	1.2		2.8	2.6	2.6

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Reference books/other materials/web resources:	
1.	JA Duffie and WA Beckman: Solar Engineering of Thermal Processes, Third Edition, John Wiley & Sons, 2006.
2.	Jan F. Kreider, Peter S. Curtiss, Ari Rabl, Heating and Cooling of buildings: Design for Efficiency, Revised Second Edition, CRC Press, 28-Dec-2009.

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3	2	1	2	-	1	3	2	2
CO2	-	1	1	2	-	1	3	3	3
CO3	-	-	2	3	-	1	3	3	2
CO4	-	-	2	2	-	3	2	3	3
CO5	1	-	2	1	-	3	3	3	2
Average:	0.8	0.6	1.6	2	-	1.8	2.8	2.8	2.4

HoD/BOS Chairman

Principal

Subject Code	Subject Name	Category	L	T	P	C
TE24015	ENERGY EFFICIENT BUILDINGS	PEC	3	0	0	3

Course Objectives:

- To learn the green buildings concepts applicable to alternate design
- To be familiar with basic terminologies related to buildings
- To learn the building (air) conditioning techniques
- To know the methods to evaluate the performance of buildings
- To incorporate Renewable energy systems in buildings

UNIT – I	**INTRODUCTION**	**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**
Energy efficient Landscape design – Microclimate, Shading, Arbors, Windbreaks, Xeriscaping, Building envelope – Thermal comfort, Psychrometry, Comfort indices, Thermal Properties of Building Materials – Thermal Resistance, 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**
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	**THERMAL PERFORMANCE OF BUILDINGS**	**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**
Introduction of renewable sources in buildings, BIPV, Solar water heating, small wind turbines, standalone PV systems, Hybrid system – Economics.		
	Total Contact Hours : 45	

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Will be familiar with climate responsive building design and basic concepts
CO2	Will Know the basic terminologies related to buildings
CO3	Will Know the passive (air) conditioning techniques
CO4	Interpret the design consideration for components of fluidized bed system.

Text book:

1. ASHRAE Handbook -2009 - Fundamentals
2. Baruch Givoni: Climate considerations in building and Urban Design, John Wiley & Sons, 1998
3. Baruch Givoni: Passive Low Energy Cooling of Buildings by, John Wiley & Sons, 15-Jul-1994

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Principal

Subject Code	Subject Name	Category	L	T	P	C
IC24005	ENGINE POLLUTION AND CONTROL	PEC	3	0	0	3

Course Objectives:

- To provide an insight about effect of engine out emissions on human health and environment
- To impart the knowledge on various pollutant species formations in SI and CI engine
- To divulge about various emission measurement techniques in engines and its significance
- To provide a discernment about various emission control methods
- To impart the knowledge about international and national driving cycles and emission standards

UNIT – I	**AIR POLLUTION – ENGINES**	**9**
Atmospheric pollution from automotive, stationary engines and gas turbines, Global warming – Greenhouse effect, Effects of engine pollution on human health and environment.		
UNIT – II	**POLLUTANT FORMATION**	**9**
Formation of Oxides of nitrogen, Carbon monoxide, Hydrocarbon, Aldehydes, Smoke and Particulate matter emissions. Effects of Engine design and operating variables on emission formation, Noise pollution.		
UNIT – III	**EMISSION MEASUREMENT TECHNIQUES**	**9**
CO, CO2 - Non dispersive infrared gas analyzer, NOx - Chemiluminescent analyzer, HC - Flame ionization detector, Smoke – Opacity and filter paper measurements, Particulate Matter – Full flow and Partial flow dilution tunnel, Gas chromatography, Noise measurement.		
UNIT – IV	**EMISSION CONTROL TECHNIQUES**	**9**
Engine design modifications, Fuel modification, Evaporative emission control, EGR, Air injection, Thermal reactors, Water injection, Common rail direct injection and Gasoline direct injection system, After treatment systems - Catalytic converters, Diesel oxidation catalyst, Particulate traps, De-NOx catalysts, SCR systems. Low temperature combustion concepts		
UNIT – V	**DRIVING CYCLES AND EMISSION STANDARDS**	**9**
Transient dynamometer, Test cells, Driving cycles for emission measurement, chassis dynamometer, CVS system, National and International emission standards		
	Total Contact Hours : 45	

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Understand about atmospheric pollution from engines and its impact on human health and environment
CO2	Understand the formation of emissions in both SI and CI engines.
CO3	Understand the various measurement techniques used globally for the measurement of automotive and stationary engine out emissions.
CO4	Learn the various control methods/techniques used in IC engine to control the engine out emissions
CO5	Learn the transient and steady state driving cycles performed on automotive and stationary engines and emission standards that are followed in the national and international level.

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Textbooks:	
1.	Ganesan V., "Internal Combustion Engines", V Edition, Tata McGraw Hill, 2012
2.	John. B. Heywood, "Internal Combustion engine fundamentals" McGraw – Hill, 1988

Reference books/other materials/web resources:	
1.	Crouse William, Automotive Emission Control, Gregg Division /McGraw-Hill,1980
2.	Ernest, S., Starkman, Combustion Generated Air Pollutions, Plenum Press, 1980
3.	George Springer and Donald J Patterson, Engine emissions, Pollutant Formation and Measurement, Plenum press, 2013
4.	Obert, E.F., Internal Combustion Engines and Air Pollution, Intext Educational Publishers, Third Edition, 1973
5.	Pundir B. P., "IC Engines Combustion and Emission" Narosa publishing house, 2010

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	1	1		1	1	3	2	2	2
CO2	1			1	1	2	3	2	2
CO3	1				2		3	3	2
CO4	1			1	2	1	3	3	2
CO5	1			1	2		2	2	3
Average:	1	0.2		0.8	1.6	1.2	2.6	2.4	2.2

HoD/BOS Chairman

Principal

Subject Code	Subject Name	Category	L	T	P	C
TE24016	SOLAR THERMAL TECHNOLOGIES	PEC	3	0	0	3

Course Objectives:

- To clarify impression of various solar thermal energy collectors
- To impart the knowledge on various pollutant species formations in SI and CI engine
- To delineate the other applications and the devices used to collect solar energy
- To learn the various solar applications
- To summarize the basic economics of solar energy collection system.

UNIT – I	**SOLAR COLLECTORS**	**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**
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 SPACE CONDITIONING SYSTEMS**	**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**
Solar Cooking – Distillation - Desalination - Solar Ponds – Solar Passive Architecture – Solar Drying – Solar Chimney.		
UNIT – V	**DRIVING CYCLES AND EMISSION STANDARDS**	**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 Contact Hours : 45

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Explain the technical and physical principles of different solar collectors
CO2	Measure and evaluate different solar energy technologies through knowledge of the physical function of the devices
CO3	Articulate the technical and economic fundamentals of solar thermal energy conversion useful to society and industry
CO4	Describe the spectrum of possible solar thermal technologies to assist industrial processing or power production
CO5	Communicate technological and socio-economic issues around solar energy in a concise and an accessible way to a target group with basic technical skills.

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Text Book:	
1.	Duffie, J.A., and Beckman, W.A. Solar Energy Thermal Process - 4 th 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.

Reference books/other materials/web resources:	
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

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	1	-	1	-	1	1	3	2	2
CO2	1	2	-	-	2	-	2	2	2
CO3	-	-	-	-	1	-	3	3	2
CO4	-	-	-	-	3	-	2	3	2
CO5	-	-	3	-	-	-	3	3	3
Average:	0.4	0.4	0.8	-	1.4	0.2	2.6	2.6	2.2

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ubject Code	Subject Name	Category	L	T	P	C
AX24001	ENGLISH FOR RESEARCH PAPER WRITING	-	2	0	0	0

Course Objectives:

- Teach how to improve writing skills and level of readability
- Tell about what to write in each section
- Summarize the skills needed when writing a Title
- Infer the skills needed when writing the Conclusion
- Ensure the quality of paper at very first-time submission

UNIT – I	**INTRODUCTION TO RESEARCH PAPER WRITING**	**6**
Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness		
UNIT – II	**PRESENTATION SKILLS**	**6**
Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction		
UNIT – III	**TITLE WRITING SKILLS**	**6**
Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check		
UNIT – IV	**RESULT WRITING SKILLS**	**6**
Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions		
UNIT – V	**VERIFICATION SKILLS**	**6**
Useful phrases, checking Plagiarism, how to ensure paper is as good as it could possibly be the first- time submission		
	Total Contact Hours : 30	

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Understand that how to improve your writing skills and level of readability
CO2	Learn about what to write in each section
CO3	Understand the skills needed when writing a Title
CO4	Understand the skills needed when writing the Conclusion
CO5	Ensure the good quality of paper at very first-time submission

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Textbooks:	
1.	Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011
2.	Day R How to Write and Publish a Scientific Paper, Cambridge University Press 2006
3.	Goldbort R Writing for Science, Yale University Press (available on Google Books) 2006

Reference books/other materials/webresources:	
1.	Highman N, Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book 1998.

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3	3	2	3	2	-	2	2	
CO2	3	3	2	3	2	-	2	2	
CO3	3	3	2	3	2	-	2	2	
CO4	3	3	2	3	2	-	2	2	
CO5	3	3	2	3	2	-	2	2	
Average:	3	3	2	3	2	-	2	2	

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Subject Code	Subject Name	Category	L	T	P	C
AX24002	DISASTER MANAGEMENT	-	2	0	0	0

Course Objectives:

- Summarize basics of disaster
- Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response
- Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives
- Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations
- Develop the strengths and weaknesses of disaster management approaches

UNIT – I	**INTRODUCTION**	**6**
Disaster: Definition, Factors and Significance; Difference between Hazard And Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude		
UNIT – II	**REPERCUSSIONS OF DISASTERS AND HAZARDS**	**6**
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 PRONE AREAS IN INDIA**	**6**
Study of Seismic Zones; Areas Prone To Floods and Droughts, Landslides And Avalanches; Areas Prone To Cyclonic and Coastal Hazards with Special Reference To Tsunami; Post-Disaster Diseases and Epidemics		
UNIT – IV	**DISASTER PREPAREDNESS AND MANAGEMENT**	**6**
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 – V	**RISK ASSESSMENT**	**6**
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		
	Total Contact Hours : 30	

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Ability to summarize basics of disaster
CO2	Ability to explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
CO3	Ability to illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives
CO4	Ability to describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
CO5	Ability to develop the strengths and weaknesses of disaster management approaches

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Textbooks:	
1.	Goel S. L., Disaster Administration And Management Text And Case Studies",Deep& Deep Publication Pvt. Ltd., New Delhi,2009.
2.	NishithaRai, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company,2007

Reference books/other materials/web resources:	
1.	Sahni, PardeepEt.Al. ," Disaster Mitigation Experiences And Reflections", Prentice Hall OfIndia, New Delhi, 2001

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3	3	2	3	-	-	2	-	1
CO2	3	3	3	3	-	-	2	-	1
CO3	3	3	3	3	-	-	2	-	1
CO4	3	3	2	3	-	-	3	-	1
CO5	3	3	2	3	-	-	3	-	1
Average:	3	3	2.4	3	-	-	2.4	-	1

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Subject Code	Subject Name	Category	L	T	P	C
AX24003	CONSTITUTION OF INDIA	-	3	0	0	0

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 nation hood in the early years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik Revolutionin1917and its impact on the initial drafting of the Indian Constitution.

UNIT – I	**HISTORY OF MAKING OF THE INDIAN CONSTITUTION**	**6**
History, Drafting Committee, (Composition & Working)		
UNIT – II	**PHILOSOPHY OF THE INDIAN CONSTITUTION**	**6**
Preamble, Salient Features		
UNIT – III	**CONTOURS OF CONSTITUTIONAL RIGHTS AND DUTIES**	**6**
Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.		
UNIT – IV	**ORGANS OF GOVERNANCE**	**6**
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**	**6**
District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO, Municipal Corporation. Pachayati raj: Introduction, PRI: Zila Pachayat. Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy(Different departments), Village level:Role of Elected and Appointed officials, Importance of grass root democracy		
	Total Contact Hours : 30	

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
CO2	Discuss the intellectual origins of the framework of argument that informed the conceptualization
CO3	of social reforms leading to revolution in India
CO4	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.
CO5	Discuss the passage of the Hindu Code Bill of 1956.

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Textbooks:	
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

Reference books/other materials/webresources:	
1.	M.P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis,2014.
2.	D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1						2			
CO2						3			
CO3						3			
CO4						3			
CO5						3			
Average:						2.8			

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Subject Code	Subject Name	Category	L	T	P	C
AX24004	நற்றமிழ்இலக்கியம்	-	2	0	0	0

UNIT – I	சங்க இலக்கியம்	6
1. தமிழின் துவக்கநூல் தொல்கொப்பியம் – எழுத்து, சொல், பொருள் 2.அகநானூறு (82) – இயற்கை இன்னிசை அரங்கம் 3. குறிஞ்சிப் பாட்டின் மலர்க்காட்சி 4. புறநானூறு (95,195) – போரை நிறுத்திய ஔவையார்		
UNIT – II	அறநெறித் தமிழ்	6
1. அறநெறி வகுத்த திருவள்ளுவர் அறம் வலியுறுத்தல், அன்புடைமை ஒப்புரவறிதல் அறிதல், ஈகை, புகழ் 2. பிறஅறநூல்கள் - இலக்கியமருந்து – ஏலாதி, சிறுபஞ்சமூலம், திரிகடுகம், ஆசரகோவை (தூய்மையை வலியுறுத்தும் நூல்)		
UNIT – III	இரட்டைக் காப்பியங்கள்	6
1. கண்ணகியின் புரட்சி – சிலப்பதிகார வழக்குரை காதை 2. சமூகசேவை இலக்கியம் மணிமேகலை – சிறைக்கோட்டம் அறக்கோட்டமக்கிய காதை		
UNIT – IV	அருள்நெறித் தமிழ்	6
1. சிறுபாணாற்றுப்படை – பாரி முல்லைக்குத் தேர் கொடுத்தது, பேகன் மயிலுக்குப் போர்வை கொடுத்தது, அதியமான் ஔவைக்கு நல்லிக்கனி கொடுத்தது, அரசர் பண்புகள் 2. நற்றிணை- அன்னைக்குரிய புன்னை சிறப்பு 3. திருமந்திரம் (617, 618) – இயமம் நியமம் விதிகள் 4. தர்மசாலையை நிறுவிய வள்ளலார் 5. புறநானூறு – சிறுவனே வள்ளலானான் 6. அகநொனூறு (4) – வண்டு நற்றிணை(11) – நண்டு கலித்தொகை (11) – யானை, புறா ஐந்திணை 50 (27) – மான் ஆகியவை பற்றிய செய்திகள்.		

