GIET UNIVERSITY, GUNUPUR, ODISHA

DEPARTMENT OF MECHANICAL ENGINEERING

SCHOOL OF ENGINEERING & TECHNOLOGY

Incorporated by Act 23 of Govt. of Odisha and under approval of UGC & AICTE

Accredited by NAAC with a CGPA of 3.28/4 at *A Grade*

FiveUG Programs CSE, ME, CHE, AEIE & EEE Accredited by NBA

Gunupur - 765022 , Dist.- Rayagada, Odisha, INDIA

www.giet.edu

COURSE STRUCTURE AND SYLLABUS

FOR

POST GRADUATE DEGREE COURSE

IN

HEAT POWER AND THERMAL ENGINEERING

2 Year M.Tech Degree Programme

Regulation 2019

Choice Based Credit System

Outcome Based Assessment

Mechanical Engineering

Programme Educational Objectives

Programme educational objectives are broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve. Programme educational objectives are broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO1: Graduates of the program will have a successful career of mechanical engineering by imparting Mechanical Engineering concepts and practical knowledge.

PEO2: Graduates of the program will pursue higher education and research in the field of mechanical engineering.

PEO3: Graduates of the program will exhibit Scientific and Engineering expertise and perform as a Professional Entrepreneur.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO 1: Ability to apply the acquired Mechanical Engineering knowledge for the development of composite materials for societal application.

PSO 2: Ability to implement the learned principles of Mechanical Engineering to analyze, evaluate and create more advanced mechanical systems by using state-of-art facilities.

PROGRAMME OUTCOMES (POs)

PO-1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.

PO-2. Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO-3. Design / Development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO- 4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO- 5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO- 6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO- 7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO- 8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO- 9. Individual and team work: Function effectively as an individual and as a member or leader in diverse teams, and in multidisciplinary settings.

PO-10.Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO-11.Project management and finance: Demonstrate knowledge and understanding of the engineering management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO- 12. Life-long learning: Recognize the need for and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.

I SEMESTER

Sl. No.	Course Category	Course Code	Course Title	L	T	P	Credits
THEORY							
1	PC		Advanced Engineering Thermodynamics	3	0	0	3
2	PC		Advanced Fluid Mechanics	3	0	0	3
3	PC		Research Methodology and IPR	2	0	0	2
4	PE		Thermal And Nuclear Power Plant	3	0	0	3
			Energy Conversion And Management				
			Renewable Energy System				
			Hydel Power And Wind Energy				
5	PE		Air Conditioning And Ventilation Systems	3	0	0	3
			Gas Dynamics				
			Internal Combustion Engines				
			Design Of Thermal System				
PRACTICAL / SESSIONAL							
6	ES		Engineering software Lab	0	0	8	4
7	Audit		Audit Course - 1	2	0	0	0
TOTAL				**16**	**0**	**8**	**18**

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	ADVANCED ENGINEERING THERMODYNAMICS	3			3	

Pre -Requisite: **Engineering Thermodynamics I, Mathematics**

Course Outcomes: Upon successful completion of this course, students should be able to:

CO1	Understand Maxwell's and thermodynamics relations of gas mixtures
CO2	Identify the models to estimate the properties of real gas
CO3	Analyze reactive and non reactive gas mixtures using the concept of statistical thermodynamics and kinetics theory of gases
CO4	Analyze chemical reaction and gas mixtures.

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2												
CO2	3	2												
CO3	3	3	1											
CO4	3	2	1											
Avg.														

SYLLABUS

UNIT:1 (12 Hours)

Review of Basics: First law and Second law analysis – concept of entropy – principle of increase of entropy – entropy generation – Availability – concept of energy – energy analysis of combustion processes. Helm Holtz function – Gibb's function – OnSagar reciprocity relation.

UNIT:2 (14 Hours)

Thermodynamic relations, Maxwell's relations, T-ds equations – specific heat relations – energy equation – Joule Thomson effect – Clausius Clapery on Equation. Criteria for Equilibrium – Gibb's phase rule – Conditions for stability. Compressibility factor, fugacity and activity, computation from the generalized charts, dependence of fugacity and activity on pressure and temperature, chemical – equilibrium. Phase rule – ideal and real solution of gases, liquids, equilibrium system.

UNIT:3 (16 Hours)

Statistical Thermodynamics: Thermodynamics probability, Maxwell statistics, Fermi Dirac and Bose – Einstein statistics, Entropy and probability, Degeneracy of energy levels, Partition functions. Kinetic Theory of Gases: Perfect gas model, Distribution of translational velocities distribution function, molecular collisions and mean free path, equipartition of

energy.
Teaching Methods: Chalk& Board/ PPT/Video Lectures/Lecture by Industry Expert.
Text Books 1. A.S. Michael, '*Thermodynamic for Engineers*', Prentice Hall, 2012. 2. P.K. Nag., '*Engineering Thermodynamics*', II Ed., McGraw Hill, 2015.
Ref. Books 1. . G.J. Van Wylen & R.E. Sonntag., '*Fundamentals of Classical Thermodynamics*', Willy Eastern Ltd. 2011 (Unit I, II & III) 2. J.P. Holman., '*Thermodynamics*', 4th Ed., McGraw Hill, 2015. 3. J. Hsieg, '*Principles of Thermodynamics*', McGraw Hill, 2017. 4. Lee and Sears, '*Statistical Thermodynamics*', Addition Wesley, 2016. 5. V. Nastrand, S. Glasstne., _*Thermodynamics for Chemists*', 2014.

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	ADVANCED FLUID MECHANICS	**3**			**3**	

Pre -Requisite:

Course Outcomes: Upon successful completion of this course, students should be able to:

CO1	Understand the concept of fluid mechanics like statics, kinematics and dynamics, including concepts of mass, momentum and energy conservation equation.
CO2	Apply the principles of high and low Reynolds number flows to fluid flow systems.
CO3	Review the concepts of boundary layer and flow in transition.
CO4	Apply the fundamentals of one dimensional isentropic flow to variable area duct and principles of compressible flow to constant area duct subjected to friction or heat transfer

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2												
CO2	3	2												
CO3	3	3	1											
CO4	3	2	1											
Avg.														

SYLLABUS

UNIT:1 (12 Hours)

Concept of continuum and definition of a fluid. Body and surface forces, stress tensor, Scalar and vector fields, Eulerian and Lagrangian description of flow. Motion of fluid element - translation, rotation and vorticity; strain rate tensor, continuity equation, stream function and velocity potential.

UNIT:2 (16 Hours)

Transport theorems, constitutive equations, derivation of Navier Stokes equations for compressible flow. Exact solutions of Navier Stokes equations : plane Poiseuille flow and Couette flow, Hagen-Poiseuille flow, flow between two concentric rotating cylinders, Stoke's first and second problem, Hiemenz flow, flow near a rotating disk.

UNIT:3 (18 Hours)

Theory of hydrodynamic lubrication. Boundary layer: derivation, exact solutions, Blasius, Falkner Skan, series solution and numerical solutions. Approximate methods. Momentum integral method. Description of turbulent flow, velocity correlations, Reynold's stresses, Prandtl's Mixing Length Theory, Karman's velocity defect law, universal velocity distribution.

Teaching Methods: Chalk& Board/ PPT/Video Lectures/Lecture by Industry Expert.
Text Books 1. Advanced Fluid Mechanics, Som and Biswas, Tata McGraw Hill.

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	RESEARCH METHODOLOGY AND IPR	**2**			**2**	

Pre -Requisite:

Course Outcomes: Upon successful completion of this course, students should be able to:

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

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	1	3												
CO2				3	2									
CO3	1	2												
CO4		2		1										
Avg.														

SYLLABUS

UNIT:1 (12 Hours)

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

Effective literature studies approaches, analysis Plagiarism, Research ethics
UNIT:2 (16 Hours) Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee. Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.
UNIT:3 (18 Hours) Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.
Teaching Methods: Chalk& Board/ PPT/Video Lectures/Lecture by Industry Expert.
References: 1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'" 2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction" 3. Ranjit Kumar, 2 nd Edition, "Research Methodology: A Step by Step Guide for beginners" 4. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007. 5. Mayall , "Industrial Design", McGraw Hill,2012. 6. Niebel , "Product Design", McGraw Hill, 2014.

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	THERMAL AND NUCLEAR POWER PLANT	**3**			**3**	

Pre -Requisite: **Thermodynamics, Basics of power plant engineering**

Course Outcomes: Upon successful completion of this course, students should be able to:

CO1	Explain various energy conversion methods available for the production of electric power.
CO2	Analyze different thermodynamic cycles, combustion mechanism, different heat exchangers etc.
CO3	Apply safety measures and pollution control technologies to coal and nuclear power plant
CO4	Understand and analyze the working principle of the components of nuclear and thermal power plant

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	1	3												
CO2				3	2									
CO3	1	2												
CO4		2		1										
Avg.														