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UNIT – V	நவீன தமிழ் இலக்கியம்	6
1. உரைநடைத் தமிழ், - தமிழின் முதல் புதினம், - தமிழின் முதல் சிறுகதை, - கட்டுரை இலக்கியம், - பயண இலக்கியம், - நாடகம், 2. நாட்டு விடுதலைப் போரட்டமும் தமிழ்இலக்கியமும், 3. சமுதாய விடுதலையும் தமிழ் இலக்கியமும், பெண்விடுதலையும் விளிம்பு நிலையினரின் மேம்பாட்டில் தமிழ் இலக்கியமும், 5. அறிவியல்தமிழ், 6. இணையத்தில் தமிழ், 7. சுற்றுச்சூழல் மேம்பொட்டில் தமிழ் இலக்கியம்.		
		Total Contact Hours : 30

Textbooks:	
1.	தமிழ் இணையக் கல்விக்கழகம் (Tamil Virtual University) - www.tamilvu.org
2.	தமிழ் விக்கிப்பீடியா (Tamil Wikipedia) -https://ta.wikipedia.org
3.	தர்மபுர ஆதீன வெளியீடு
Reference books/other materials/web resources:	
1.	வாழ்வியல் களஞ்சியம் – தமிழ்ப்பல்கலைக் கழகம், தஞ்சாவூர்
2.	தமிழ்கலைக் களஞ்சியம் – தமிழ்வளர்ச்சித் துறை (thamilvalarchithurai.com)
3.	அறிவியல் களஞ்சியம் – தமிழ்ப் பல்கலைக்கழகம், தஞ்சாவூர்.

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Subject Code	Subject Name	Category	L	T	P	C
OCE24001	INTEGRATED WATER RESOURCES MANAGEMENT	OEC	3	0	0	3

Course Objectives:

- To introduce students to the fundamental concepts and principles of Integrated Water Resources Management (IWRM).
- To explore the economic aspects of water resources management, including cost-benefit analysis and resource allocation.
- To examine the role of public-private partnerships in effective water governance and infrastructure development.
- To analyze the interconnections between water and key sectors such as health and food security.
- To familiarize students with legal and regulatory frameworks relevant to water management at national and international levels.

UNIT – I	**CONTEXT FOR IWRM**	**9**
Water as a global issue: key challenges – Definition of IWRM within the broader context of development – Key elements of IWRM - Principles – Paradigm shift in water management - Complexity of the IWRM process – UN World Water Assessment - SDGs.		
UNIT – II	**WATER ECONOMICS**	**9**
Economic view of water issues: economic characteristics of water good and services – Nonmarket monetary valuation methods – Water economic instruments – Private sector involvement in water resources management: PPP objectives, PPP models, PPP processes, PPP experiences through case studies		
UNIT – III	**LEGAL AND REGULATORY SETTINGS**	**9**
Basic notion of law and governance: principles of international and national law in the area of water management - Understanding UN law on non-navigable uses of international water courses – International law for groundwater management – World Water Forums – Global Water Partnerships - Development of IWRM in line with legal and regulatory framework.		
UNIT – IV	**WATER AND HEALTH WITHIN THE IWRM CONTEXT**	**9**
Links between water and health: options to include water management interventions for health – Health protection and promotion in the context of IWRM – Global burden of Diseases - Health impact assessment of water resources development projects – Case studies		
UNIT – V	**AGRICULTURE IN THE CONCEPT OF IWRM**	**9**
Water for food production: 'blue' versus 'green' water debate – Water foot print - Virtual water trade for achieving global water and food security — Irrigation efficiencies, irrigation methods - current water pricing policy– scope to relook pricing.		
		Total Contact Hours : 45

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Describe the context and principles of IWRM; Compare the conventional and integrated ways of water management.
CO2	Select the best economic option among the alternatives; illustrate the pros and cons of PPP through case studies.
CO3	Apply law and governance in the context of IWRM.
CO4	Discuss the linkages between water-health; develop a HIA framework.
CO5	Analyse how the virtual water concept pave way to alternate policy options.

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Textbooks:	
1.	Cech Thomas V., Principles of water resources: history, development, management and policy. John Wiley and Sons Inc., New York. 2003.
2.	Mollinga .P. etal " Integrated Water Resources Management", Water in South Asia Volume I, Sage Publications, 2006.
3.	Technical Advisory Committee, Integrated Water Resources management, Technical Advisory Committee Background Paper No: 4. Global water partnership, Stockholm, Sweden. 2002

Reference books/other materials/webresources:	
1.	Technical Advisory Committee, Dublin principles for water as reflected in comparative assessment of institutional and legal arrangements for Integrated Water Resources Management, Technical Advisory Committee Background paper No: 3. Global water partnership, Stockholm, Sweden. 1999
2.	Technical Advisory Committee, Effective Water Governance". Technical Advisory Committee Background paper No: 7. Global water partnership, Stockholm, Sweden, 2003.

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3	3	2	3			2		1
CO2	3	3	3	3			2		1
CO3	3	3	3	3			2		1
CO4	3	3	2	3			3		1
CO5	3	3	2	3			3		1
Average:	3	3	2.6	3			2.4		1

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Subject Code	Subject Name	Category	L	T	P	C
OCE24002	WATER, SANITATION AND HEALTH	OEC	3	0	0	3

Course Objectives:

- To understand the current challenges and managerial practices in the water and sanitation sectors.
- To explore the linkages between water management and public health outcomes in developing regions.
- To analyze the effectiveness of existing health and sanitation initiatives in addressing waterborne diseases.
- To evaluate the impact of inadequate water and sanitation infrastructure on community health.
- To identify sustainable strategies and policy interventions to improve water, sanitation, and health outcomes in emerging economies.

UNIT – I	**FUNDAMENTALS WASH**	**9**
Meanings and Definition: Safe Water- Health, Nexus: Water- Sanitation - Health and Hygiene – Equity issues-Water security - Food Security. Sanitation And Hygiene (WASH) and Integrated Water Resources Management (IWRM) - Need and Importance of WASH		
UNIT – II	**MANAGERIAL IMPLICATIONS AND IMPACT**	**9**
Third World Scenario – Poor and Multidimensional Deprivation--Health Burden in Developing Scenario -Factors contribute to water, sanitation and hygiene related diseases-Social: Social Stratification and Literacy Demography: Population and Migration- Fertility – MortalityEnvironment: Water Borne-Water Washed and Water Based Diseases - Economic: Wage - Water and Health Budgeting -Psychological: Non-compliance - Disease Relapse - Political: Political Will		
UNIT – III	**CHALLENGES IN MANAGEMENT AND DEVELOPMENT**	**9**
Common Challenges in WASH - Bureaucracy and Users- Water Utilities -Sectoral Allocation:-Infrastructure- Service Delivery: Health services: Macro and Micro- level: Community and Gender Issues- Equity Issues - Paradigm Shift: Democratization of Reforms and Initiatives.		
UNIT – IV	**GOVERNANCE**	**9**
Public health -Community Health Assessment and Improvement Planning (CHA/CHIP)-Infrastructure and Investments on Water, (WASH) - Cost Benefit Analysis – Institutional Intervention-Public Private Partnership - Policy Directives - Social Insurance -Political Will vs Participatory Governance		
UNIT – V	**INITIATIVES**	**9**
Management vs Development -Accelerating Development- Development Indicators -Inclusive Development-Global and Local- Millennium Development Goal (MDG) and Targets - Five Year Plans - Implementation - Capacity Building - Case studies on WASH. T		
		Total Contact Hours : 45

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Capture to fundamental concepts and terms which are to be applied and understood all through the study
CO2	Comprehend the various factors affecting water sanitation and health through the lens of third world scenario
CO3	Critically analyse and articulate the underlying common challenges in water, sanitation and health.
CO4	Acquire knowledge on the attributes of governance and its say on water sanitation and health.

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CO5	Gain an overarching insight in to the aspects of sustainable resource management in the absence of a clear level playing field in the developmental aspects

Textbooks:	
1.	Bonitha R., Beaglehole R.,Kjellstorm, 2006, "Basic Epidemiology", 2nd Edition, World Health Organization.
2.	Van Note Chism, N. and Bickford, D. J. (2002), Improving the environment for learning: An expanded agenda. New Directions for Teaching and Learning, 2002: 91–98. doi: 10.1002/tl.83Improving the Environment for learning: An Expanded Agenda
3.	National Research Council. Global Issues in Water, Sanitation, and Health: Workshop Summary. Washington, DC: The National Academies Press, 2009.

Reference books/other materials/webresources:	
1.	Sen, Amartya 1997. On Economic Inequality. Enlarged edition, with annex by JamesFoster and Amartya Sen, Oxford: Claredon Press, 1997.
2.	Intersectoral Water Allocation Planning and Management, 2000, World Bank Publishers www. Amazon.com

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	3	3	3		3	2	2
CO2	3	3	3	3	3		3	3	3
CO3	2	3	3	3	2		3	3	2
CO4	3	1	2	2	3		3	3	2
CO5	2	3	2	3	2		3	1	2
Average:	2.4	2.4	2.6	2.8	2.6		3	2.4	2.2

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Subject Code	Subject Name	Category	L	T	P	C
OCE24003	PRINCIPLES OF SUSTAINABLE DEVELOPMENT	OEC	3	0	0	3

Course Objectives:

- To introduce the key environmental, social, and economic dimensions of sustainability.
- To examine the evolution of sustainability principles through major global landmark events and summits.
- To analyze the interrelationship between sustainable development goals (SDGs) and global development challenges.
- To promote critical thinking about current unsustainable practices and their long-term impacts.
- To cultivate an action-oriented mindset toward sustainable development through policy, innovation, and behavioral change.

UNIT – I	SUSTAINABILITY AND DEVELOPMENT CHALLEGES	9

Definition of sustainability – environmental, economical and social dimensions of sustainability - sustainable development models – strong and weak sustainability – defining development millennium development goals – mindsets for sustainability: earthly, analytical, precautionary, action and collaborative– syndromes of global change: utilisation syndromes, development syndromes, and sink syndromes – core problems and cross cutting Issues of the 21 century - global, regional and local environmental issues – social insecurity - resource degradation – climate change – desertification.

UNIT – II	PRINCIPLES AND FRAME WORK	9

History and emergence of the concept of sustainable development - our common future - Stockholm to Rio plus 20– Rio Principles of sustainable development – Agenda 21 natural step peoples earth charter – business charter for sustainable development –UN Global Compact - Role of civil society, business and government – United Nations' 2030 Agenda for sustainable development – 17 sustainable development goals and targets, indicators and intervention areas

UNIT – III	SUSTAINABLE DEVELOPMENT AND WELLBEING	9

The Unjust World and inequities - Quality of Life - Poverty, Population and Pollution - Combating Poverty - - Demographic dynamics of sustainability - Strategies to end Rural and Urban Poverty and Hunger – Sustainable Livelihood Framework- Health, Education and Empowerment of Women, Children, Youth, Indigenous People, Non-Governmental Organizations, Local Authorities and Industry for Prevention, Precaution , Preservation and Public participation.

UNIT – IV	SUSTAINABLE SOCIO-ECONOMIC SYSTEMS	9

Sustainable Development Goals and Linkage to Sustainable Consumption and Production – Investing in Natural Capital- Agriculture, Forests, Fisheries - Food security and nutrition and sustainable agriculture- Water and sanitation - Biodiversity conservation and Ecosystem integrity –Ecotourism - Sustainable Cities – Sustainable Habitats- Green Buildings - Sustainable Transportation — Sustainable Mining - Sustainable Energy– Climate Change – Mitigation and Adaptation - Safeguarding Marine Resources - Financial Resources and Mechanisms

UNIT – V	ASSESSING PROGRESS AND WAY FORWARD	9

Nature of sustainable development strategies and current practice- Sustainability in global, regional and national context –Approaches to measuring and analysing sustainability– limitations of GDP- Ecological Footprint- Human Development Index- Human Development Report – National initiatives for Sustainable Development - Hurdles to Sustainability - Science and Technology for sustainable development –Performance indicators of sustainability and

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Assessment mechanism – Inclusive Green Growth and Green Economy – National Sustainable Development Strategy Planning and National Status of Sustainable Development Goals	
	Total Contact Hours : 45

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Explain and evaluate current challenges to sustainability, including modern world social, environmental, and economic structures and crises.
CO2	Identify and critically analyze the social environmental, and economic dimensions of sustainability in terms of UN Sustainable development goals
CO3	Develop a fair understanding of the social, economic and ecological linkage of Human well being, production and consumption
CO4	Evaluate sustainability issues and solutions using a holistic approach that focuses on connections between complex human and natural systems.
CO5	Integrate knowledge from multiple sources and perspectives to understand environmental limits governing human societies and economies and social justice dimensions of sustainability

Textbooks:	
1.	Tom Theis and Jonathan Tomkin, Sustainability: A Comprehensive Foundation, Rice University, Houston, Texas, 2012
2.	A guide to SDG interactions:from science to implementation, International Council for Science, Paris,2017
3.	Karel Mulder, Sustainable Development for Engineers - A Handbook and Resource Guide, Rouledge Taylor and Francis, 2017

Reference books/other materials/webresources:	
1.	The New Global Frontier - Urbanization, Poverty and Environmentin the 21st Century - George Martine,Gordon McGranahan,Mark Montgomery and Rogelio FernándezCastilla, IIED and UNFPA, Earthscan, UK, 2008
2.	Nolberto Munier, Introduction to Sustainability: Road to a Better Future, Springer, 2006
3.	Barry Dalal Clayton and Stephen Bass, Sustainable Development Strategies- a resource book", Earthscan Publications Ltd, London, 2002.