SYLLABUS

UNIT:1 (14 Hours)

Energy scenario. Overview of steam power plant. Analysis of steam cycles. Feedwater heaters. Deaerator and drain cooler. Optimization of cycle parameters, reheat and regeneration. Analysis of multi-fluid coupled cycles. Cogeneration of power and process heat. Combined cycle power generation. Fuels. Combustion mechanisms. Draft systems. Combustion control. Furnaces for burning coal in fluidized beds and in pulverized form. Coal handling installation.

UNIT:2 (12 Hours)

Different types of boilers and their specific uses. Boiler mountings and accessories. Feedwater treatment. Boiler maintenance. Circulation theory. Downcomers and risers. Drum and its internals. Economiser. Convective and radiant super heaters. Superheat temperature control. Recuperative and regenerative air preheaters. Dust and ash

removal systems. Environmental aspects of power generation
UNIT:3 (14 Hours) Basic concepts of reactor physics, radioactivity. Neutron Scattering. Thermal and fast reactors. Nuclear cross-sections. Neutron flux and reaction rates. Moderator criteria. Reactor core design. Conversion and breeding. Types of reactors. Characteristics of boiling water, pressurized water, pressurized heavy water, gas cooled and liquid metal cooled reactors. Future trends in reactor design and operation. Thermal-hydraulics of reactors. Heavy water management. Containment system for nuclear reactor. Reactor safety radiation shields. Waste management. Indian nuclear power programme.
Teaching Methods: Chalk& Board/ PPT/Video Lectures/Lecture by Industry Expert.
Text Books 1. M.M.El. Wakil., _Nuclear Power Engineering', McGraw Hill Book Company, New York, 3rd edition 2016. 2. S. Glasstone and A. Setonske., _Nuclear Reactors, Engineering', 4th Ed., CBS Publishers and Distributors, 2016.
Ref. Books 1. Loftness, Nuclear Power Plants', D. Van Nostrand Company Inc, Princeton, 4th edition 2012 2. S. Sarg et al., Physics of Nuclear Reactors', Tata McGraw Hill Publishing Company Ltd., 3rd Edition 2017. 3. T. J. Connoly., Fundamentals of Nuclear Energy', John Wiley, 6th Edition 2012.

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	ENERGY CONVERSION AND MANAGEMENT	3			3	

Pre -Requisite: **Advanced Maths, Thermodynamics, power plant**

Course Outcomes: Upon successful completion of this course, students should be able to:

CO1	Understanding of energy conservation and identification of energy conservation opportunities in various industrial processes
CO2	Knowledge of various tools and components for energy auditing
CO3	Ability to evaluate the performance of industrial boilers, furnaces etc. by direct and indirect methods
CO4	Understanding of energy management in industry, Environmental and economic evaluation of advanced pollution control technology.

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3													
CO2	3	3												
CO3		1	3											
CO4	2		02											
Avg.														

SYLLABUS

UNIT:1 (10 Hours)

Significance and Scope of Energy conservation and Management, Basic principles and total energy concept, First law optimization, availability. Exergy analysis. Second law optimization of thermal systems.

UNIT:2 (13 Hours)

Energy audits and conservation programme, elements of energy accounting. Plant energy studies : concepts, resources, procedures and implementation. Energy accounting indices, energy budget and variance analysis- statistical and engineering models. Economic aspects, payback. Waste Heat recovery; high, medium and low temperature applications, Methods of energy conservation in domestic and industrial sectors; case studies.

UNIT:3 (17 Hours)

Energy sources, Classification and characterization of fuels (fossil and bio-fuel), conversion and utilization, environmental and economic issues, optimum use of energy resources, Thermodynamic cycles, Principles of thermal energy conversion in boilers, internal combustion engines and gas turbines, cogeneration and combined cycle power generation, fuel cells and MHD technology, solar, wind and nuclear power, utilization of industrial heat, Energy management in industry, Environmental and economic evaluation advanced pollution control technology.
Teaching Methods: Chalk& Board/ PPT/Video Lectures/Lecture by Industry Expert.
Text Books 1. *R. Gold Stick and A. Thumann, Principles of Waste Heat Recovery, PHI, 2012.*
Ref. Books 1. *D. Y. Goswami, F. Kreith, Energy Conversion- CRC Press, 2016* 2. *V. Kadambi, and M. Prasad, Introduction to energy conversion turbo machinery: Energy conversion cycle- Wiley Eastern, New Delhi, 2014*

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	RENEWABLE ENERGY SYSTEM	**3**			**3**	

Pre -Requisite: **Thermodynamics, Basics of mechanical engineering**

Course Outcomes: Upon successful completion of this course, students should be able to:

CO1	Enable students to understand various renewable energy technologies and systems
CO2	To impart the knowledge of Storage technologies form the autonomous renewable energy sources
CO3	Equip the students with knowledge and understanding of various possible mechanisms about renewable energy projects
CO4	Create awareness among students about Non-Conventional sources of energy technologies

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3		2											
CO2		3												
CO3	3	1												
CO4	3		2											
Avg.														

SYLLABUS

UNIT:1 (14 Hours)

Energy scenario and renewable energy sources : global and Indian situation. Potential of non-conventional energy sources, economics. Solar Radiation: Solar thermal process, heat transfer devices, solar radiation measurement, estimation of average solar radiation. Solar energy storage: stratified storage, well mixed storage, comparison.

UNIT:2 (12 Hours)

Hot water system, practical consideration, solar ponds, Non-convective solar pond, extraction of thermal energy and application of solar ponds. Wind energy: The nature of wind. Wind energy resources and modeling. Geothermal energy: Origin and types of geothermal energy and utilization.

UNIT:3 (14 Hours)

OTEC: Ocean temperature differences. OTEC systems. Recent OTEC developments. Wave

energy: Fundamentals. Availability Wave-energy conversion systems. Tidal energy: Fundamentals. Availability Tidal-energy conversion systems. ; Energy from biomass: Photosynthesis; Biomass resource; Utilisation of biomass.
Teaching Methods: Chalk& Board/ PPT/Video Lectures/Lecture by Industry Expert.
Text Books 1. S.P.Sukhatme, Solar Energy Principle of Thermal Collection and Storage', Tata McGraw Hill, 2017. 2. G.L. Johnson, Wind energy systems, Prentice Hall Inc. New Jersey2016. 3. J.M.Kriender, Principles of Solar Engineering', McGraw Hill, 2017.
Ref. Books 1. V.S. Mangal, Solar Engineering', Tata McGraw Hill, 2012. 2. N.K.Bansal, Renewable Energy Source and Conversion Technology', Tata McGraw Hill, 2017. 3. P.J. Lunde., Solar Thermal Engineering', John Willey & Sons, New York, 2016. 4. J.A. Duffie, and W.A. Beckman, Solar Engineering2014

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	HYDEL POWER AND WIND ENERGY	**3**			**3**	

Pre -Requisite: **Thermodynamics, Fluid mechanics**

Course Outcomes: Upon successful completion of this course, students should be able to:

CO1	To understand Power house structures and Layout
CO2	To analyze the firm capacity, reservoir capacity and capacity factor
CO3	Able to understand wind turbine aerodynamics and momentum theories
CO4	To understand the Wind Energy Conversion System (WECS) setting, rotor selection, Annual Energy Output (AEO).

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3		2											
CO2			2											
CO3	2		2											
CO4	3													
Avg.														

SYLLABUS

UNIT:1 (14 Hours)

Elements of hydropower scheme, hydropower development in India. Power house structures and Layout. Hydropower plants classification: Surface and underground power stations, Low- medium-high head plants-layout and components, pumped storage plants. Load and power studies: load curve, load factor, load duration curve, firm capacity, reservoir capacity, capacity factor.

UNIT:2 (12 Hours)

Hydraulic turbines and types and classification, constructional features, selection, characteristic curves, governing of turbine, drafts tubes-types, hydraulic principles. Gates and valves types. Penstock and surge tanks. Wind machine types, classification, parameters. Wind measurements, data presentation, power in the wind. Wind turbine aerodynamics, momentum theories, basic aerodynamics, airfoils and their characteristics

UNIT:3 (14 Hours)

Horizontal Axis Wind Turbine (HAWT) - Blade Element Theory, wake analysis, Vertical Axis Wind Turbine (VAWT) aerodynamics. HAWT rotor design considerations, number of blades, blade profile, 2/3 blades and teetering, coning, power regulation, yaw system, tower.