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	3	3	3		3	3	2
CO2	3	3	3	3	3		3	3	3
CO3	2	3	2	3	2		2	3	2
CO4	3	1	2	2	3		1	3	2
CO5	2	3	2	3	2		3	1	2
Average:	2.6	2.4	2.4	2.8	2.6		2.4	2.6	2.2

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Subject Code	Subject Name	Category	L	T	P	C
OCE24004	ENVIRONMENTAL IMPACT ASSESSMENT	OEC	3	0	0	3

Course Objectives:

- To introduce the concept and purpose of Environmental Clearance and its legal and regulatory framework.
- To familiarize students with the step-by-step methodology of conducting an Environmental Impact Assessment (EIA).
- To provide knowledge on various environmental prediction tools and modeling techniques used in EIA.
- To develop understanding of how to formulate and implement an effective Environmental Management Plan (EMP).
- To analyze real-world case studies to understand the practical application and challenges of EIA in various sectors.

UNIT – I	**INTRODUCTION**	**9**
Historical development of Environmental Impact Assessment (EIA). Environmental ClearanceEIA in project cycle. legal and regulatory aspects in India – types and limitations of EIA –EIA process- screening – scoping - terms of reference in EIA- setting – analysis – mitigation. Cross sectoral issues –public hearing in EIA- EIA consultant accreditation.		
UNIT – II	**IMPACT INDENTIFICATION AND PREDICTION**	**9**
Matrices – networks – checklists – cost benefit analysis – analysis of alternatives – expert systems in EIA. prediction tools for EIA – mathematical modeling for impact prediction – assessment of impacts – air – water – soil – noise – biological — cumulative impact assessmen		
UNIT – III	**SOCIO-ECONOMIC IMPACT ASSESSMENT**	**9**
Socio-economic impact assessment - relationship between social impacts and change in community and institutional arrangements. factors and methodologies- individual and family level impacts. communities in transition-rehabilitation		
UNIT – IV	**EIA DOCUMENTATION AND ENVIRONMENTAL MANAGEMENT PLAN**	**9**
Environmental management plan - preparation, implementation and review – mitigation and rehabilitation plans – policy and guidelines for planning and monitoring programmes – post project audit – documentation of EIA findings – ethical and quality aspects of environmental impact assessment		
UNIT – V	**CASE STUDIES**	**9**
Mining, power plants, cement plants, highways, petroleum refining industry, storage & handling of hazardous chemicals, common hazardous waste facilities, CETPs, CMSWMF, building and construction project		
	Total Contact Hours : 45	

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Course Outcomes:	Upon completion of the course students should be able to:
CO1	Understand need for environmental clearance, its legal procedure, need of EIA, its types, stakeholders and their role
CO2	Understand various impact identification methodologies, prediction techniques and model of impacts on various environments
CO3	Understand relationship between social impacts and change in community due to development activities and rehabilitation methods
CO4	Document the EIA findings and prepare environmental management and monitoring plan
CO5	Identify, predict and assess impacts of similar projects based on case studies

Textbooks:	
1.	EIA Notification 2006 including recent amendments, by Ministry of Environment, Forest and Climate Change, Government of India
2.	Sectoral Guidelines under EIA Notification by Ministry of Environment, Forest and Climate Change, Government of Indi
3.	Canter, L.W., Environmental Impact Assessment, McGraw Hill, New York. 1996

Reference books/other materials/webresources:	
1.	Lawrence, D.P., Environmental Impact Assessment – Practical solutions to recurrent problems, Wiley-Interscience, New Jersey. 2003
2.	Lee N. and George C. 2000. Environmental Assessment in Developing and Transitional Countries. Chichester: Willey
3.	World Bank –Source book on EIA ,1999

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1							2		
CO2	3	2	3	2	2	2		2	2
CO3		2	3	2	2	2		2	
CO4			3		3	2		2	2
CO5	3			2					
Average:	1.2	0.8	1.8	1.2	1.4	1.2	0.4	1.2	0.8

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Subject Code	Subject Name	Category	L	T	P	C
OIC24001	BLOCKCHAIN TECHNOLOGIES	OEC	3	0	0	3

Course Objectives:

- To introduce the fundamental concepts and architecture of Blockchain technology.
- To provide an understanding of how Blockchain ensures security, transparency, and immutability.
- To explore various applications of Blockchain across different domains such as finance, healthcare, supply chain, etc.
- To differentiate between public and private Blockchain frameworks and their use cases.
- To develop practical knowledge of smart contracts and their implementation within Blockchain environments.

UNIT – I	**INTRODUCTION OF CRYPTOGRAPHY AND BLOCKCHAIN**	**9**
Introduction to Blockchain, Blockchain Technology Mechanisms & Networks, Blockchain Origins, Objective of Blockchain, Blockchain Challenges, Transactions and Blocks, P2P Systems, Keys as Identity, Digital Signatures, Hashing, and public key cryptosystems, private vs. public Blockcha		
UNIT – II	**BITCOIN AND CRYPTOCURRENCY**	**9**
Introduction to Bitcoin, The Bitcoin Network, The Bitcoin Mining Process, Mining Developments, Bitcoin Wallets, Decentralization and Hard Forks, Ethereum Virtual Machine (EVM), Merkle Tree, Double-Spend Problem, Blockchain and Digital Currency, Transactional Blocks, Impact of Blockchain Technology on Cryptocurrency		
UNIT – III	**INTRODUCTION TO ETHEREUM**	**9**
Introduction to Ethereum, Consensus Mechanisms, Metamask Setup, Ethereum Accounts, , Transactions, Receiving Ethers, Smart Contracts		
UNIT – IV	**INTRODUCTION TO HYPERLEDGER AND SOLIDITY PROGRAMMING**	**9**
Introduction to Hyperledger, Distributed Ledger Technology & its Challenges, Hyperledger & Distributed Ledger Technology, Hyperledger Fabric, Hyperledger Composer. Solidity - Language of Smart Contracts, Installing Solidity & Ethereum Wallet, Basics of Solidity, Layout of a Solidity Source File & Structure of Smart Contracts, General Value Types.		
UNIT – V	**BLOCKCHAIN APPLICATIONS**	**9**
Internet of Things, Medical Record Management System, Domain Name Service and Future of Blockchain, Alt Coins.		
		Total Contact Hours : 45

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Understand and explore the working of Blockchain technology
CO2	Analyze the working of Smart Contracts
CO3	Understand and analyze the working of Hyperledger
CO4	Apply the learning of solidity to build de-centralized apps on Ethereum
CO5	Develop applications on Blockchain

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extbooks:	
1.	Imran Bashir, "Mastering Blockchain: Distributed Ledger Technology, Decentralization, and Smart Contracts Explained", Second Edition, Packt Publishing, 2018
2.	Narayanan, J. Bonneau, E. Felten, A. Miller, S. Goldfeder, "Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction" Princeton University Press, 2016
3.	Antonopoulos, Mastering Bitcoin, O'Reilly Publishing, 2014. .

Reference books/other materials/webresources:	
1.	Antonopoulos and G. Wood, "Mastering Ethereum: Building Smart Contracts and Dapps", O'Reilly Publishing, 2018
2.	D. Drescher, Blockchain Basics. Apress, 2017

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	2	1	3	2	2	3			
CO2	2	1	2	3	2	2			
CO3	2	1	3	1	2	1			
CO4	2	1	2	3	2	2			
CO5									
Average:	1.6	0.8	2	1.8	1.6	1.6			

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Subject Code	Subject Name	Category	L	T	P	C
OIC24002	DEEP LEARNING	OEC	3	0	0	3

Course Objectives:

- Develop and Train Deep Neural Networks.
- Develop a CNN, R-CNN, Fast R-CNN, Faster-R-CNN, Mask-RCNN for detection and recognition
- Build and train RNNs, work with NLP and Word Embeddings
- The internal structure of LSTM and GRU and the differences between them
- The Auto Encoders for Image Processing

UNIT – I	**DEEP LEARNING CONCEPTS**	**9**
Fundamentals about Deep Learning. Perception Learning Algorithms. Probabilistic modelling. Early Neural Networks. How Deep Learning different from Machine Learning. Scalars. Vectors. Matrixes, Higher Dimensional Tensors. Manipulating Tensors. Vector Data. Time Series Data. Image Data. Video Data.		
UNIT – II	**NEURAL NETWORKS**	**9**
About Neural Network. Building Blocks of Neural Network. Optimizers. Activation Functions. Loss Functions. Data Pre-processing for neural networks, Feature Engineering. Overfitting and Underfitting. Hyperparameters.		
UNIT – III	**CONVOLUTIONAL NEURAL NETWORK**	**9**
About CNN. Linear Time Invariant. Image Processing Filtering. Building a convolutional neural network. Input Layers, Convolution Layers. Pooling Layers. Dense Layers. Back propagation Through the Convolutional Layer. Filters and Feature Maps. Back propagation Through the Pooling Layers. Dropout Layers and Regularization. Batch Normalization. Various Activation Functions. Various Optimizers. LeNet, AlexNet, VGG16, ResNet. Transfer Learning with Image Data. Transfer Learning using Inception Oxford VGG Model, Google Inception Model, Microsoft ResNet Model. RCNN, Fast R-CNN, Faster R-CNN, Mask-RCNN, YOLO		
UNIT – IV	**NATURAL LANGUAGE PROCESSING USING RNN**	**9**
About NLP & its Toolkits. Language Modelling. Vector Space Model (VSM). Continuous Bag of Words (CBOW). Skip-Gram Model for Word Embedding. Part of Speech (PoS) Global Co-occurrence Statistics–based Word Vectors. Transfer Learning. Word2Vec. Global Vectors for Word Representation GloVe. Backpropagation Through Time. Bidirectional RNNs (BRNN) . Long Short Term Memory (LSTM). Bi-directional LSTM. Sequence-to-Sequence Models (Seq2Seq). Gated recurrent unit GRU.		
UNIT – V	**DEEP REINFORCEMENT & UNSUPERVISED LEARNING**	**9**
About Deep Reinforcement Learning. Q-Learning. Deep Q-Network (DQN). Policy Gradient Methods. Actor-Critic Algorithm. About Autoencoding. Convolutional Auto Encoding. Variational Auto Encoding. Generative Adversarial Networks. Auto encoders for Feature Extraction. Auto Encoders for Classification. Denoising Auto encoders. Sparse Auto encoders		
		Total Contact Hours : 45

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Course Outcomes:	Upon completion of the course students should be able to:
CO1	Feature Extraction from Image and Video Data
CO2	Implement Image Segmentation and Instance Segmentation in Images
CO3	Implement image recognition and image classification using a pretrained network (Transfer Learning)
CO4	Traffic Information analysis using Twitter Data
CO5	Autoencoder for Classification & Feature Extraction

Textbooks:	
1.	Deep Learning A Practitioner's Approach Josh Patterson and Adam Gibson O'Reilly Media, Inc.2017
2.	Learn Keras for Deep Neural Networks, Jojo Moolayil, Apress,2018
3.	Deep Learning Projects Using Tensor Flow 2, Vinita Silaparasetty, Apress, 2020

Reference books/other materials/webresources:	
1.	Deep Learning with Python, FRANÇOIS CHOLLET, MANNING SHELTER ISLAND,2017
2.	Pro Deep Learning with Tensor Flow, Santanu Pattanayak, Apress,2017

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	2	2	3	3	3		3	2	2
CO2	3	3	3	3	3		3	3	3
CO3	2	3	3	3	2		3	3	2
CO4	3	1	2	2	3		3	3	2
CO5	2	3	2	3	2		3	1	2
Average:	2.4	2.4	2.6	3	2.6		3	2.4	2.2

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Subject Code	Subject Name	Category	L	T	P	C
OBA24001	SUSTAINABLE MANAGEMENT	OEC	3	0	0	3

Course Objectives:

- To introduce students to the fundamental concepts and principles of corporate sustainability.
- To examine the environmental and socio-technical impacts of organizational activities.
- To explore the interconnection between environmental and social performance and business competitiveness.
- To familiarize students with various sustainability approaches, models, and frameworks used in corporate contexts.
- To develop the ability to apply sustainability assessment methods within organizational strategies and decision-making processes.