Wind turbine loads, aerodynamic loads in steady operation, wind turbulence, static - dynamic - fatigue analysis, yawed operation and tower shadow, WECS control system, requirements and strategies. Wind Energy Conversion System (WECS) siting, rotor selection, Annual Energy Output (AEO). Synchronous and asynchronous generators and loads, integration of wind energy converters to electrical networks, inverters. Testing of WECS.
Teaching Methods: Chalk& Board/ PPT/Video Lectures/Lecture by Industry Expert.
Text Books 1. Water Power Engineering: M.M.Desmukh, Dhanpat rai and Sons 2016 2. Wind Energy Conversion Systems, Freris L.L., Prentice Hall 2017.
Ref. Books 1. Water power Development: Mosonyi 2. Hydroelectric hand book: Creagar, W.P. and Justin, J.D., John Wiley & Sons,New York 3. Davis' Handbook of applied hydraulics : Zipparro, V. J. and Hasen H., Mc-GrawHill, Inc., 4. Hydropower structures : R.S.Varshiray, Nem Chand and Bros. Roorkee.

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	GAS DYNAMICS	**3**			**3**	

Pre -Requisite: **Thermodynamics, Fluid mechanics**

Course Outcomes: Upon successful completion of this course, students should be able to:

CO1	To understand One dimensional Isentropic Flow and governing equation.
CO2	To derive the conditions for the change in pressure, density and temperature for flow through a normal shock.
CO3	To determine the strength of oblique shock waves on wedge shaped bodies and concave corners.
CO4	To determine the change in flow conditions through a Prandtl-Meyer expansion wave.

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3													
CO2		3	2											
CO3	3		1											
CO4	2		3											
Avg.														

SYLLABUS

UNIT:1 (14 Hours)

Fundamental Aspects of Gas Dynamics: Introduction, Isentropic flow in a stream tube, speed of sound, Mach waves; One dimensional Isentropic Flow: Governing equations, stagnation conditions, critical conditions, maximum discharge velocity, isentropic relations ; Normal Shock Waves: Shock waves, stationary normal shock waves, normal shock wave relations in terms of Mach number

UNIT:2 (12 Hours)

Oblique Shock Waves: Oblique shock wave relations, reflection of oblique shock waves, interaction of oblique shock waves, conical shock waves; Expansion Waves: Prandtl-Meyer flow, reflection and interaction of expansion waves, flow over bodies involving shock and expansion waves ; Variable Area Flow: Equations for variable area flow, operating characteristics of nozzles, convergent-divergent supersonic diffusers ;

Adaiabatic Flow in a Duct with Friction: Flow in a constant area duct, friction factor variations, the Fanno line.
UNIT:3 (14 Hours) Flow with Heat addition or removal: One-dimensional flow in a constant area duct neglecting viscosity, variable area flow with heat addition, one-dimensional constant area flow with both heat exchanger and friction ; Generalized Quasi-One-Dimensional Flow: Governing equations and influence coefficients, solution procedure for generalized flow with and without sonic point ; Two-Dimensional Compressible Flow: Governing equations, vorticity considerations, the velocity potential, linearized solutions, linearized subsonic flow, linearized supersonic flow, method of characteristics.
Teaching Methods: Chalk& Board/ PPT/Video Lectures/Lecture by Industry Expert.
Text Books 1. L. D. Landau and E. M. Lifshitz, Fluid Mechanics. 6th ed., Butterworth-Heinemann, 2015. 2. H. W. Liepmann, and A. Roshko, Elements of Gas Dynamics, Dover Pub, 2011.
Ref. Books 1. P. H. Oosthuizen and W. E. Carscallen. Compressible Fluid Flow. NY, McGraw-Hill, 2017. 2. M. A. Saad, Compressible Fluid Flow. 5th ed. Upper Saddle River, NJ: Prentice-Hall, 2013. 3. F. M. White, Viscous Fluid Flow. 4th ed. New York: McGraw-Hill, 2011. 4. A.H. Shapiro, Compressible Fluid Flow 1 and 2. Hoboken NJ: John Wiley.

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	INTERNAL COMBUSTION ENGINES	**3**			**3**	

Pre -Requisite: **Engineering Maths, Thermodynamics**

Course Outcomes: Upon successful completion of this course, students should be able to:

CO1	To illustrate design and performance of IC Engines through thermodynamic cycles, and Types of Supercharging.
CO2	To analyze of Fuels for SI and CI engines and Principle of modern carburetion
CO3	To analyze and evaluate the advance fuel injection system and Exhaust gas properties with its effects on the environment.
CO4	To design and create the advanced I C Engines.

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3		3											
CO2	3	1												
CO3	2		2											
CO4	3													
Avg.														

SYLLABUS

UNIT:1 (16 Hours)

Thermodynamic Analysis of I.C.Engine Cycles. Effect of design and operating parameters on cycle efficiency. Modified fuel-air cycle considering heat losses and valve timing. Engine dynamics and torque analysis. Use of Combustion chart . Thermodynamic cycle with supercharging both S.I. and C.I. Engines. Limits of Supercharging. Methods of Supercharging and Superchargers.

UNIT:2 (12 Hours)

Fuels and combustion in S.I. engines, knocking and fuel rating. Energy balance, volumetric efficiency, measurement of indicated and brake power. Advanced theory of carburetion. Fuel Injection Systems for S.I. and C.I. Engines. Cooling of engine and governing of engine. Ignition system : conventional and electronic.

UNIT:3 (14 Hours)

Variable compression ratio engine. Theoretical analysis, methods of obtaining variable compression ratio, Wankel rotary combustion engine, Stratified charged engine, Methods of charge stratification, Dual fuel and Multifuel engines, Biofuels, Variable Valve timing engines, Exhaust emissions, its measurement and control. Fault diagnosis of S.I. Engines.
Teaching Methods: Chalk& Board/ PPT/Video Lectures/Lecture by Industry Expert.
Text Books 1. Fundamentals of I.C. Engines by H.B.Heywood, McGraw Hill
Ref. Books 1. I.C.Engine Theory and Practices, Vol.I & II C.F.Taylor, MIT Press 2. I.C.Engine, Mathur and Sharma, Dhanpat Rai and Sons 3. Fundamentals of I.C.Engine Books

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	DESIGN OF THERMAL SYSTEM	**3**			**3**	

Pre -Requisite: **Thermodynamics, Mathematics**

Course Outcomes: Upon successful completion of this course, students should be able to:

CO1	To Integrate thermal component models and simulate a thermal system.
CO2	To Perform an economic analysis of a thermal system.
CO3	To apply optimization procedures and design optimized thermal systems
CO4	Understand the ethical issues associated with decision making

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3													
CO2		2												
CO3	3		3											
CO4	3	2												
Avg.														

SYLLABUS

UNIT:1 (14 Hours)

Modeling of Thermal Systems: types of models, mathematical modeling, curve fitting, linear algebraic systems, numerical model for a system, system simulation, methods for numerical simulation

UNIT:2 (12 Hours)

Acceptable Design of a Thermal System: initial design, design strategies, design of systems from different application areas, additional considerations for large practical systems; Economic Considerations: calculation of interest, worth of money as a function of time, series of payments, raising capital, taxes, economic factor in design, application to thermal systems

UNIT:3 (14 Hours)

Problem Formulation for Optimization: optimization methods, optimization of thermal systems, practical aspects in optimal design, Lagrange multipliers, optimization of constrained and unconstrained problems, applicability to thermal systems; search methods: single-variable problem, multivariable constrained optimization, examples of thermal systems; geometric, linear, and dynamic programming and other methods for

optimization, knowledge-based design and additional considerations, professional ethics.
Teaching Methods: Chalk& Board/ PPT/Video Lectures/Lecture by Industry Expert.
Text Books 1. W.F. Stoecker, Design of Thermal Systems - McGraw-Hill, 2011
Ref. Books 1. Y. Jaluria, Design and Optimization of Thermal Systems –CRC Press, 2007. 2. Bejan, G. Tsatsaronis, M.J. Moran, Thermal Design and Optimization - Wiley, 2016. 3. R. F. Boehm, Developments in the Design of Thermal Systems - Cambridge University Press, 2017. 4. N.V. Suryanarayana, Design & Simulation of Thermal Systems - MGH, 2002.

II SEMESTER [FIRST YEAR]

Sl. No.	Course Category	Course Code	Course Title	L	T	P	Credits
THEORY							
1	PC		Advanced Heat Transfer	3	0	0	3
2	PC		Steam Engineering	3	0	0	3
3	PE		Cryogenic Technology	3	0	0	3
			Solar Energy Technology				
			Computational Methods In Thermal Engineering				
			Experimental Methods In Thermal Engineering				
4	PE		Computational Fluid Dynamics	3	0	0	3
			Modelling of IC Engines				
			Design of Heat Exchangers				
			Aircraft And Rocket Propulsion				
PRACTICAL / SESSIONAL							
5	ES		Advanced Thermal Engg. Laboratory	0	0	8	4
6	CORE		Mini-Project	0	0	4	2
7	Audit		Audit- 2	2	0	0	0
TOTAL				**14**	**0**	**12**	**18**

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	ADVANCED HEAT TRANSFER	**3**			**3**	

Pre -Requisite: **Engineering Thermodynamics I, Fluid mechanics, Mathematics**

Course Outcomes: Upon successful completion of this course, students should be able to:

CO1	Ability to analyze the Practical correlations on flow over surfaces.
CO2	Able to Understand the concept of combined forced and free convection, combined convection and radiation in flows.
CO3	Ability to understand the various types of heat exchangers and their uses
CO4	Ability to design and analyze the performance of heat exchangers and evaporators

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	1													
CO2				3	2									
CO3	1	2												
CO4		2		1										
Avg.														

SYLLABUS

UNIT:1 (10 Hours)

Conduction- one and two dimensional, Fins, conduction with heat source, unsteady state heat transfer.

UNIT:2 (16 Hours)

Natural and forced convection, integral equation, analysis and analogies, Transpiration cooling, ablation heat transfer, boiling, condensation and two phase flow mass transfer, cooling, fluidized bed combustion

UNIT:3 (10 Hours)

Heat pipes, Radiation, shape factor, analogy, shields, Radiation of gases & vapours.

Teaching Methods: Chalk& Board/ PPT/Video Lectures/Lecture by Industry Expert.

Text Books

1. J.P. Holman., '*Heat and Mass Transfer*', Tata McGraw Hill, 9th Ed., 2016.
2. D.D. Kern, '*Extended Surface Heat Transfer*', New Age International Ltd., 2015.

Ref. Books

1. Incropera and Dewitt, "Fundamentals of Heat and Mass Transfer", John Wiley and Sons, NewYork, 2010.
2. Frank Kreith, "Principles of Heat Transfer", Harper and Row Publishers, New York, 2013.
3. Donald Q. Kern "Process Heat Transfer", Tata McGraw Hill Publishing Company Ltd., New Delhi, 2015.
4. Gupta and Prakash, "Engineering Heat Transfer", New Chand and Bros, Roorkee (U.P.) India, 2016.
5. R.C. Sachdeva "Fundamentals of Engineering Heat and Mass Transfer", Wiley Eastern Ltd., India, 2016

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	STEAM ENGINEERING	**3**			**3**	

Pre -Requisite: **Engineering Thermodynamics I, Fluid mechanics, Mathematics**

Course Outcomes: Upon successful completion of this course, students should be able to:

CO1	Ability to explain working of different boilers and significance of mountings and accessories and use techniques, skills, and modern engineering tools necessary for boiler performance assessment.
CO2	Students will have a theoretical and practical background in thermal systems, and will have a good understanding of energy conservation fundamentals. Students will have the ability to analyze thermal systems for energy conservation
CO3	Ability to design a steam piping system, its components for a process and also design economical and effective insulation and analyze a thermal system for sources of waste heat design a systems for waste heat recovery.
CO4	Ability to design and develop controls and instrumentation for effective monitoring of the process.

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	1													
CO2				3	2									
CO3	1	2												
CO4		2												
Avg.														

SYLLABUS

UNIT:1 (14 Hours)

Introduction :-

Fundamentals of steam generation, Quality of steam, Use of steam table, Mollier Chart Boilers ,Types, Mountings and Accessories, Combustion in boilers, Determination of adiabatic flame temperature, quantity of flue gases, Feed Water and its quality, Blow down; IBR, Boiler standards

Piping & Insulation :-

Water Line, Steam line design and insulation; Insulation-types and application, Economic thickness of insulation, Heat savings and application criteria, Refractory-types, selection

and application of refractory, Heat loss.
UNIT:2 (16 Hours) Steam Systems :- Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system, Steam Engineering Practices; Steam Based Equipments / Systems. Boiler Performance Assessment:- Performance Test codes and procedure, Boiler Efficiency, Analysis of losses; performance evaluation of accessories; factors affecting boiler performance.
UNIT:3 (10 Hours) Energy Conservation and Waste Minimization:- Energy conservation options in Boiler; waste minimization, methodology; economical viability of waste minimization Instrumentation & Control :- Process instrumentation; control and monitoring. Flow, pressure and temperature measuring and controlling instruments, its selection
Teaching Methods: Chalk& Board/ PPT/Video Lectures/Lecture by Industry Expert.
Ref. Books 1. T. D. Estop, A. McConkey, Applied Thermodynamics, Parson Publication 6th Ed 2016 2. Domkundwar; A Course in Power Plant Engineering; Dhanapat Rai and Sons 3. Yunus A. Cengel and Boles, "Engineering Thermodynamics ",Tata McGraw-Hill Publishing Co. Ltd 4th 2015 4. Book II - Energy Efficiency in Thermal Utilities; Bureau of Energy Efficiency 3rd Ed 2016 5. Book IV - Energy Performance Assessment for Equipment & Utility Systems; Bureau of Energy Efficiency 4th Ed 2015 6. Edited by J. B. Kitto & S C Stultz; Steam: Its Generation and Use; The Babcock and Wilcox Company 5th Ed 2015 7. P. Chatopadhyay; Boiler Operation Engineering: Questions and Answes; Tata McGrawHill Education Pvt Ltd, N Delhi 4th Ed 2016

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	CRYOGENIC TECHNOLOGY	**3**			**3**	

Pre -Requisite: **Engineering Thermodynamics, Heat transfer, Fluid mechanics,**

Course Outcomes: Upon successful completion of this course, students should be able to:

CO1	To relate the physics properties of materials at cryogenics parameters.
CO2	To Apply cryogenic treatments and cryogenic insulations in the technical application
CO3	To Design and analyze the Characterization of cryogenically processed materials
CO4	To evaluate & prepare Cryogenic processing of materials for different applications in the real world with a consideration for environmental hazards

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	1													
CO2				3	2									
CO3	1	2												
CO4		2												
Avg.														

SYLLABUS

UNIT:1 (10 Hours)

Introduction: Cryogenic heat transfer applications, Material Properties at cryogenic temperatures, specific heats and thermal conductivity of solid, liquid and gases, Cryogenic insulations, gas-filled and evacuated powders and fibrous materials, microsphere and multi-layer insulations.

UNIT:2 (14 Hours)

Conduction: One-dimensional steady-state and transient conduction, conduction in composite materials, thermal contact resistance, cool-down in coated surfaces and fluid-storage vessels. ; Convection: Free and forced convection over external surfaces and tubes, Heat transfer in nearcritical region and its correlations, Kapitza conductance. ; Two-Phase Heat Transfer: Flow regimes, pressure drop, Lockhart-Martinelli correlation, pool boiling, forced convection boiling

UNIT:3 (16 Hours)

Radiation: Radiation from LNG fires, free-molecular flow and heat transfer, free-molecular heat transfer in enclosures. ; Heat Exchanger: Cryogenic heat exchanger types, NTU-

effectiveness design method, Giauque- Hampson design, Plate-fin and perforated-plate heat exchanger design, effect of variable specific heat, effect of longitudinal heat conduction, effect of heat transfer from ambient, Regenerators, Regenerator design.
Teaching Methods: Chalk& Board/ PPT/Video Lectures/Lecture by Industry Expert.
Text Books 1. R.F. Barron, _Cryogenic Systems', McGraw Hill, 2015. 2. R.B. Scott, _Cryogenics Engineering', Van Nostrand & Co., 2012.
Ref. Books 1. H. Weinstock, _Cryogenic Technology', 2012. 2. K. D. Timmerhaus and T. M. Flynn., _Cryogenic Process Engineering', Plenum Press, New York, 2011 3. R. W. Vance., _Cryogenic Technology', John Wiley & Sons Inc., New York, London, 2011. 4. Sengapatha, A. Bose, _Cryogenics – Progress and Applications'

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	SOLAR ENERGY TECHNOLOGY	3			3	

Pre -Requisite: **Thermodynamics, Advanced Mathematics**

Course Outcomes: Upon successful completion of this course, students should be able to:

CO1	To recall various alternate energy sources and its uses.
CO2	To design the various Components of solar energy systems and analysis the collector performance.
CO3	To understand Solar thermal systems applications to power generation, heating and cooling
CO4	To analyze the economics of solar and wind energy systems.