UNIT – I	**MANAGEMENT OF SUSTAINABILITY**	**9**
Management of sustainability -rationale and political trends: An introduction to sustainability management, International and European policies on sustainable development, theoretical pillars in sustainability management studies.		
UNIT – II	**CORPORATE SUSTAINABILITY AND RESPONSIBILITY**	**9**
Corporate sustainability parameter, corporate sustainability institutional framework, integration of sustainability into strategic planning and regular business practices, fundamentals of stakeholder engagement		
UNIT – III	**SUSTAINABILITY MANAGEMENT: STRATEGIES AND APPROACHES**	**9**
Corporate sustainability management and competitiveness: Sustainability-oriented corporate strategies, markets and competitiveness, Green Management between theory and practice, Sustainable Consumption and Green Marketing strategies, Environmental regulation and strategic postures; Green Management approaches and tools; Green engineering: clean technologies and innovation processes; Sustainable Supply Chain Management and Procurement		
UNIT – IV	**SUSTAINABILITY AND INNOVATION**	**9**
Socio-technical transitions and sustainability, Sustainable entrepreneurship, Sustainable pioneers in green market niches, Smart communities and smart specializations.		
UNIT – V	**SUSTAINABLE MANAGEMENT OF RESOURCES, COMMODITIES AND COMMONS**	**9**
Energy management, Water management, Waste management, Wild Life Conservation, Emerging trends in sustainable management, Case Studies.		
		Total Contact Hours : 45

Course Outcomes:	Upon completion of the course students should be able to:
CO1	An understanding of sustainability management as an approach to aid in evaluating and minimizing environmental impacts while achieving the expected social impact.
CO2	An understanding of corporate sustainability and responsible Business Practices
CO3	Knowledge and skills to understand, to measure and interpret sustainability performances

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CO4	Knowledge of innovative practices in sustainable business and community management
CO5	Deep understanding of sustainable management of resources and commodities

Textbooks:	
1.	Daddi, T., Iraldo, F., Testa, Environmental Certification for Organizations and Products: Management, 2015
2.	Christian N. Madu, Handbook of Sustainability Management 2012
3.	Petra Molthan-Hill, The Business Student's Guide to Sustainable Management: Principles and Practice, 2014

Reference books/other materials/webresources:	
1.	Margaret Robertson, Sustainability Principles and Practice, 2014
2.	Peter Rogers, An Introduction to Sustainable Development, 2006

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	2	1	2	2			
CO2	3	2	2	2	1	2			
CO3	3	3	1	2	2	3			
CO4	3	3	2	1	1	2			
CO5	3	3	2	1	2	2			
Average:	3	2.8	1.8	1.4	1.6	2.2			

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Subject Code	Subject Name	Category	L	T	P	C
OBA24002	MICRO AND SMALL BUSINESS MANAGEMENT	OEC	3	0	0	3

Course Objectives:

- To familiarize students with the fundamental theories and principles of small business management.
- To explore the key components of planning, organizing, financing, and operating a small business.
- To understand the legal and regulatory frameworks affecting small businesses.
- To analyze the impact of legal issues on small business operations and decision-making.
- To encourage entrepreneurial thinking by examining case studies and real-world practices in small business environments.

UNIT – I	**INTRODUCTION TO SMALL BUSINESS**	**9**
Creation, Innovation, entrepreneurship and small business - Defining Small Business –Role of Owner – Manager – government policy towards small business sector –elements of entrepreneurship –evolution of entrepreneurship –Types of Entrepreneurship – social, civic, corporate - Business life cycle - barriers and triggers to new venture creation – process to assist start ups – small business and family business		
UNIT – II	**SCREENING THE BUSINESS OPPORTUNITY AND FORMULATING THE BUSINESS PLAN**	**9**
Concepts of opportunity recognition; Key factors leading to new venture failure; New venture screening process; Applying new venture screening process to the early stage small firm Role planning in small business – importance of strategy formulation – management skills for small business creation and development.		
UNIT – III	**BUILDING THE RIGHT TEAM AND MARKETING STRATEGY**	**9**
Management and Leadership – employee assessments – Tuckman's stages of group development - The entrepreneurial process model - Delegation and team building - Comparison of HR management in small and large firms - Importance of coaching and how to apply a coaching model. Marketing within the small business - success strategies for small business marketing - customer delight and business generating systems, - market research, - assessing market performance- sales management and strategy - the marketing mix and marketing strategy		
UNIT – IV	**FINANCING SMALL BUSINESS**	**9**
Main sources of entrepreneurial capital; Nature of 'bootstrap' financing - Difference between cash and profit - Nature of bank financing and equity financing - Funding-equity gap for small firms. Importance of working capital cycle - Calculation of break-even point - Power of gross profit margin- Pricing for profit - Credit policy issues and relating these to cash flow management and profitability		
UNIT – V	**VALUING SMALL BUSINESS AND CRISIS MANAGEMENT**	**9**
Causes of small business failure - Danger signals of impending trouble - Characteristics of poorly performing firms - Turnaround strategies - Concept of business valuation - Different valuation measurements - Nature of goodwill and how to measure it - Advantages and disadvantages of buying an established small firm - Process of preparing a business for sale		
		Total Contact Hours : 45

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Course Outcomes:	Upon completion of the course students should be able to:
CO1	Familiarise the students with the concept of small business
CO2	In depth knowledge on small business opportunities and challenges
CO3	Ability to devise plans for small business by building the right skills and marketing strategies
CO4	Identify the funding source for small start ups
CO5	Business evaluation for buying and selling of small firms

Textbooks:	
1.	Hankinson,A.(2000). "The key factors in the profile of small firm owner-managers that influence business performance. The South Coast Small Firms Survey, 1997-2000." Industrial and Commercial Training 32(3):94-98.
2.	Parker,R.(2000). "Small is not necessarily beautiful: An evaluation of policy support for small and medium-sized enterprise in Australia." Australian Journal of Political Science 35(2):239-253.

Reference books/other materials/webresources:	
1.	Journal articles on SME's.

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	2	2	1	1	-	-			
CO2	3	3	3	3	2	3			
CO3	3	3	2	2	3	3			
CO4	3	2	2	2	1	1			
CO5	3	2	2	3	2	1			
Average:	2.8	2.4	2	2.2	1.6	1.6			

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Subject Code	Subject Name	Category	L	T	P	C
OBA24003	INTELLECTUAL PROPERTY RIGHTS	OEC	3	0	0	3

Course Objectives:

- To provide foundational knowledge of Intellectual Property Rights (IPR), including types such as patents, trademarks, copyrights, and trade secrets.
- To understand the legal and procedural aspects of acquiring and protecting intellectual property.
- To explore national and international frameworks governing IPR, including treaties, conventions, and organizations like WIPO.
- To examine case studies to understand the strategic use and enforcement of IPR in various industries.
- To introduce the concept of IPR valuation and its role in commercialization, licensing, and competitive advantage.

UNIT – I	**INTRODUCTION**	**9**
Intellectual property rights - Introduction, Basic concepts, Patents, Copyrights, Trademarks, Trade Secrets, Geographic Indicators; Nature of Intellectual Property, Technological Research, Inventions and Innovations, History - the way from WTO to WIPO, TRIPS		
UNIT – II	**PROCESS**	**9**
New Developments in IPR, Procedure for grant of Patents, TM, GIs, Patenting under Patent Cooperation Treaty, Administration of Patent system in India, Patenting in foreign countries		
UNIT – III	**STATUTES**	**9**
International Treaties and conventions on IPRs, The TRIPs Agreement, PCT Agreement, The Patent Act of India, Patent Amendment Act (2005), Design Act, Trademark Act, Geographical Indication Act, Bayh- Dole Act and Issues of Academic Entrepreneurship.		
UNIT – IV	**STRATEGIES IN INTELLECTUAL PROPERTY**	**9**
Strategies for investing in R&D, Patent Information and databases, IPR strength in India, Traditional Knowledge, Case studies		
UNIT – V	**MODELS**	**9**
The technologies Know-how, concept of ownership, Significance of IP in Value Creation, IP Valuation and IP Valuation Models, Application of Real Option Model in Strategic Decision Making, Transfer and Licensing.		
		Total Contact Hours : 45

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Understanding of intellectual property and appreciation of the need to protect it
CO2	Understanding of the statutes related to IPRAwareness about the process of patenting
CO3	Ability to apply strategies to protect intellectual property
CO4	Ability to apply models for making strategic decisions related to IPR
CO5	Awareness about the process of patenting

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Textbooks:	
1.	V. Sople Vinod, Managing Intellectual Property by (Prentice hall of India Pvt.Ltd), 2006.
2.	Intellectual Property rights and copyrights, EssEss Publications.
3.	Primer, R. Anita Rao and Bhanoji Rao, Intellectual Property Rights, Lastain Book company.

Reference books/other materials/webresources:	
1.	Edited by Derek Bosworth and Elizabeth Webster, The Management of Intellectual Property, Edward Elgar Publishing Ltd., 2006.
2.	WIPO Intellectual Property Hand book.

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3	3	2	3	2	3			
CO2	3	3	2	3	1	3			
CO3	3	3	3	3	2	3			
CO4	3	3	3	2	1	3			
CO5	3	3	3	2	2	3			
Average:	3	3	2.6	2.6	1.6	3			

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Subject Code	Subject Name	Category	L	T	P	C
OBA24004	ETHICAL MANAGEMENT	OEC	3	0	0	3

Course Objectives:

- To introduce the fundamental concepts and theories of ethics as they apply to business and management.
- To help students recognize ethical issues and dilemmas in organizational settings and evaluate them from multiple ethical perspectives.
- To develop students' ability to apply ethical principles in real-world managerial decision-making processes.
- To explore the role of corporate social responsibility (CSR) and ethical leadership in sustainable organizational success.
- To encourage critical thinking and reflective skills necessary for making responsible and value-based decisions in complex business environments.

UNIT – I	**ETHICS AND SOCIETY**	**9**
Ethical Management- Definition, Motivation, Advantages-Practical implications of ethical management. Managerial ethics, professional ethics, and social Responsibility-Role of culture and society's expectations- Individual and organizational responsibility to society and the community		
UNIT – II	**ETHICAL DECISION MAKING AND MANAGEMENT IN A CRISIS**	**9**
Managing in an ethical crisis, the nature of a crisis, ethics in crisis management, discuss case studies, analyze real-world scenarios, develop ethical management skills, knowledge, and competencies. Proactive crisis management		
UNIT – III	**STAKEHOLDERS IN ETHICAL MANAGEMENT**	**9**
Stakeholders in ethical management, identifying internal and external stakeholders, nature of stakeholders, ethical management of various kinds of stakeholders: customers (product and service issues), employees (leadership, fairness, justice, diversity) suppliers, collaborators, business, community, the natural environment (the sustainability imperative, green management, Contemporary issues).		
UNIT – IV	**INDIVIDUAL VARIABLES IN ETHICAL MANJAGEMENT**	**9**
Understanding individual variables in ethics, managerial ethics, concepts in ethical psychologyethical awareness, ethical courage, ethical judgment, ethical foundations, ethical emotions/intuitions/intensity. Utilization of these concepts and competencies for ethical decisionmaking and management.		
UNIT – V	**PRACTICAL FIELD-GUIDE, TECHNIQUES AND SKILLS**	**9**
Ethical management in practice, development of techniques and skills, navigating challenges and dilemmas, resolving issues and preventing unethical management proactively. Role modelling and creating a culture of ethical management and human flourishing.		
		Total Contact Hours : 45

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Role modelling and influencing the ethical and cultural context.
CO2	Respond to ethical crises and proactively address potential crises situations.
CO3	: Understand and implement stakeholder management decisions.
CO4	Develop the ability, knowledge, and skills for ethical management
CO5	Develop practical skills to navigate, resolve and thrive in management situations

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Textbooks:	
1.	Brad Agle, Aaron Miller, Bill O' Rourke, The Business Ethics Field Guide: the essential companion to leading your career and your company, 2016.
2.	Steiner & Steiner, Business, Government & Society: A managerial Perspective, 2011

Reference books/other materials/webresources:	
1.	Lawrence & Weber, Business and Society: Stakeholders, Ethics, Public Policy, 2020

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3	3	2	3	2	3			
CO2	-	3	2	3	1	3			
CO3	3	3	3	3	2	3			
CO4	3	3	3	2	1	3			
CO5	3	3	3	2	2	3			
Average:	2.8	3	2.6	2.6	1.6	3			

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Subject Code	Subject Name	Category	L	T	P	C
ET24003	IoT FOR SMART SYSTEMS	OEC	3	0	0	3

Course Objectives:

- To study about Internet of Things technologies and its role in real time applications.
- To introduce the infrastructure required for IoT
- To familiarize the accessories and communication techniques for IoT.
- To provide insight about the embedded processor and sensors required for IoT
- To familiarize the different platforms and Attributes for IoT

UNIT – I	**INTRODUCTION TO INTERNET OF THINGS**	**9**
Overview, Hardware and software requirements for IOT, Sensor and actuators, Technology drivers, Business drivers, Typical IoT applications, Trends and implications.		
UNIT – II	**IOT ARCHITECTURE**	**9**
IoT reference model and architecture -Node Structure - Sensing, Processing, Communication, Powering, Networking - Topologies, Layer/Stack architecture, IoT standards, Cloud computing for IoT, Bluetooth, Bluetooth Low Energy beacons.		
UNIT – III	**PROTOCOLS AND WIRELESS TECHNOLOGIES FOR IOT**	**9**
PROTOCOLS: NFC, SCADA and RFID, Zigbee MIPI, M-PHY, UniPro, SPMI, SPI, M-PCIe GSM, CDMA, LTE, GPRS, small cell. Wireless technologies for IoT: WiFi (IEEE 802.11), Bluetooth/Bluetooth Smart, ZigBee/ZigBee Smart, UWB (IEEE 802.15.4), 6LoWPAN, Proprietary systems-Recent trends.		
UNIT – IV	**IOT PROCESSORS**	**9**
Services/Attributes: Big-Data Analytics for IOT, Dependability,Interoperability, Security, Maintainability. Embedded processors for IOT :Introduction to Python programming -Building IOT with RASPERRY PI and Arduino.		
UNIT – V	**CASE STUDIES**	**9**
Industrial IoT, Home Automation, smart cities, Smart Grid, connected vehicles, electric vehicle charging, Environment, Agriculture, Productivity Applications, IOT Defense		
	Total Contact Hours : 45	

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Analyze the concepts of IoT and its present developments.
CO2	Compare and contrast different platforms and infrastructures available for IoT
CO3	Explain different protocols and communication technologies used in IoT
CO4	Analyze the big data analytic and programming of IoT
CO5	Implement IoT solutions for smart applications

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Textbooks:	
1.	ArshdeepBahga and VijaiMadisetti : A Hands-on Approach "Internet of Things",Universities Press 2015.
2.	Oliver Hersent , David Boswarthick and Omar Elloumi " The Internet of Things", Wiley,2016
3.	Samuel Greengard, " The Internet of Things", The MIT press, 2015

Reference books/other materials/webresources:	
1.	Adrian McEwen and Hakim Cassimally"Designing the Internet of Things "Wiley,2014.
2.	Jean- Philippe Vasseur, Adam Dunkels, "Interconnecting Smart Objects with IP: The Next Internet" Morgan Kuffmann Publishers, 2010
3.	Adrian McEwen and Hakim Cassimally, "Designing the Internet of Things", John Wiley and sons, 2014.