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	1		3											
CO2					2									
CO3	1	2												
CO4		2												
Avg.														

SYLLABUS

UNIT:1 (14 Hours)

Current alternate energy sources-thermodynamic view point and conversion methods. Components of solar energy systems, collector performance. Radiation and meteorological data processing, long term conversion factors. System configurations and system performance prediction.

UNIT:2 (12 Hours)

Simulations, design methods. System design and optimizations. Solar thermal systems applications to power generation, heating and cooling.

UNIT:3 (14 Hours)

Solar passive devices solar stills, ponds, greenhouse, dryers. Trombe wall, overhangs and winged walls. Wind energy conversion systems. Economics of solar and wind energy systems.

Teaching Methods: Chalk& Board/ PPT/Video Lectures/Lecture by Industry Expert.
Text Books 1. S. P. Sukhatme, Solar Energy - Principles of thermal collection and storage, second edition, Tata McGraw-Hill, New Delhi, 2016 2. J. A. Duffie and W. A. Beckman, Solar Engineering of Thermal Processes, second edition, John Wiley, New York, 2011
Ref. Books 1. D. Y. Goswami, F. Kreith and J. F. Kreider, Principles of Solar Engineering, Taylor and Francis, Philadelphia, 2010 2. D. D. Hall and R. P. Grover, Biomass Regenerable Energy, John Wiley, New York, 2017. 3. J. Twidell and T. Weir, Renewable Energy Resources, E & F N Spon Ltd, London, 2016.

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	COMPUTATIONAL METHODS IN THERMAL ENGINEERING	3			3	

Pre -Requisite: **Engineering Thermodynamics, Heat transfer Fluid mechanics, Mathematics**

Course Outcomes: Upon successful completion of this course, students should be able to:

CO1	Understand the stepwise procedure to completely solve a fluid dynamics problem using computational methods.
CO2	Derive the governing equations and understand the behavior of the equations
CO3	Analyze the consistency, stability and convergence of various discretisation schemes for parabolic, elliptic and hyperbolic partial differential equations
CO4	Analyze variations of SIMPLE schemes for incompressible flows and Variations of Flux Splitting algorithms for compressible flows.

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	1	3												
CO2														
CO3	1	2												
CO4		2												
Avg.														

SYLLABUS

UNIT:1 (12 Hours)

Introduction: Concepts of consistency, stability, and convergence of numerical schemes. Various finite difference and finite element methods and their applications to fundamental partial differential equations in engineering and applied sciences. Case studies selected from fluid mechanics and heat transfer.

UNIT:2 (12 Hours)

Finite Difference Method: Classification, Initial and Boundary conditions, Forward, Backward difference, Uniform and non-uniform Grids, Grid Independence Test. Basic finite difference schemes. Boundary treatments. Fourth order RK methods and Predictor-corrector methods and Nachsheim-Swigert iteration with applications to flow and heat transfer.

UNIT:3 (16 Hours)

Parabolic and hyperbolic problems: Model problems and stability estimates. Examples of the methods of lines. The Lax-Richtmyer equivalence theorem. Stability analysis. Discrete

Fourier series. Von- Neumann stability analysis. Consistency, convergence and error estimates. Keller Box and Smith's method with applications to thermal boundary layers. ; Convection dominated problems: The failure of standard discretization, Upwinding and Higher order methods.
Teaching Methods: Chalk& Board/ PPT/Video Lectures/Lecture by Industry Expert.
Text Books 1. K.Muralidhar and T.Sundararajan, "*Computational Fluid Flow and Heat Transfer*", Narosa Publishing House ,New Delhi2015. 2. P.S., Ghoshdasdidar, "*Computer Simulation of flow and heat transfer*" TMH Ltd., 2017.
Ref. Books 1. S.V. Patankar, "*Numerical heat transfer fluid flow*", Hemisphere Publishing Co, 2010. 2. D.A. Anderson, I.I. Tannehill, and R.H. Pletcher, *Computational Fluid Mechanics and Heat Transfer*, Hemishphere Publishing Corporation, New York, USA, 2014. 3. C.A.J. Fletcher, ,"*Computational Techniques for Fluid Dynamics* 4. *Fundamental and General Techniques*, Springer-Verlag,2017.

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	EXPERIMENTAL METHODS IN THERMAL ENGINEERING	3			3	

Pre -Requisite **;Engineering Thermodynamics, Heat transfer, Fluid mechanics, Mathematics**

Course Outcomes: Upon successful completion of this course, students should be able to:

CO1	To identify the suitable instrument for measuring transport parameters and estimate error
CO2	To detect suitable range of pressure gauge and compute its dynamic response
CO3	To distinguish different flow visualization methods and temperature measurements
CO4	To determine thermal conductivity in solids, liquids and gases and radiation measurements

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	1													
CO2	3													
CO3	1	2												
CO4		2												
Avg.														

SYLLABUS

UNIT:1 (10 Hours)

Probability and Statistics: Fundamental definition, Conditional probability and Bayes theorem, Mean, median, mode and standard deviation, Random variables, Poisson, Normal and Binomial distributions, Regression analysis, Elements of sampling theory.

UNIT:2 (16 Hours)

Introduction to measurement: Importance of measurement and experimentation, calibration, uncertainty analysis, error propagation, Gaussian or Normal distribution, confidence level, regression analysis, correlation coefficient, Chi-Square test, zeroth-, first- and second-order systems. Pressure Measurement: Manometers, bourdon tube pressure gage, diaphragm gage, bellow gage, McLeod gage, Pirani gage and ionization gage. Flow measurement: Positive displacement flow meters, venture, orifice, impact tube, flow nozzle, sonic nozzle, rotameter, pitot static tube, hot-wire anemometer, laser Doppler anemometer, flow visualization techniques – shadowgraph, Schlieren and interferometer

UNIT:3 (16 Hours)

Temperature measurement: Hg-in-glass thermometer, RTD, thermistor, thermocouple, thermopile, liquid-crystal thermography, optical pyrometer. Thermal conductivity measurement: Guarded hot plate apparatus, heat flux meter. Data acquisition and processing: Signal conditioning, data transmission, storage, A to D and D to A conversion.
Teaching Methods: Chalk& Board/ PPT/Video Lectures/Lecture by Industry Expert.
Text Books 1. J. P. Holman, Experimental Methods for Engineers
Ref. Books 1. T.G. Beckwith, J.H. Lienhard V,R. D. Marngoni, Mechanical Measurements.¬ E.O. Doebelin, Measurement systems, Application and Design

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	COMPUTATIONAL FLUID DYNAMICS	**3**			**3**	

Pre -Requisite: **Engineering Thermodynamics , Fluid mechanics, Mathematics**

Course Outcomes: Upon successful completion of this course, students should be able to:

CO1	Ability to Understand the solution of aerodynamic flows. Appraise & compare current CFD software. Simplify flow problems and solve them exactly.
CO2	Able to analyze the concept of discrete representation of flow and heat transfer domain
CO3	Ability to solve the Error analyze in discretization using FVM/FDM
CO4	To Understand the both flow physics and mathematical properties of governing Navier-Stokes equations and define proper boundary conditions for solution

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	1													
CO2		3												
CO3	2	3												
CO4	3	2												
Avg.														

SYLLABUS

UNIT:1 (12 Hours)

Introduction: Basic tools of CFD, Numerical Vs experimental tools. ; Mathematical Behavior of PDEs: Parabolic, Hyperbolic and Elliptic PDEs. ; Methodology of CFDHT: Discrete representation of flow and heat transfer domain: Grid generation, Governing equations and boundary conditions based on FVM/FDM, Solution of resulting set of linear algebraic equations.

UNIT:2 (14 Hours)

Graphical representation and analysis of qualitative results, Error analysis in discretization using FVM/FDM. ; Solution of 1-D/2-D steady/unsteady: Diffusion problems, Convection problems, Convection-diffusion problems, source term linearization.

UNIT:3 (16 Hours)

Explicit and Implicit Approach: Explicit and implicit formulation of unsteady problems, Stability analysis. ; Solution of Navier-Stokes Equations for Incompressible Flows: Staggered and collocated grid system, SIMPLE and SIMPLER algorithms. ; Special Topics in CFDHT: Numerical Methodology for Complex Geometry, Multi-block structured grid system,

Solution of phase change Problems.
Teaching Methods: Chalk& Board/ PPT/Video Lectures/Lecture by Industry Expert.
Text Books 1. S.V. Patankar, *Numerical Heat Transfer and Fluid Flow*, Taylor and Francis, ISBN-10: 0891165223.
Ref. Books 1. H. K. Versteeg and W. Malalasekra, *Introduction to Computational Fluid Dynamics: The Finite Volume Method,* Prentice Hall (2nd Edition), ISBN-10: 0131274988. 2. Jr. D. A. Anderson, *Computational Fluid Mechanics and Heat Transfer* by McGraw-Hill Education 3. M. N. Ozisik, *Finite Difference Method,* CRC (4th Edition).