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	1	2	1						
CO2		2							
CO3	1	2		1	3				
CO4	2		3	3	3	3			
CO5	3	2	3	3	3	3			
Average:	1.4	1.6	1.4	1.4	1.8	1.2			

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Subject Code	Subject Name	Category	L	T	P	C
ET24002	MACHINE LEARNING AND DEEP LEARNING	OEC	3	0	0	3

Course Objectives:

- Understanding about the learning problem and algorithms
- Providing insight about neural networks
- Introducing the machine learning fundamentals and significance
- Enabling the students to acquire knowledge about pattern recognition.
- Motivating the students to apply deep learning algorithms for solving real life problems

UNIT – I	**LEARNING PROBLEMS AND ALGORITHMS**	**9**
Various paradigms of learning problems, Supervised, Semi-supervised and Unsupervised algorithms		
UNIT – II	**NEURAL NETWORKS**	**9**
Differences between Biological and Artificial Neural Networks - Typical Architecture, Common Activation Functions, Multi-layer neural network, Linear Separability, Hebb Net, Perceptron, Adaline, Standard Back propagation Training Algorithms for Pattern Association - Hebb rule and Delta rule, Hetero associative, Auto associative, Kohonen Self Organising Maps, Examples of Feature Maps, Learning Vector Quantization, Gradient descent, Boltzmann Machine Learning		
UNIT – III	**MACHINE LEARNING – FUNDAMENTALS & FEATURE SELECTIONS & CLASSIFICATIONS**	**9**
Classifying Samples: The confusion matrix, Accuracy, Precision, Recall, F1- Score, the curse of dimensionality, training, testing, validation, cross validation, overfitting, under-fitting the data, early stopping, regularization, bias and variance. Feature Selection, normalization, dimensionality reduction, Classifiers: KNN, SVM, Decision trees, Naïve Bayes, Binary classification, multi class classification, clustering.		
UNIT – IV	**DEEP LEARNING: CONVOLUTIONAL NEURAL NETWORKS**	**9**
Feed forward networks, Activation functions, back propagation in CNN, optimizers, batch normalization, convolution layers, pooling layers, fully connected layers, dropout, Examples of CNNs		
UNIT – V	**DEEP LEARNING: RNNS, AUTOENCODERS AND GANS**	**9**
State, Structure of RNN Cell, LSTM and GRU, Time distributed layers, Generating Text, Autoencoders: Convolutional Autoencoders, Denoising autoencoders, Variational autoencoders, GANs: The discriminator, generator, DCGANs		
	Total Contact Hours : 45	

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Illustrate the categorization of machine learning algorithms.
CO2	Compare and contrast the types of neural network architectures, activation functions
CO3	Acquaint with the pattern association using neural networks
CO4	Elaborate various terminologies related with pattern recognition and architectures of convolutional neural networks
CO5	Construct different feature selection and classification techniques and

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	advanced neural network architectures such as RNN, Auto encoders, and GANs.

Textbooks:	
1.	J. S. R. Jang, C. T. Sun, E. Mizutani, Neuro Fuzzy and Soft Computing - A Computational Approach to Learning and Machine Intelligence, 2012, PHI learni
2.	Deep Learning, Ian Good fellow, YoshuaBengio and Aaron Courville, MIT Press, ISBN: 978026
3.	The Elements of Statistical Learning. Trevor Hastie, Robert Tibshirani and Jerome Friedman. Second Edition. 2009

Reference books/other materials/webresources:	
1.	Pattern Recognition and Machine Learning. Christopher Bishop. Springer. 2006.
2.	Understanding Machine Learning. Shai Shalev-Shwartz and Shai Ben-David. Cambridge University.

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**
CO1	1	3	1						
CO2	2	3	2						
CO3	3		3		3				
CO4	2	3	3						
CO5	3	3	3		3				
Average:	2.2	2.4	2.4		1.2				

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Subject Code	Subject Name	Category	L	T	P	C
PX24010	RENEWABLE ENERGY TECHNOLOGY	OEC	3	0	0	3

Course Objectives:

- Different types of renewable energy technologies
- Standalone operation, grid connected operation of renewable energy systems

UNIT – I	**INTRODUCTION**	**9**

Classification of energy sources – Co2 Emission - Features of Renewable energy - Renewable energy scenario in India -Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment Per Capital Consumption - CO2 Emission - importance of renewable energy sources, Potentials – Achievements– Applications

UNIT – II	**SOLAR PHOTOVOLTAICS**	**9**

Solar Energy: Sun and Earth-Basic Characteristics of solar radiation- angle of sunrays on solar collector-Estimating Solar Radiation Empirically - Equivalent circuit of PV Cell- Photovoltaic cell characteristics: P-V and I-V curve of cell-Impact of Temperature and Insolation on I-V characteristics-Shading Impacts on I-V characteristics-Bypass diode -Blocking diode.

UNIT – III	**PHOTOVOLTAIC SYSTEM DESIGN**	**9**

Block diagram of solar photo voltaic system : Line commutated converters (inversion mode) - Boost and buck-boost converters - selection of inverter, battery sizing, array sizing - PV systems classification- standalone PV systems - Grid tied and grid interactive inverters- grid connection issue

UNIT – IV	**WIND ENERGY CONVERSION SYSTEMS**	**9**

Origin of Winds: Global and Local Winds- Aerodynamics of Wind turbine-Derivation of Betz's limit Power available in wind-Classification of wind turbine: Horizontal Axis wind turbine and Vertical axis wind turbine- Aerodynamic Efficiency-Tip Speed-Tip Speed Ratio-Solidity-Blade Count-Power curve of wind turbine - Configurations of wind energy conversion systems: Type A, Type B, Type C and Type D Configurations- Grid connection Issues - Grid integrated SCIG and PMSG based WECS

UNIT – V	**OTHER RENEWABLE ENERGY SOURCES**	**9**

Qualitative study of different renewable energy resources: ocean, Biomass, Hydrogen energy systems, Fuel cells, Ocean Thermal Energy Conversion (OTEC), Tidal and wave energy, Geothermal Energy Resources.

Total Contact Hours : 45

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Demonstrate the need for renewable energy sources.
CO2	Develop a stand-alone photo voltaic system and implement a maximum power point tracking in the PV system.
CO3	Design a stand-alone and Grid connected PV system.
CO4	Analyze the different configurations of the wind energy conversion systems.
CO5	Realize the basic of various available renewable energy sources

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Textbooks:	
1.	S.N.Bhadra, D. Kastha, & S. Banerjee "Wind Electrical Systems", Oxford UniversityPress, 2009.
2.	Rai. G.D, "Non conventional energy sources", Khanna publishes, 1993
3.	. Rai. G.D," Solar energy utilization", Khanna publishes, 1993.

Reference books/other materials/webresources:	
1.	Chetan Singh Solanki, "Solar Photovoltaics: Fundamentals, Technologies and Applications", PHI Learning Private Limited, 2012.
2.	John Twideu and Tony Weir, "Renewal Energy Resources" BSP Publications, 2006
3.	Gray, L. Johnson, "Wind energy system", prentice hall of India, 1995

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3		2	2	2	1			
CO2	3		2	3	3	3			
CO3	3		2	3	3	3			
CO4	3		2	3	3	2			
CO5	3		2	2	2	2			
Average:	3		2	2.8	2.6	2.2			

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Subject Code	Subject Name	Category	L	T	P	C
PS24003	SMART GRID	OEC	3	0	0	3

Course Objectives:

- To Study about Smart Grid technologies, different smart meters and advanced metering infrastructure
- To know about the function of smart grid.
- To familiarize the power quality management issues in Smart Grid
- To familiarize the high performance computing for Smart Grid applications
- To get familiarized with the communication networks for Smart Grid applications

UNIT – I	**INTRODUCTION TO SMART GRID**	**9**
Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, Comparison of Micro grid and Smart grid, Present development & International policies in Smart Grid, Smart Grid Initiative for Power Distribution Utility in India – Case Study.		
UNIT – II	**SMART GRID TECHNOLOGIES**	**9**
Technology Drivers, Smart Integration of energy resources, Smart substations, Substation Automation, Feeder Automation ,Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control, Distribution systems: DMS, Volt/Var control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV) – Grid to Vehicle and Vehicle to Grid charging concepts		
UNIT – III	**SMART METERS AND ADVANCED METERING INFRASTRUCTURE**	**9**
Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit(PMU) & their application for monitoring & protection. Demand side management and demand response programs, Demand pricing and Time of Use, Real Time Pricing, Peak Time Pricing		
UNIT – IV	**POWER QUALITY MANAGEMENT IN SMART GRID**	**9**
Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.		
UNIT – V	**HIGH PERFORMANCE COMPUTING FOR SMART GRID APPLICATIONS**	**9**
Architecture and Standards -Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), PLC, Zigbee, GSM, IP based Protocols, Basics of Web Service and CLOUD Computing, Cyber Security for Smart Grid.		
	Total Contact Hours : 45	

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Relate with the smart resources, smart meters and other smart devices.
CO2	Explain the function of Smart Grid
CO3	Experiment the issues of Power Quality in Smart Grid.
CO4	Analyze the performance of Smart Grid.
CO5	Recommend suitable communication networks for smart grid applications

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Textbooks:	
1.	Stuart Borlase 'Smart Grid: Infrastructure, Technology and Solutions', CRC Press 2012
2.	JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, 'Smart Grid: Technology and Applications', Wiley, 2012.
3.	Mini S. Thomas, John D McDonald, 'Power System SCADA and Smart Grids', CRC Press, 2015

Reference books/other materials/webresources:	
1.	Kenneth C.Budka, Jayant G. Deshpande, Marina Thottan, 'Communication Networks for Smart Grids', Springer, 2014
2.	SMART GRID Fundamentals of Design and Analysis, James Momoh, IEEE press, A John Wiley & Sons, Inc., Publication.

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3	2		2	2	2			
CO2	3		2	2		2			
CO3	2		1						
CO4	1			3	3	1			
CO5		2	2	2	2	3			
Average:	1.8	0.8	1	1.8	1.4	1.6			

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Subject Code	Subject Name	Category	L	T	P	C
CP24007	SECURITY PRACTICES	OEC	3	0	0	3

Course Objectives:

- To gain a basic knowledge of system security
- To gain a basic knowledge of network security
- To know the fund medal knowledge about security management
- To obtain knowledge about cyber security and cloud security
- To gain basic knowledge about privacy and storage security

UNIT – I	**SYSTEM SECURITY**	**9**
Model of network security – Security attacks, services and mechanisms – OSI security architecture -A Cryptography primer- Intrusion detection system- Intrusion Prevention system - Security web applications- Case study: OWASP - Top 10 Web Application Security Risks		
UNIT – II	**NETWORK SECURITY**	**9**
Internet Security - Intranet security- Local Area Network Security - Wireless Network Security - Wireless Sensor Network Security- Cellular Network Security - Mobile security - IOT security - Case Study - Kali Linux		
UNIT – III	**SECURITY MANAGEMENT**	**9**
Information security essentials for IT Managers- Security Management System - Policy Driven System Management- IT Security - Online Identity and User Management System. Case study: Metasplo		
UNIT – IV	**CYBER SECURITY AND CLOUD SECURITY**	**9**
Cyber Forensics- Disk Forensics – Network Forensics – Wireless Forensics – Database Forensics – Malware Forensics – Mobile Forensics – Email Forensics- Best security practices for automate Cloud infrastructure management – Establishing trust in IaaS, PaaS, and SaaS Cloud types. Case study: DVWA		
UNIT – V	**PRIVACY AND STORAGE SECURITY**	**9**
Privacy on the Internet - Privacy Enhancing Technologies - Personal privacy Policies - Detection of Conflicts in security policies- privacy and security in environment monitoring systems. Storage Area Network Security - Storage Area Network Security Devices - Risk management - Physical Security Essentials		
	Total Contact Hours : 45	

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Understand the core fundamentals of system security
CO2	Apply the security concepts to wired and wireless networks
CO3	Implement and Manage the security essentials in IT Sector
CO4	Explain the concepts of Cyber Security and Cyber forensics
CO5	Be aware of Privacy and Storage security Issues.

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Textbooks:	
1.	John R. Vacca, Computer and Information Security Handbook, Third Edition, Elsevier 2017
2.	Michael E. Whitman, Herbert J. Mattord, Principles of Information Security, Seventh Edition, Cengage Learning, 2022
3.	Richard E. Smith, Elementary Information Security, Third Edition, Jones and Bartlett Learning, 2019

Reference books/other materials/webresources:	
1.	Mayor, K.K.Mookhey, Jacopo Cervini, Fairuzan Roslan, Kevin Beaver, Metasploit Toolkit for Penetration Testing, Exploit Development and Vulnerability Research, Syngress publications, Elsevier, 2007. ISBN : 978-1-59749-074-0
2.	John Sammons, "The Basics of Digital Forensics- The Primer for Getting Started in Digital Forensics", Syngress, 2012
3.	Cory Altheide and Harlan Carvey, "Digital Forensics with Open Source Tools",2011 Syngress, ISBN: 9781597495875

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	1	2	1	1	2	1	-	-	-
CO2	2	1	3	1	1	2	-	-	-
CO3	-	-	2	3	3	3	-	-	-
CO4	2	2	1	2	1	3	-	-	-
CO5	1	-	1	1	2	3	-	-	-
Average:	1.2	1	1.6	1.6	1.8	2.4	-	-	-

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Subject Code	Subject Name	Category	L	T	P	C
MP24002	CLOUD COMPUTING TECHNOLOGIES	OEC	3	0	0	3

Course Objectives:

- To gain expertise in Virtualization, Virtual Machines and deploy practical virtualization solution
- To understand the architecture, infrastructure and delivery models of cloud computing
- To explore the roster of AWS services and illustrate the way to make applications in AWS
- To gain knowledge in the working of Windows Azure and Storage services offered by Windows Azure
- To develop the cloud application using various programming model of Hadoop and Aneka

UNIT – I	**VIRTUALIZATION AND VIRTUALIZATION INFRASTRUCTURE**	**9**
Basics of Virtual Machines - Process Virtual Machines – System Virtual Machines –Emulation – Interpretation – Binary Translation - Taxonomy of Virtual Machines. Virtualization – Management Virtualization — Hardware Maximization – Architectures – Virtualization Management – Storage Virtualization – Network Virtualization- Implementation levels of virtualization – virtualization structure – virtualization of CPU, Memory and I/O devices – virtual clusters and Resource Management – Virtualization for data center automation		
UNIT – II	**CLOUD PLATFORM ARCHITECTURE**	**9**
Cloud Computing: Definition, Characteristics - Cloud deployment models: public, private, hybrid, community – Categories of cloud computing: Everything as a service: Infrastructure, platform, software- A Generic Cloud Architecture Design – Layered cloud Architectural Development – Architectural Design Challenges		
UNIT – III	**AWS CLOUD PLATFORM - IAAS**	**9**
Amazon Web Services: AWS Infrastructure- AWS API- AWS Management Console - Setting up AWS Storage - Stretching out with Elastic Compute Cloud - Elastic Container Service for Kubernetes- AWS Developer Tools: AWS Code Commit, AWS Code Build, AWS Code Deploy, AWS Code Pipeline, AWS code Star - AWS Management Tools: Cloud Watch, AWS Auto Scaling, AWS control Tower, Cloud Formation, Cloud Trail, AWS License Manage		
UNIT – IV	**PAAS CLOUD PLATFORM**	**9**
Windows Azure: Origin of Windows Azure, Features, The Fabric Controller – First Cloud APP in Windows Azure- Service Model and Managing Services: Definition and Configuration, Service runtime API- Windows Azure Developer Portal- Service Management API- Windows Azure Storage Characteristics-Storage Services- REST API- Blops		
UNIT – V	**PROGRAMMING MODEL**	**9**
Introduction to Hadoop Framework - Mapreduce, Input splitting, map and reduce functions, specifying input and output parameters, configuring and running a job –Developing Map Reduce Applications - Design of Hadoop file system –Setting up Hadoop Cluster- Aneka: Cloud Application Platform, Thread Programming, Task Programming and Map-Reduce Programming in Aneka		
		Total Contact Hours : 45

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Course Outcomes:	Upon completion of the course students should be able to:
CO1	Employ the concepts of virtualization in the cloud computing
CO2	Identify the architecture, infrastructure and delivery models of cloud computing
CO3	Develop the Cloud Application in AWS platform
CO4	Apply the concepts of Windows Azure to design Cloud Application
CO5	Develop services using various Cloud computing programming models.

Textbooks:	
1.	Bernard Golden, Amazon Web Service for Dummies, John Wiley & Sons, 2013
2.	Raoul Alongi, AWS: The Most Complete Guide to Amazon Web Service from Beginner to Advanced Level, Amazon Asia- Pacific Holdings Private Limited, 2019.
3.	Sriram Krishnan, Programming: Windows Azure, O'Reilly,2010

Reference books/other materials/webresources:	
1.	Rajkumar Buyya, Christian Vacchiola, S.Thamarai Selvi, Mastering Cloud Computing , MCGraw Hill Education (India) Pvt. Ltd., 2013
2.	Danielle Ruest, Nelson Ruest, —Virtualization: A Beginner"s Guidell, McGraw-Hill Osborne Media, 2009
3.	Jim Smith, Ravi Nair , "Virtual Machines: Versatile Platforms for Systems and Processes", Elsevier/Morgan Kaufmann, 2005.

	CO-PO Mapping											CO-PSO Mapping		
PO& PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	-	2	3	2	-	-	-	-	-	-	-	-
CO2	3	-	2	2	-	2	-	-	-	-	-	-	-	-
CO3	2	-	1	-	-	-	-	-	-	-	-	-	-	-
CO4	2	-	-	2	3	1	-	-	-	-	-	-	-	-
CO5	-	2	2	2	3	3	-	-	-	-	-	-	-	-
Average:	2	0.8	1	1.6	1.8	1.6	-	-	-	-	-	-	-	-

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Subject Code	Subject Name	Category	L	T	P	C
IF24001	DESIGN THINKING	OEC	3	0	0	3

Course Objectives:

- To provide a sound knowledge in UI & UX
- To understand the need for UI and UX
- Research Methods used in Design
- Tools used in UI & UX
- Creating a wireframe and prototype

UNIT – I	**UX LIFECYCLE TEMPLATE**	**9**

Introduction. A UX process lifecycle template. Choosing a process instance for your project. The system complexity space. Meet the user interface team. Scope of UX presence within the team. More about UX lifecycles. Business Strategy. Value Innovation. Validated User Research. Killer UX Design. The Blockbuster Value Proposition. What Is a Value Proposition?

UNIT – II	**CONTEXTUAL INQUIRY**	**9**

The system concept statement. User work activity data gathering. Look for emotional aspects of work practice. Abridged contextual inquiry process. Data-driven vs. model-driven inquiry. Organizing concepts: work roles and flow model. Creating and managing work activity notes. Constructing your work activity affinity diagram (WAAD). Abridged contextual analysis process. History of affinity diagrams

UNIT – III	**DESIGN THINKING, IDEATION, AND SKETCHING**	**9**

Design-informing models: second span of the bridge . Some general "how to" suggestions. A New example domain: slideshow presentations. User models. Usage models. Work environment models. Barrier summaries. Model consolidation. Protecting your sources. Abridged methods for design-informing models extraction. Design paradigms. Design thinking. Design perspectives. User personas. Ideation. Sketching

UNIT – IV	**UX GOALS, METRICS, AND TARGETS**	**9**

Introduction. UX goals. UX target tables. Work roles, user classes, and UX goals. UX measures. Measuring instruments. UX metrics. Baseline level. Target level. Setting levels. Observed results. Practical tips and cautions for creating UX targets. How UX targets help manage the user experience engineering proces

UNIT – V	**ANALYSING USER EXPERIENCE**	**9**

Sharpening Your Thinking Tools. UX Research and Strength of Evidence. Agile Personas. How to Prioritize Usability Problems. Creating Insights, Hypotheses and Testable Design Ideas. How to Manage Design Projects with User Experience Metrics. Two Measures that Will Justify Any Design Change. Evangelizing UX Research. How to Create a User Journey Map. Generating Solutions to Usability Problems. Building UX Research Into the Design Studio Methodology. Dealing with Common objections to UX Research. The User Experience Debrief Meeting. Creating a User Experience Dashboard

Total Contact Hours : 45

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Hands on Design Thinking process for a product
CO2	Defining the Look and Feel of any new Project
CO3	Create a Sample Pattern Library for that product (Mood board, Fonts, Colors based on UI principles
CO4	Identify a customer problem to solve.
CO5	Conduct end-to-end user research - User research, creating personas,

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	Ideation process (User stories, Scenarios), Flow diagrams, Flow Mapping

Textbooks:	
1.	.Build UI for user Applications
2.	Use the UI Interaction behaviors and principles
3.	Evaluate UX design of any product or application

Reference books/other materials/web resources:	
1.	Demonstrate UX Skills in product development
2.	Implement Sketching principles

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2		2	2	2			
CO2	3	2	2	2		2			
CO3	2		2						
CO4	3			3	3	1			
CO5		2	2	2	2	3			
Average:	2.2	1.2	1.2	1.8	1.4	1.4			

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Subject Code	Subject Name	Category	L	T	P	C
MU24001	PRINCIPLES OF MULTIMEDIA	OEC	3	0	0	3

Course Objectives:

- To get familiarity with gamut of multimedia and its significance
- To acquire knowledge in multimedia components
- To acquire knowledge about multimedia tools and authoring
- To acquire knowledge in the development of multimedia applications.
- To explore the latest trends and technologies in multimedia

UNIT – I	INTRODUCTION	9

Introduction to Multimedia – Characteristics of Multimedia Presentation – Multimedia Components – Promotion of Multimedia Based Components – Digital Representation – Media and Data Streams – Multimedia Architecture – Multimedia Documents, Multimedia Tasks and Concerns, Production, sharing and distribution, Hypermedia, WWW and Internet, Authoring, Multimedia over wireless and mobile networks.

Suggested Activities: 1. Flipped classroom on media Components. 2. External learning – Interactive presentation. Suggested Evaluation Methods: 1. Tutorial – Handling media components 2. Quizzes on different types of data presentation.

UNIT – II	ELEMENTS OF MULTIMEDIA	9

Text-Types, Font, Unicode Standard, File Formats, Graphics and Image data representations – data types, file formats, color models; video – color models in video, analog video, digital video, file formats, video display interfaces, 3D video and TV: Audio – Digitization, SNR, SQNR, quantization, audio quality, file formats, MIDI; Animation- Key Frames and Tweening, other Techniques, 2D and 3D Animation.

Suggested Activities: 1. Flipped classroom on different file formats of various media elements. 2. External learning – Adobe after effects, Adobe Media Encoder, Adobe Audition. Suggested Evaluation Methods: MU24001 PRINCIPLES OF MULTIMEDIA L T P C 1. Demonstration on after effects animations. 2. Quizzes on file formats and color models.

UNIT – III	MULTIMEDIA TOOLS	9

Authoring Tools – Features and Types – Card and Page Based Tools – Icon and Object Based Tools – Time Based Tools – Cross Platform Authoring Tools – Editing Tools – Painting and Drawing Tools – 3D Modeling and Animation Tools – Image Editing Tools – Sound Editing Tools – Digital Movie Tools.

Suggested Activities: 1. Flipped classroom on multimedia tools. 2. External learning – Comparison of various authoring tools. Suggested Evaluation Methods: 1. Tutorial – Audio editing tool. 2. Quizzes on animation tools

UNIT – IV	MULTIMEDIA SYSTEMS	9

Compression Types and Techniques: CODEC, Text Compression: GIF Coding Standards, JPEG standard – JPEG 2000, basic audio compression – ADPCM, MPEG Psychoacoustics, basic Video compression techniques – MPEG, H.26X – Multimedia Database System – User Interfaces – OS Multimedia Support – Hardware Support – Real Time Protocols – Play Back Architectures – Synchronization – Document Architecture – Hypermedia Concepts: Hypermedia Design – Digital Copyrights, Content analysis.

Suggested Activities: 1. Flipped classroom on concepts of multimedia hardware architectures. 2. External learning – Digital repositories and hypermedia design. Suggested Evaluation Methods: 1. Quizzes on multimedia hardware and compression techniques. 2. Tutorial – Hypermedia design.

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UNIT – V	MULTIMEDIA APPLICATIONS FOR THE WEB AND MOBILE PLATFORMS	9
ADDIE Model – Conceptualization – Content Collection – Storyboard–Script Authoring Metaphors – Testing – Report Writing – Documentation. Multimedia for the web and mobile platforms. Virtual Reality, Internet multimedia content distribution, Multimedia Information sharing – social media sharing, cloud computing for multimedia services, interactive cloud gaming. Multimedia information retrieval. Suggested Activities: 1. External learning – Game consoles. 2. External learning – VRML scripting languages. Suggested Evaluation Methods: 1. Demonstration of simple interactive games. 2. Tutorial – Simple VRML program.		
		Total Contact Hours : 45

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Handle the multimedia elements effectively.
CO2	Articulate the concepts and techniques used in multimedia applications.
CO3	Develop effective strategies to deliver Quality of Experience in multimedia applications.
CO4	Design and implement algorithms and techniques applied to multimedia objects
CO5	Design and develop multimedia applications following software engineering models.

Textbooks:	
1.	Li, Ze-Nian, Drew, Mark, Liu, Jiangchuan, "Fundamentals of Multimedia", Springer, Third Edition, 2021
2.	Prabhat K.Andleigh, Kiran Thakrar, "MULTIMEDIA SYSTEMS DESIGN", Pearson Education, 2015

Reference books/other materials/webresources:	
1.	Gerald Friedland, Ramesh Jain, "Multimedia Computing", Cambridge University Press, 2018. (digital book)
2.	Ranjan Parekh, "Principles of Multimedia", Second Edition, McGraw-Hill Education, 2017

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	-	2	2	2	-	-	-
CO2	3	-	2	2	-	2	-	-	-
CO3	3	2	1	-	-	-	-	-	-
CO4	3	-	-	3	3	1	-	-	-
CO5	-	2	2	3	2	3	-	-	-
Average:	2.4	1.2	1	2	1.4	1.6	-	-	-

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Subject Code	Subject Name	Category	L	T	P	C
DS24001	BIG DATA ANALYTICS	OEC	3	0	0	3

Course Objectives:

- To understand the basics of big data analytics
- To understand the search methods and visualization
- To learn mining data streams
- To learn frameworks
- To gain knowledge on R language

UNIT – I	**INTRODUCTION TO BIG DATA**	**9**

Introduction to Big Data Platform – Challenges of Conventional Systems - Intelligent data analysis –Nature of Data - Analytic Processes and Tools - Analysis Vs Reporting - Modern Data Analytic Tools- Statistical Concepts: Sampling Distributions - Re-Sampling - Statistical Inference - Prediction Error.