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	DESIGN OF HEAT EXCHANGERS	3			3	

Pre -Requisite: Thermodynamics and Fluids Fundamentals

Course Outcomes: Upon successful completion of this course, students should be able to:

CO1	Students will demonstrate a basic understanding of several types of heat exchangers that will include shell-and-tube, double pipe, plate-and-frame, finned tube, and plate-fin heat exchangers, Heat pipes.
CO2	Students will design and analyses of shell-and-tube double pipe, compact, plate heat exchangers.
CO3	Students will demonstrate the performance degradation of heat exchangers subject to fouling.
CO4	

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	1		1		1									
CO2	1	2	1											
CO3	1				1									
CO4	1	2	3	2	2									
Avg.														

SYLLABUS

UNIT:1 (16 Hours)

Heat Exchangers – Classification according to transfer process, number of fluids, surface compactness, and construction features. Tubular heat exchanger, plate type heat exchangers, extended surface heat exchangers, heat pipe, Regenerators. Classification according to flow arrangement: counter flow, parallel flow, cross flow exchanger. Heat exchanger design methodology, assumption for heat transfer analysis, problem formulation, e-NTU method, P-NTU method, Mean temperature difference method, fouling of heat exchanger, effects of fouling, categories of fouling, fundamental processes of fouling.

UNIT:2 (10 Hours)

Double Pipe Heat Exchangers: Thermal and Hydraulic design of inner tube, Thermal and hydraulic analysis of Annulus, Total pressure drop

Compact Heat Exchangers: Thermal and Hydraulic design of compact heat exchanger
UNIT:3 (16 Hours) Shell and Tube heat exchangers – Tinker's, kern's, and Bell Delaware's methods, for thermal and hydraulic design of Shell and Tube heat exchangers Mechanical Design of Heat Exchangers – design standards and codes, key terms in heat exchanger design, material selection, and thickness calculation for major components such as tube sheet, shell, tubes, flanges and nozzles. Introduction to simulation and optimization of heat exchangers, flow induced vibrations.
Teaching Methods: Chalk& Board/ PPT/Video Lectures/Lecture by Industry Expert.
Text Books 1. G.C. Oates, *Aerothermodynamics of Aircraft Engine Components*, AIAA Education Series, New York, 2015. 2. W.W. Bathie, *Fundamentals of Gas Turbines*- John Wiley & Sons, 2014.
Ref. Books 1. Ramesh K. Shah and Dusan P. Sekulic, "Fundamentals of Heat Exchanger Design" John Wiley & sons Inc., 2013. 2. D.C. Kern, "Process Heat Transfer", McGraw Hill, 2010. 3. Sadik Kakac and Hongton Liu, "Heat Exchangers: Selection, Rating and Thermal Design" CRC Press, 2017. 4. A .P. Frass and M.N. Ozisik, "Heat Exchanger Design", McGraw Hill, 2014 5. Afgan N. and Schlinder E.V. "Heat Exchanger Design and Theory Source Book". 6. T. Kuppan, "Hand Book of Heat Exchanger Design". 7. "T.E.M.A. Standard", New York, 2010. 8. G. Walkers, "Industrial Heat Exchangers-A Basic Guide", McGraw Hill, 2012.

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	MODELLING OF IC ENGINE	**3**			**3**	

Pre -Requisite: Thermodynamics and Fluids Fundamentals

Course Outcomes: Upon successful completion of this course, students should be able to:

CO1	Students will demonstrate a basic understanding of several types of engine models that will include zero dimensional thermodynamic model, one dimensional and multi-dimensional, single zone, two zone etc models.
CO2	Students will develop models and simulate them for diesel engine petrol engine, gas engine.
CO3	Students will demonstrate the performance evaluation and emission standards for such modeled engines
CO4	

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3		2											
CO2		3	1											
CO3		3												
CO4	3	1												
Avg.														

SYLLABUS

UNIT:1 (10 Hours)

Fundamentals: Governing equations, Equilibrium charts of combustion chemistry, chemical reaction rates, and approaches of modeling, model building and integration methods, gas exchange through valves, engine and porting geometry, exhaust gas recirculation, valve lift curves.

UNIT:2 (16 Hours)

Thermodynamic Combustion Models of CI Engines: Single zone models, premixed and diffusive combustion models, combustion heat release using wiebe function, wall heat transfer correlations, ignition delay, internal energy estimations, two zone model, application of heat release analysis.

Fuel spray behavior: Fuel injection, spray structure, fuel atomization, droplet turbulence interactions, droplet impingement on walls. Modeling of charging system: Constant

pressure and pulse turbo charging, compressor and turbine maps, charge air cooler.
UNIT:3 (14 Hours) Mathematical models of SI Engines: Simulation of Otto cycle at full throttle, part throttle and supercharged conditions. Progressive combustion, Auto ignition modeling, single zone models, mass burning rate estimation, SI Engine with stratified charge. Friction in pumping, piston assembly, bearings and valve train etc. friction estimation for warm and warm up engines.
Teaching Methods: Chalk& Board/ PPT/Video Lectures/Lecture by Industry Expert.
Ref. Books 1. Haywood, "I.C. Engines", Mc Graw Hill. 2. Ramos J (2009) Internal Combustion Engine Modeling. Hemisphere Publishing Company 3. C. D. Rakopoulos and E. G. Giakoumis, "Diesel Engine Transient 4. Operation Principles of Operation and Simulation Analysis", Springer, 2009. 5. V. Ganeshan, "Internal Combustion Engines", Tata McGraw Hill, New Delhi, 2016. 6. P.A. Lakshminarayanan and Y. V. Aghav, " Modelling Diesel Combustion" Springer, 2014 7. Bernard Challen and Rodica Baranescu, "Diesel Engine Reference Book" ButterworthHeinemann, 2011.

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	AIRCRAFT AND ROCKET PROPULSION	3			3	

Pre -Requisite: Thermodynamics and Fluids Fundamentals

Course Outcomes: Upon successful completion of this course, students should be able to:

CO1	To be familiarity with common types of aircraft and spacecraft propulsion systems
CO2	Able to use of thermodynamic cycle analysis, including the thermodynamic treatment of chemically reacting systems
CO3	To understand the preliminary cycle design and performance analysis of propulsion systems for both aircraft and spacecraft
CO4	To acquire the knowledge of the basic operation and design requirements of propulsion turbo machinery components (inlets, compressors, combustors, turbines, afterburners, and nozzles).

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3		1											1
CO2		2												
CO3	1		3											
CO4	3		2											
Avg.														

SYLLABUS

UNIT:1 (10 Hours)

Introduction, Rocket system and aerodynamics of rockets, Fundamentals of gas turbine engines, Illustration of working principles of gas turbine engine, Propulsion system and operating principle, Thermodynamics of propulsion system, Engine performance parameters

UNIT:2 (14 Hours)

The ramjet cycle, Working principles of ideal ramjet cycle, The turbojet cycle, Working principles of turbojet cycle, Non-ideal turbojet cycle, Axial flow fans and compressors, Polytrophic efficiency of compression, Calculation of stage performance and overall performance, Working principles of turbofan cycle, Rocket performance

UNIT:3 (16 Hours)

Introduction and working principles of multistage rocket, Solid propellant rockets, Liquid propellant rockets ,Thrust control in liquid rockets Cooling in liquid rockets, Hybrid rockets, Limitations of hybrid rockets, Relative advantages of liquid rockets over solid rockets
Teaching Methods: Chalk& Board/ PPT/Video Lectures/Lecture by Industry Expert.
Text Books 3. G.C. Oates, *Aerothermodynamics of Aircraft Engine Components*, AIAA Education Series, New York, 2015. 4. W.W. Bathie*, Fundamentals of Gas Turbines*- John Wiley & Sons, 2014.
Ref. Books 1. M.L. Mathur, and R.P. Sharma, *Gas Turbine Jet and Rocket Propulsion*, Standard Publishers and Distributors, Delhi, 2017. 2. P.G. Hill, *Mechanics and Thermodynamics of Propulsion*- Addison Wesley, 2010. 3. S.M. Yahya, *Fundamentals of Compressible Flow* - John Wiley, New York, 2012. 4. A.K. Mohanty, *Fluid Mechanics* - Prentice Hall, New Delhi, 2003.