UNIT – II	**SEARCH METHODS AND VISUALIZATION**	**9**

Search by simulated Annealing – Stochastic, Adaptive search by Evaluation – Evaluation Strategies –Genetic Algorithm – Genetic Programming – Visualization – Classification of Visual Data Analysis Techniques – Data Types – Visualization Techniques – Interaction techniques – Specific Visual data analysis Techniques.

UNIT – III	**MINING DATA STREAMS**	**9**

Introduction To Streams Concepts – Stream Data Model and Architecture - Stream Computing - Sampling Data in a Stream – Filtering Streams – Counting Distinct Elements in a Stream – Estimating Moments – Counting Oneness in a Window – Decaying Window - Real time Analytics Platform(RTAP) Applications - Case Studies - Real Time Sentiment Analysis, Stock Market Predictions.

UNIT – IV	**FRAMEWORKS**	**9**

MapReduce – Hadoop, Hive, MapR – Sharding – NoSQL Databases - S3 - Hadoop Distributed File Systems – Case Study- Preventing Private Information Inference Attacks on Social Networks- Grand Challenge: Applying Regulatory Science and Big Data to Improve Medical Device Innovation.

UNIT – V	**R LANGUAGE**	**9**

Overview, Programming structures: Control statements -Operators -Functions -Environment and scope issues -Recursion -Replacement functions, R data structures: Vectors -Matrices and arrays -Lists -Data frames -Classes, Input/output, String manipulations.

Total Contact Hours : 45

Course Outcomes:	Upon completion of the course students should be able to:
CO1	understand the basics of big data analytics
CO2	Ability to use Hadoop, Map Reduce Framework.
CO3	Ability to identify the areas for applying big data analytics for increasing the business outcome.
CO4	To gain knowledge on R language
CO5	Contextually integrate and correlate large amounts of information to gain faster insights.

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Textbooks:	
1.	Michael Berthold, David J. Hand, Intelligent Data Analysis, Springer, 2007.
2.	Bill Franks, Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics, John Wiley & sons, 2012.

Reference books/other materials/webresources:	
1.	Anand Rajaraman and Jeffrey David Ullman, Mining of Massive Datasets, Cambridge University Press, 3rd edition 2020.
2.	Norman Matloff, The Art of R Programming: A Tour of Statistical Software Design, No Starch Press, USA, 2011.

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3	3	3	3	2	1	3		
CO2	3	3	3	3	2	1	2	2	
CO3	3	3	3	3	2	1	2	2	
CO4	3	3	3	3	2	1	3	3	1
CO5	3	3	3	3	2	1	3	2	2
Average:	3	3	3	3	2	1	2.6	1.8	0.6

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Subject Code	Subject Name	Category	L	T	P	C
NC24001	INTERNET OF THINGS AND CLOUD	OEC	3	0	0	3

Course Objectives:

- Objective 1:To understand Smart Objects and IoT Architectures
- Objective 2:To learn about various IOT-related protocols
- Objective 3:To build simple IoT Systems using Arduino and Raspberry Pi.
- Objective 4:To understand data analytics and cloud in the context of IoT
- Objective 5:To develop IoT infrastructure for popular applications

UNIT – I	**FUNDAMENTALS OF IoT**	**9**
Introduction to IoT – IoT definition – Characteristics – IoT Complete Architectural Stack – IoT enabling Technologies – IoT Challenges. Sensors and Hardware for IoT – Hardware Platforms – Arduino, Raspberry Pi, Node MCU. A Case study with any one of the boards and data acquisition from sensors.		
UNIT – II	**PROTOCOLS FOR IoT**	**9**
Infrastructure protocol (IPV4/V6/RPL), Identification (URIs), Transport (Wifi, Lifi, BLE), Discovery, Data Protocols, Device Management Protocols. – A Case Study with MQTT/CoAP usage-IoT privacy, security and vulnerability solutions.		
UNIT – III	**CASE STUDIES/INDUSTRIAL APPLICATIONS**	**9**
Case studies with architectural analysis: IoT applications – Smart City – Smart Water – Smart Agriculture – Smart Energy – Smart Healthcare – Smart Transportation – Smart Retail – Smart waste management.		
UNIT – IV	**CLOUD COMPUTING INTRODUCTION**	**9**
Introduction to Cloud Computing - Service Model – Deployment Model- Virtualization Concepts – Cloud Platforms – Amazon AWS – Microsoft Azure – Google APIs.		
UNIT – V	**IoT AND CLOUD**	**9**
IoT and the Cloud - Role of Cloud Computing in IoT - AWS Components - S3 – Lambda – AWS IoT Core -Connecting a web application to AWS IoT using MQTT- AWS IoT Examples. Security Concerns, Risk Issues, and Legal Aspects of Cloud Computing- Cloud Data Security		
		Total Contact Hours : 45

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Understand the various concept of the IoT and their technologies.
CO2	Develop IoT application using different hardware platforms.
CO3	Implement the various IoT Protocols.
CO4	Understand the basic principles of cloud computing.
CO5	Develop and deploy the IoT application into cloud environment.

Textbooks:

1. "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", by Pethuru Raj and Anupama C. Raman ,CRC Press, 2017.
2. Adrian McEwen, Designing the Internet of Things, Wiley,2013.

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Reference books/other materials/webresources:	
1.	Bart Baesens, "Analytics in a Big Data World: The Essential Guide to Data Science and its Applications", Wiley Publishers, 2015.
2.	EMC Education Services, "Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data", Wiley publishers, 2015.

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	1	3	2	1
CO2	3	3	2	2	2	2	3	2	2
CO3	2	3	3	2	2	2	3	3	2
CO4	2	2	3	2	3	1	2	2	3
CO5	3	2	3	2	3	2	3	2	3
Average:	2.6	2.4	2.6	1.8	2.4	1.6	2.8	2.2	2.2

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Subject Code	Subject Name	Category	L	T	P	C
MX24001	MEDICAL ROBOTICS	OEC	3	0	0	3

Course Objectives:

- To explain the basic concepts of robots and types of robots
- To discuss the designing procedure of manipulators, actuators and grippers.
- To impart knowledge on various types of sensors and power sources.
- To explore various applications of Robots in Medicine.
- To impart knowledge on wearable robots.

UNIT – I	INTRODUCTION TO ROBOTICS	9

Introduction to Robotics, Overview of robot subsystems, Degrees of freedom, configurations and concept of workspace, Dynamic Stabilization.

Sensors and Actuators

Sensors and controllers, Internal and external sensors, position, velocity and acceleration sensors, Proximity sensors, force sensors Pneumatic and hydraulic actuators, Stepper motor control circuits, End effectors, Various types of Grippers, PD and PID feedback actuator models.

UNIT – II	MANIPULATORS & BASIC KINEMATICS	9

Construction of Manipulators, Manipulator Dynamic and Force Control, Electronic and pneumatic manipulator, Forward Kinematic Problems, Inverse Kinematic Problems, Solutions of Inverse Kinematic problems.

Navigation and Treatment Planning

Variable speed arrangements, Path determination – Machinery vision, Ranging – Laser – Acoustic, Magnetic, fiber optic and Tactile sensor.

UNIT – III	SURGICAL ROBOTS	9

Da Vinci Surgical System, Image guided robotic systems for focal ultrasound based surgical applications, System concept for robotic Tele-surgical system for off-pump, CABG surgery, Urologic applications, Cardiac surgery, Neuro-surgery, Pediatric and General Surgery, Gynecologic Surgery, General Surgery and Nanorobotics. Case Study

UNIT – IV	REHABILITATION AND ASSISTIVE ROBOTS	9

Pediatric Rehabilitation, Robotic Therapy for the Upper Extremity and Walking, Clinical-Based Gait Rehabilitation Robots, Motion Correlation and Tracking, Motion Prediction, Motion Replication. Portable Robot for Tele rehabilitation, Robotic Exoskeletons – Design considerations, Hybrid assistive limb. Case Study

UNIT – V	WEARABLE ROBOTS	9

Augmented Reality, Kinematics and Dynamics for Wearable Robots, Wearable Robot technology, Sensors, Actuators, Portable Energy Storage, Human–robot cognitive interaction (cHRI), Human – robot physical interaction (pHRI), Wearable Robotic Communication - case study

Total Contact Hours : 45

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Describe the configuration, applications of robots and the concept of grippers and actuators.
CO2	Explain the functions of manipulators and basic kinematics.
CO3	Describe the application of robots in various surgeries.
CO4	Design and analyze the robotic systems for rehabilitation.
CO5	Design the wearable robots.

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Textbooks:	
1.	Nagrath and Mittal, "Robotics and Control", Tata McGraw Hill, First edition, 2003
2.	Spong and Vidhyasagar, "Robot Dynamics and Control", John Wiley and Sons, First edition, 2008

Reference books/other materials/webresources:	
1.	Fu.K.S, Gonzalez. R.C., Lee, C.S.G, "Robotics, control", sensing, Vision and Intelligence, Tata McGraw Hill International, First edition, 2008
2.	Shane (S.Q.) Xie, Advanced Robotics for Medical Rehabilitation - Current State of the Art and Recent Advances, Springer, 2016

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1				1			3	2	1
CO2				2			3	2	2
CO3	2		2	2	2	2	2	3	2
CO4	2		2	2	3	2	3	3	2
CO5	2		2	2	3	3	3	2	3
Average:	1.2		1.2	1.8	1.6	1.4	2.8	2.4	2

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Subject Code	Subject Name	Category	L	T	P	C
VE24001	EMBEDDED AUTOMATION	OEC	3	0	0	3

Course Objectives:

- To learn about the process involved in the design and development of real-time embedded system.
- To develop the embedded C programming skills on 8-bit microcontroller.
- To study about the interfacing mechanism of peripheral devices with 8-bit Microcontrollers.
- To learn about the tools, firmware related to microcontroller programming.
- To build a home automation system.

UNIT – I	**INTRODUCTION TO EMBEDDED C PROGRAMMING**	**9**
C Overview and Program Structure - C Types, Operators and Expressions - C Control Flow – C Functions and Program Structures - C Pointers And Arrays - FIFO and LIFO - C Structures - Development Tools		
UNIT – II	**AVR MICROCONTROLLER**	**9**
ATMEGA 16 Architecture - Nonvolatile and Data Memories - Port System - Peripheral Features : Time Base, Timing Subsystem, Pulse Width Modulation, USART, SPI, Two Wire Serial Interface, ADC, Interrupts - Physical and Operating Parameters.		
UNIT – III	**HARDWARE AND SOFTWARE INTERFACING WITH 8-BIT SERIES CONTROLLERS**	**9**
Lights and Switches - Stack Operation - Implementing Combinational Logic - Expanding I/O - Interfacing Analog To Digital Convertors - Interfacing Digital To Analog Convertors – LED Displays : Seven Segment Displays, Dot Matrix Displays - LCD Displays - Driving Relays - Stepper Motor Interface - Serial EEPROM - Real Time Clock - Accessing Constants Table - Arbitrary Waveform Generation - Communication Links - System Development Tools.		
UNIT – IV	**VISION SYSTEM**	**9**
Fundamentals of Image Processing - Filtering - Morphological Operations - Feature Detection and Matching - Blurring and Sharpening - Segmentation - Thresholding - Contours – Advanced Contour Properties - Gradient - Canny Edge Detector - Object Detection – Background Subtraction.		
UNIT – V	**HOME AUTOMATION**	**9**
Home Automation - Requirements - Water Level Notifier - Electric Guard Dog - Tweeting Bird Feeder - Package Delivery Detector - Web Enabled Light Switch - Curtain Automation – Android Door Lock - Voice Controlled Home Automation - Smart Lighting - Smart Mailbox – Electricity Usage Monitor -Proximity Garage Door Opener - Vision Based Authentic Entry System		
		Total Contact Hours : 45

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Analyze the 8-bit series microcontroller architecture, features and pin details.
CO2	Write embedded C programs for embedded system application.
CO3	Design and develop real time systems using AVR microcontrollers.
CO4	Design and develop the systems based on vision mechanism.
CO5	Design and develop a real time home automation system.

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Textbooks:	
1.	Dhananjay V. Gadre, "Programming and Customizing the AVR Microcontroller", McGraw- Hill, 2001.
2.	Joe Pardue, "C Programming for Microcontrollers ", Smiley Micros, 2005.

Reference books/other materials/webresources:	
1.	Steven F. Barrett, Daniel J. Pack, "ATMEL AVR Microcontroller Primer : Programming and Interfacing", Morgan & Claypool Publishers, 2012
2.	Mike Riley, "Programming Your Home - Automate With Arduino, Android and Your Computer", the Pragmatic Programmers, Llc, 2012.

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	1		1	1	1		3	2	1
CO2	1	3	1	1	1	3	3	2	2
CO3	1	3	1	1	1	3	3	3	2
CO4	1	3	1	1	1	3	2	2	3
CO5	1	3	1	1	1	3	3	3	3
Average:	1	2.4	1	1	1	2.4	2.8	2.4	2.2

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Subject Code	Subject Name	Category	L	T	P	C
CX24001	ENVIRONMENTAL SUSTAINABILITY	OEC	2	0	0	3

Course Objectives:

- To introduce fundamental concepts of environmental valuation, property rights, and externalities.
- To explain the principles of sustainable development and the role of natural resource economics.
- To highlight the importance of biodiversity, forest habitats, and the effects of air pollution.
- To understand the various types and impacts of pollution including water, solid waste, and global warming.
- To explore environmental economics policies and the relationship between development, poverty, and environmental sustainability.

UNIT – I	**INTRODUCTION**	**9**
Valuing the Environment: Concepts, Valuing the Environment: Methods, Property Rights, Externalities, and Environmental Problems		
UNIT – II	**CONCEPT OF SUSTAINABILITY**	**9**
Sustainable Development: Defining the Concept, the Population Problem, Natural Resource Economics: An Overview, Energy, Water, Agriculture		
UNIT – III	**SIGNIFICANCE OF BIODIVERSITY**	**9**
Biodiversity, Forest Habitat, Commercially Valuable Species, Stationary - Source Local Air Pollution, Acid Rain and Atmospheric Modification, Transportation		
UNIT – IV	**POLLUTION IMPACTS**	**9**
Water Pollution, Solid Waste and Recycling, Toxic Substances and Hazardous Wastes, Global Warming.		
UNIT – V	**ENVIRONMENTAL ECONOMICS**	**9**
Development, Poverty, and the Environment, Visions of the Future, Environmental economics and policy by Tom Tietenberg, Environmental Economics		
	Total Contact Hours : 45	

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Describe methods to value the environment and explain related economic concepts like externalities and property rights.
CO2	Analyze sustainability issues with respect to population, energy, water, and agriculture.
CO3	Assess the significance of biodiversity and the environmental impacts of air pollution and habitat loss.
CO4	Evaluate pollution types and their environmental consequences including waste management and global warming.
CO5	Discuss environmental economic policies and their role in addressing poverty and promoting sustainable development.

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Textbooks:	
1.	Development, Poverty, and the Environment, Visions of the Future, Environmental economics and policy by Tom Tietenberg, Environmental Economics
2.	Stephen Doven, Environment and Sustainability Policy: Creation, Implementation, Evaluation, the Federation Press, 2005

Reference books/other materials/webresources:	
1.	Robert Brinkmann., Introduction to Sustainability, Wiley-Blackwell., 2016
2.	Bhavik R Bakshi., Sustainable Engineering: Principles and Practice, Cambridge University Press, 2019
3.	Niko Roorda., Fundamentals of Sustainable Development, 3rd Edn, Routledge, 2020

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	3	2	2	1
CO2	3	3	2	2	3	3	3	2	2
CO3	2	2	2	2	3	3	3	3	2
CO4	2	3	2	2	2	3	2	2	2
CO5	3	2	3	2	3	3	3	2	2
Average:	2.6	2.4	2.2	1.8	2.6	3	2.6	2.2	1.8

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Subject Code	Subject Name	Category	L	T	P	C
TX24001	TEXTILE REINFORCED COMPOSITES	OEC	2	0	0	3

Course Objectives:

- To introduce the fundamentals of composite materials, focusing on reinforcements and their properties.
- To study the chemistry, preparation, and interaction mechanisms of various matrix materials used in composites.
- To familiarize students with different composite manufacturing techniques for thermoplastics and thermosets.
- To understand testing methods for composites, including mechanical and physical property evaluation.
- To analyze the mechanics of composites using micro, macro, and classical lamination theories, including failure predictions.

UNIT – I	**REINFORCEMENTS**	**9**
Introduction – composites –classification and application; reinforcements- fibres and its properties; preparation of reinforced materials and quality evaluation; preforms for various composites		
UNIT – II	**MATRICES**	**9**
Preparation, chemistry, properties and applications of thermoplastic and thermoset resins; mechanism of interaction of matrices and reinforcements; optimization of matrices		
UNIT – III	**COMPOSITE MANUFACTURING**	**9**
Classification; methods of composites manufacturing for both thermoplastics and thermosets- Hand layup, Filament Winding, Resin transfer moulding, prepregs and autoclave moulding, pultrusion, vacuum impregnation methods, compression moulding; post processing of composites and composite design requirements		
UNIT – IV	**TESTING**	**9**
Fibre volume and weight fraction, specif. ic gravity of composites, tensile, f lexural, impact, compression, inter laminar shear stress and fatigue properties of thermoset and thermoplastic composites.		
UNIT – V	**MECHANICS**	**9**
Micro mechanics, macro mechanics of single layer, macro mechanics of laminate, classical lamination theory, failure theories and prediction of inter laminar stresses using at ware		
	Total Contact Hours : 45	

Course Outcomes:	Upon completion of the course students should be able to:
CO1	Describe types of reinforcements, fiber properties, and methods to prepare reinforced composite materials.
CO2	Explain the characteristics and role of thermoplastic and thermoset matrices in composites.
CO3	Select appropriate composite manufacturing processes for given applications and materials.
CO4	Conduct and interpret composite material testing for tensile, impact, compression, and fatigue properties.
CO5	Apply micromechanics and classical lamination theory to analyze composite behavior and predict failure modes.

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Textbooks:	
1.	BorZ.Jang,"Advanced Polymer composites",ASM International,USA,1994.
2.	Carlsson L.A. and Pipes R.B., "Experimental Characterization of advanced composite Materials",SecondEdition,CRCPress,NewJersey,1996.
3.	George LubinandStanley T.Peters, "Handbook of Composites", Springer Publications,1998.

Reference books/other materials/webresources:	
1.	Mel. M. Schwartz, "Composite Materials", Vol. 1 &2, Prentice Hall PTR, New Jersey,1997.
2.	RichardM.Christensen,"Mechanics of compositematerials",DoverPublications,2005.
3.	Sanjay K. Mazumdar, "Composites Manufacturing: Materials, Product, and Process Engineering",CRCPress,2001

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3	2	2	2	2	1	2	2	1
CO2	3	2	2	2	2	2	2	2	2
CO3	3	3	3	2	3	2	3	2	2
CO4	3	3	3	2	3	2	3	2	2
CO5	3	3	3	3	3	2	3	3	2
Average:	3	2.6	2.6	2.2	2.6	1.8	2.6	2.2	1.8

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Subject Code	Subject Name	Category	L	T	P	C
NT24001	NANOCOMPOSITE MATERIALS	OEC	2	0	0	3

Course Objectives:

- To provide foundational knowledge on the structure, properties, and processing of nanocomposites.
- To explore metal-based nanocomposites, their synthesis techniques, and functional properties.
- To understand the design, characterization, and applications of polymer-based nanocomposites.
- To introduce natural and synthetic biomaterial-based nanocomposites and their biomedical applications.
- To familiarize students with technological applications of nanocomposites in textiles, cosmetics, and food industries.

UNIT – I	**BASICS OF NANOCOMPOSITES**	**9**
Nomenclature, Properties, features and processing of nanocomposites. Sample Preparation and Characterization of Structure and Physical properties. Designing, stability and mechanical properties and applications of super hard nanocomposites.		
UNIT – II	**METAL BASED NANOCOMPOSITES**	**9**
Metal-metal nanocomposites, some simple preparation techniques and their properties. Metal-Oxide or Metal-Ceramic composites, Different aspects of their preparation techniques and their final properties and functionality. Fractal based glass-metal nanocomposites, its designing and fractal dimension analysis. Core-Shell structured nanocomposites		
UNIT – III	**POLYMER BASED NANOCOMPOSITES**	**9**
Preparation and characterization of diblock Copolymer based nanocomposites; Polymer Carbon nanotubes based composites, their mechanical properties, and industrial possibilities.		
UNIT – IV	**NANOCOMPOSITE FROM BIOMATERIALS**	**9**
Natural nanocomposite systems - spider silk, bones, shells; organic-inorganic nanocomposite formation through self-assembly. Biomimetic synthesis of nanocomposites material; Use of synthetic nanocomposites for bone, teeth replacement.		
UNIT – V	**NANOCOMPOSITE TECHNOLOGY**	**9**
Nanocomposite membrane structures- Preparation and applications. Nanotechnology in Textiles and Cosmetics-Nano-fillers embedded polypropylene fibers – Soil repellence, Lotus effect - Nano finishing in textiles (UV resistant, anti-bacterial, hydrophilic, self-cleaning, flame retardant finishes), Sun-screen dispersions for UV protection using titanium oxide – Colour cosmetics. Nanotechnology in Food Technology - Nanopackaging for enhanced shelf life - Smart/Intelligent packaging.		
		Total Contact Hours : 45

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Course Outcomes:	Upon completion of the course students should be able to:
CO1	Explain the basic concepts, processing methods, and mechanical behavior of nanocomposites.
CO2	Describe preparation techniques and analyze the properties of various metal-based nanocomposites.
CO3	Evaluate the synthesis and mechanical performance of polymer-based nanocomposites for industrial use.
CO4	Analyze the role of biomaterials in forming nanocomposites and their application in biomedicine.
CO5	Assess the use of nanocomposites in consumer technologies such as textiles, cosmetics, and food packaging.

Textbooks:	
1.	Introduction to Nanocomposite Materials. Properties, Processing, Characterization- Thomas E. Twardowski. 2007. DEStech Publications. USA.
2.	Nanocomposites Science and Technology - P. M. Ajayan, L.S. Schadler, P. V.Braun 2006.

Reference books/other materials/webresources:	
1.	P. Brown and K. Stevens, Nanofibers and Nanotechnology in Textiles, Woodhead publication, London, 2006
2.	Nanometer versus micrometer-sized particles-Christian Brosseau, Jamal BeN Youssef, Philippe Talbot, Anne-Marie Konn, (Review Article) J. Appl. Phys, Vol 93, 2003
3.	Diblock Copolymer, - Aviram (Review Article), Nature, 2002

	CO-PO Mapping						CO-PSO Mapping		
PO& PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3	2	2	2	2	2	2	2	2
CO2	3	3	2	2	3	2	3	2	2
CO3	3	3	3	2	3	2	3	2	3
CO4	2	3	2	2	2	2	2	3	2
CO5	3	3	3	2	3	3	3	3	3
Average:	2.8	2.8	2.4	2	2.6	2.2	2.6	2.4	2.4

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Subject Code	Subject Name	Category	L	T	P	C
BY24001	IPR, BIOSAFETY AND ENTREPRENEURSHIP	OEC	2	0	0	3

Course Objectives:

- To introduce the fundamentals of Intellectual Property Rights (IPR) and its significance in research and development.
- To familiarize students with various international treaties, patent filing processes, and legal implications of patents.
- To impart knowledge on biosafety principles, containment levels, and national/international biosafety guidelines.
- To understand the regulation and risk assessment of genetically modified organisms (GMOs) and related international protocols.
- To develop entrepreneurial skills and explore opportunities in biotechnology and small-scale enterprises.

UNIT – I	**IPR**	**9**
Intellectual property rights – Origin of the patent regime – Early patents act & Indian pharmaceutical industry – Types of patents – Patent Requirements – Application preparation filing and prosecution – Patentable subject matter – Industrial design, Protection of GMO's IP as a factor in R&D,IP's of relevance to biotechnology and few case studies.		
UNIT – II	**AGREEMENTS, TREATIES AND PATENT FILING PROCEDURES**	**9**
History of GATT Agreement – Madrid Agreement – Hague Agreement – WIPO Treaties – Budapest Treaty – PCT – Ordinary – PCT – Conventional – Divisional and Patent of Addition – Specifications – Provisional and complete – Forms and fees Invention in context of "prior art" – Patent databases – Searching International Databases – Country-wise patent searches (USPTO, espacenet(EPO) – PATENT Scope (WIPO) – IPO, etc National & PCT filing procedure – Time frame and cost – Status of the patent applications filed – Precautions while patenting – disclosure/non-disclosure – Financial assistance for patenting – Introduction to existing schemes Patent licensing and agreement Patent infringement – Meaning, scope, litigation, case studies		
UNIT – III	**BIOSAFETY**	**9**
Introduction – Historical Backround – Introduction to Biological Safety Cabinets – Primary Containment for Biohazards – Biosafety Levels – Biosafety Levels of Specific Microorganisms – Recommended Biosafety Levels for Infectious Agents and Infected Animals – Biosafety guidelines – Government of India.		
UNIT – IV	**GENETICALLY MODIFIED ORGANISMS**	**9**
Definition of GMOs & LMOs – Roles of Institutional Biosafety Committee – RCGM – GEAC etc. for GMO applications in food and agriculture – Environmental release of GMOs – Risk Analysis – Risk Assessment – Risk management and communication – Overview of National Regulations and relevant International Agreements including Cartegana Protocol.		
UNIT – V	**ENTREPRENEURSHIP DEVELOPMENT**	**9**
Introduction – Entrepreneurship Concept – Entrepreneurship as a career – Entrepreneurial personality – Characteristics of successful Entrepreneur – Factors affecting entrepreneurial growth – Entrepreneurial Motivation – Competencies – Mobility – Entrepreneurship Development Programmes (EDP) - Launching Of Small Enterprise - Definition, Characteristics – Relationship between small and large units – Opportunities for an Entrepreneurial career – Role of small enterprise in economic development – Problems of small scale industries – Institutional finance to entrepreneurs - Institutional support to entrepreneurs.		
		Total Contact Hours : 45

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Course Outcomes:	Upon completion of the course students should be able to:
CO1	Understand the scope, types, and procedures involved in Intellectual Property Rights (IPR) and patents.
CO2	Analyze global treaties and agreements related to patent protection and apply patent filing procedures.
CO3	Apply bio safety guidelines to laboratory practices and interpret safety levels for various biohazards.
CO4	Evaluate bio safety regulations and risk management strategies associated with GMOs and LMOs.
CO5	Demonstrate entrepreneurial knowledge by identifying opportunities and challenges in establishing small enterprises.

Textbooks:	
1.	Bouchoux, D.E., "Intellectual Property: The Law of Trademarks, Copyrights, Patents, and Trade Secrets for the Paralegal", 3rd Edition, Delmar Cengage Learning, 2008.
2.	Fleming, D.O. and Hunt, D.L., "Biological Safety: Principles and Practices", 4th Edition, American Society for Microbiology, 2006.

Reference books/other materials/web resources:	
1.	Irish, V., "Intellectual Property Rights for Engineers", 2nd Edition, The Institution of Engineering and Technology, 2005.
2.	Mueller, M.J., "Patent Law", 3rd Edition, Wolters Kluwer Law & Business, 2009.
3.	S.S Khanka, "Entrepreneurial Development", S.Chand & Company LTD, New Delhi, 2007.

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CO3	3	2	2	2	2	2	2	3	2
CO4	2	2	3	2	2	3	3	3	2
CO5	2	3	3	2	3	3	3	3	3
Average:	2.6	2.4	2.6	2	2.4	2.4	2.6	2.6	2.2

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