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	Advanced Thermal Engg. Laboratory	**3**			**3**	

Pre -Requisite: **Engineering Thermodynamics I, Mathematics**

Course Outcomes: Upon successful completion of this course, students should be able to:

CO1	Students will acquire hands on experience on the various test-rigs, Experimental set up.
CO2	Students should able to measure the various technical parameters by instrument and by mathematical relationship.
CO3	Students will able to identify the effect of various parameters on the system and able to correlate them.

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3													
CO2		1												
CO3	2		2											
CO4		2	3											
Avg.														

SYLLABUS

The lab practice consists of the tutorials and experiments as decided by the course supervisors of the Program Core Courses (PCC) namely Fluid Dynamics, Advanced Heat Transfer, Thermodynamics and Combustion, Refrigeration and Cryogenics.

The lab practice consists of the tutorials and experiments as decided by the course supervisors of the Program Core Courses (PCC) namely Design of Heat Exchangers and Computational Fluid Dynamics, Modelling of I C Engine.

Teaching Methods: Chalk& Board/ PPT/Video Lectures/Lecture by Industry Expert.

Text Books

Ref. Books

III SEMESTER [SECOND YEAR]

Sl. No.	Course Category	Course Code	Course Title	L	T	P	Credits
THEORY							
1	PE		Boiling,Condensation And Two-Phase Flow	3	0	0	3
			Advanced Mathematical Methods in Engineering				
			Theory Of Combustion And Emission				
			Finite Element Methods In Thermal Engineering				
2	OE		Project Management And Costing	3	0	0	3
			Business Analytics				
			Industrial Safety				
			Operations Research				
			Composite Materials				
			Waste to Energy				
PRACTICAL / SESSIONAL							
3	ES	MTEES3120	Dissertation Phase-I	0	0	20	10
TOTAL				**6**	**0**	**20**	**16**

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	BOILING, CONDENSATION AND TWO-PHASE FLOW	**3**			**3**	

Pre -Requisite: **Engineering Thermodynamics, Heat transfer, Fluid mechanics**

Course Outcomes: Upon successful completion of this course, students should be able to:

CO1	Identify the mechanisms of heat transfer during phase change processes
CO2	Design heat transfer equipment in which phase change (boiling or condensation) takes place
CO3	To understand the two Fluid-Population Balance techniques.
CO4	Able to understand the laminar film condensation on a vertical plate

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3			3										
CO2		1												
CO3	2		2											
CO4		2	3											
Avg.														

SYLLABUS

UNIT:1 (10 Hours)

Introduction, Flow Regimes, Homogeneous Flow, Drift Flux, Separated Flow, Bubbly, Slug, Annular and Stratified Flow, Measurement of Void Fraction. Signal Analysis,

UNIT:2 (14 Hours)

Two Fluid-Population Balance technique, Volume of Fluid Method, Lattice Boltzmann Model, Smoothed Particle Hydrodynamics. Molecular Dynamics, Boiling, Condensation, Solid-Liquid Flow, Gas-Solid-Flow.

UNIT:3 (16 Hours)

Condensation and Boiling

Dimensionless parameters, boiling modes, correlations, Forced convection boiling, laminar film condensation on a vertical plate, turbulent film condensation

Teaching Methods: Chalk& Board/ PPT/Video Lectures/Lecture by Industry Expert.

Text Books

1. Ghiaasiaan,S. M., Two-Phase flow,Boiling, and Condensation, Cambridge University Press

2. 2.Brennen, C.E., Fundamentals of Multiphase Flow, Cambridge University Press

Ref. Books

1. Collier, J. G. and Thome, J. R., Convective Boiling and Condensation, 5th ed., Oxford University Press
2. Wallis, G.B., One Dimensional Two Phase Flow, McGraw Hill Higher Education

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	ADVANCED MATHEMATICAL METHODS IN ENGINEERING	3			3	

Pre -Requisite:

Course Outcomes: Upon successful completion of this course, students should be able to:

CO1	Students will be able to analyze and develop the mathematical model of thermal system.
CO2	Student should able analyze the reliability and maintainability of the series and parallel thermal system.
CO3	Students will be able to solve differential equations using numerical techniques.

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3													
CO2		1	2											
CO3	2		2											
CO4		2	3											
Avg.														

SYLLABUS

UNIT:1 (16 Hours)

Ordinary Differential Equations:
First-order equations (Linear, Equidimensional, Separable Exact, Homogeneous,); Second-order linear differential equations (homegeneous and nonhomogeneous); Solution methods such as undertermined coefficients and variation o parameters.

Partial Differential Equations:
First order partial differential equations; Second order partial differential equations; Canonical forms; Fourier series, Second order equation (Parabolic, Elliptic and Hyperbolic) in rectangular, cylindrical polar and spherical coordinate systems; Solution techniques such as separation of variables, eigenfunction expansions, integral transforms (Fourier and

Laplace transforms); D'Alembert's solution for the Wave equation; Maximum principle for Elliptic equations; Variational methods for approximate solutions of differential equations.
UNIT:2 (10 Hours) Standard discrete and continuous distributions like Binomial, Poisson, Normal, Exponential etc. Central Limit Theorem and its significance. Some sampling distributions like c2, t, F. ANOVA: One – way, Two – way with/without interactions, Latin
UNIT:3 (14 Hours) Squares ANOVA technique, Principles of Design Of Experiments, some standard designs such as CRD, RBD, LSD. Some of the relevant topics required for ANOVA (sample estimates and test hypothesis) may also be included.
Teaching Methods: Chalk& Board/ PPT/Video Lectures/Lecture by Industry Expert.
Ref. Books 1. J.B. Doshi, "Differential Equations for Scientists and Engineers", Narosa, 2010. 2. Peter O'Neil, "Advanced Engineering Mathematics", Seventh Edition, Cengage Learning, 2012 (Indian Edition). 3. Michael Greenberg, "Advanced Engineering Mathematics", Second Edition, Pearson Education, 2012 (Indian Edition). 4. Jennings. A., Matrix Computation for Engineers and Scientists. John Wiley and Sons, 2012. 5. Prem.K.Kythe, Pratap Puri, Michael R.Schaferkotter, Introduction to Partial Differential Equations and Boundary Value problems with Mathematics, CRC Press, 2002. 6. Kreyszig, Erwin, I.S., Advanced Engineering Mathematics, Wiley, 2010. 7. Ramamurthy. V., Computer Aided Design in Mechanical Engineering., Tata McGraw Hill Publishing Co., 2017 8. Fundamental Concepts in the Design of Experiments, 5th Ed., by Hicks and Turner 9. Devore, Jay L., Probability and Statistics for Engineering and the Sciences, 9th edition, Brooks- Cole (2016)

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	THEORY OF COMBUSTION AND EMISSION	**3**			**3**	

Pre -Requisite: **Engineering Thermodynamics, RAC, IC engines, Mathematics**

Course Outcomes: Upon successful completion of this course, students should be able to:

CO1	To understand various concept of refrigeration and power cycles
CO2	To understand various combustion mechanism in SI and CI engines, and to analysis ignition and burning rate.
CO3	To understand fundamentals of bubbling bed, types of gas and liquid burners, gas turbine combustion systems and various combustion modeling.
CO4	To design of combustion systems for boilers, furnaces, gas turbines and internal combustion engines and to determine combustion chamber performance

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3			2										
CO2		1												
CO3	2		2											
CO4		2	3											
Avg.														

SYLLABUS

UNIT:1 (10 Hours)

CYCLE ANALYSIS; Gas, steam and combined power cycles, refrigeration and air conditioning cycles, second law analysis.

UNIT:2 (14 Hours)

COMBUSTION THEORY ; Fuels and types, combustion process, combustion mechanism, adiabatic flame temperature, flame propagation, stability, kinetics, combustion aerodynamics, gaseous detonations, flame ignition and extinction and condensed phase combustion, combustion in SI and CI engines, ignition and burning rate analysis.

UNIT:3 (16 Hours)

COMBUSTION SYSTEMS ; Solid burning equipments, stokers, pulverized coal burning systems, cyclone combustors, emissions, types of fluidized beds, fluidized bed combustion, fundamentals bubbling bed, gas and liquid burners types, gas turbine combustion systems, combustion modeling.

DESIGN OF COMBUSTION SYSTEMS ; Design of combustion systems for boilers, furnaces, gas turbines and internal combustion engines, combustion chamber performance. PROPELLANT SYSTEMS; Types, theory of combustion, energy balance calculations
Teaching Methods: Chalk& Board/ PPT/Video Lectures/Lecture by Industry Expert.
Text Books 1. C.R. Ferguson and A.T. Kirk Patrick, —*Internal Combustion Engines*_, John Wiley & Sons. Inc. 2011.
Ref. Books 1. Stephen R Turns, —*Introduction to Combustion: Concepts and Applications*_, McGraw Hill, 2010 2. G.L. Borman and K.N. Ragland, —*Combustion Engineering*_, McGraw Hill, 2017. 3. D.Winterbone, —Advanced Thermodynamics for Engineers_, Elsevier, 2016

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	FINITE ELEMENT METHODS IN THERMAL ENGINEERING	3			3	

Pre -Requisite: Thermodynamics and Fluids Fundamentals

Course Outcomes: Upon successful completion of this course, students should be able to:

CO1	To apply basic principles of finite element analysis procedure
CO2	To understand the theory and characteristics of finite elements that represent engineering structures
CO3	To apply finite element solutions to structural, thermal, dynamic problem to Develop the knowledge and skills needed to effectively evaluate finite element analyze performed by others.
CO4	To represent the model complex geometry problems and solution techniques.

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	1	1	2		1									
CO2			2	1	1									
CO3	1	3	1	1										
CO4	1	1						2						
Avg.														

SYLLABUS

UNIT:1 (16 Hours)

Introduction to FEM: basic concepts, historical back ground, application of FEM, general description, comparison of fem with other methods, variational approach, Co-ordinates, basic element shapes, interpolation function. Rayleigh- Ritz method, properties of stiffness matrix, treatment of boundary conditions, solution of system of equations, shape functions . 1-D structural problems – axial bar element – stiffness matrix, load vector, temperature effects, Quadratic shape function. Analysis of Trusses – Plane Truss and Space Truss elements. Analysis of beams – Hermite shape functions – stiffness matrix – Load vector – Problems – analysis

UNIT:2 (14 Hours)

2-D problems –CST, force terms, Stiffness matrix and load vector, boundary conditions, Isoparametric element – quadrilateral element, Shape functions – Numerical Integration 3-

D problems – Tetrahedran element – Jacobian matrix – Stiffness matrix
UNIT:3 (10 Hours) Scalar field problems - 1-D Heat conduction – 1-D fin element – 2-D heat conduction Problems Dynamic considerations, Dynamic equations- consistent mass matrix-Eigen Values, Eigen Vector, natural frequencies-mode shapes-modal analysis.
Teaching Methods: Chalk& Board/ PPT/Video Lectures/Lecture by Industry Expert.
Text Books 1. Introduction to finite elements in engineering – Tirupathi K. Chandrupatla and Ashok 2. 2. D. Belagundu. /Prentice- Hall India
Ref. Books 1. The finite element methods in Engineering – S.S. Rao _ Pergamon, New York 2. An Introduction to Finite Element Methods – J. N. Reddy – Mc Grawhill 3. The Finite element method in engineering science – O.C. Aienkowitz, Mc Grawhill 4. Concepts and applications of finite element analysis – Robert Cook./ John Wiley & Sons 5. Finite Element Procedures in Engineering analysis – K.J Bathe

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	PROJECT MANAGEMENT AND COSTING	**3**			**3**	

Pre -Requisite: **Mathematics, Basics of Costing**

Course Outcomes: Upon successful completion of this course, students should be able to:

CO1	Gain the knowledge and confidence to manage a project from beginning to end
CO2	Identify the different stages involved in project planning
CO3	To understand the concept of Project Scheduling and to analysis the Project Feasibility
CO4	To understand the concept of Break even analysis and overhead allocation Techniques.

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1										2	3			
CO2									1	1	3			
CO3									1	1	2			
CO4										1	2			
Avg.														

SYLLABUS

UNIT:1 (10 Hours)

Project Feasibility Analysis: Technical feasibility, commercial and financial viability, Environment Analysis.

Project Engineering: Project Management Techniques : PERT, CPM, Project Scheduling Crashing, PERT / COST, LOB.

UNIT:2 (14 Hours)

Projects Financing alternatives, Sources of finance, their advantages, Choice of Financing mix, Capital budgeting.

Costing: Fixed and variable cost. Break even analysis, Overhead allocation Techniques.

UNIT:3 (16 Hours)

Project Organisation, management and control: Project organisation and control staffing, monitoring: cost, time and control and progress monitoring techniques.

Product and service pricing: Availability and quality based pricing for services.
Teaching Methods: Chalk& Board/ PPT/Video Lectures/Lecture by Industry Expert.
Text Books 1. Prasanna Chandra: Project Engineering and Management, Prentice Hall
Ref. Books 1. Levy and Weist: Management guide to PERT / CPM, Prentice Hall

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	BUSINESS ANALYTICS	**3**			**3**	

Pre -Requisite:

Course Outcomes: Upon successful completion of this course, students should be able to:

CO1	Students will demonstrate knowledge of data analytics.
CO2	Students will demonstrate the ability of think critically in making decisions based on data and deep analytics.
CO3	Students will demonstrate the ability to use technical skills in predicative and prescriptive modeling to support business decision-making.
CO4	Students will demonstrate the ability to translate data into clear, actionable insights.

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1		3												
CO2			1											
CO3		2		2										
CO4			2	3										
Avg.														

SYLLABUS

UNIT:1 (16 Hours)

Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.

Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.
Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression. Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.

UNIT:2 (12 Hours)

Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes. Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization. Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.
UNIT:3 (14 Hours) Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model. Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making. Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.
Teaching Methods: Chalk& Board/ PPT/Video Lectures/Lecture by Industry Expert.
Ref. Books 1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press. 2016 2. 2. Business Analytics by James Evans, persons Education.2nd Ed,2015

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	INDUSTRIAL SAFETY	**3**			**3**	

Pre -Requisite:

Course Outcomes: Upon successful completion of this course, students should be able to:

CO1	To provide exposure to the students about safety and health provisions related to hazardous processes as laid out in Factories act 1948.
CO2	To familiarize students with powers of inspectorate of factories.
CO3	To help students to learn about Environment act 1986 and rules framed under the act.
CO4	To provide wide exposure to the students about various legislations applicable to an industrial unit.

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3													
CO2		2		1										
CO3	2			3										
CO4			2											
Avg.														

SYLLABUS

UNIT:1 (16 Hours)

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

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

UNIT:2 (14 Hours) Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods. Fault tracing: Fault tracing-concept and importance, decision treeconcept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic,automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.
UNIT:3 (12 Hours) Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance
Teaching Methods: Chalk& Board/ PPT/Video Lectures/Lecture by Industry Expert.
Ref. Books 1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services. 2. Maintenance Engineering, H. P. Garg, S. Chand and Company. 3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication. 4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	OPERATIONS RESEARCH	**3**			**3**	

Pre -Requisite:

Course Outcomes: Upon successful completion of this course, students should be able to:

CO1	Students should able to apply the dynamic programming to solve problems of discreet and continuous variables.
CO2	Students should able to apply the concept of non-linear programming
CO3	Students should able to carry out sensitivity analysis
CO4	Student should able to model the real world problem and simulate it.

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3													
CO2		2	2	1										
CO3	3		1	2										
CO4	2		1											
Avg.														

SYLLABUS

UNIT:1 (16 Hours)

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

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

UNIT:2 (12 Hours)

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

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

UNIT:3 (10Hours)

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

Teaching Methods: Chalk& Board/ PPT/Video Lectures/Lecture by Industry Expert.
Ref. Books 1. H.A. Taha, Operations Research, An Introduction, PHI, 2018 2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 2012. 3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2018 4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009 5. Pannerselvam, Operations Research: Prentice Hall of India 2015 6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	COMPOSITE MATERIALS	**3**			**3**	

Pre -Requisite:

Course Outcomes: Upon successful completion of this course, students should be able to:

CO1	Explain concept of the composite materials and its terminologies used and the different processing/ fabrication techniques of composite materials especially fiber components
CO2	Describe the polymer materials and its applications which are having better improved properties to suit with conventional materials.
CO3	Analyze the fiber and matrix properties for structural applications.
CO4	Evaluate the optimum fabrication techniques for metal matrix materials and powder metallurgy techniques to enhance material properties.

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3		2	2										
CO2	3	2												
CO3	3	1	2											
CO4	2		2											
Avg.														

SYLLABUS

UNIT:1 (16 Hours)

UNIT:1 (16 Hours)

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

EINFORCEMENTS: Preparation-layup, curing, properties and applications of glass fibers carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle einforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures

Isostrain and Isostress conditions..
UNIT:2 (14 Hours) Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications. Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.
UNIT:3 (10 Hours) Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.
Teaching Methods: Chalk& Board/ PPT/Video Lectures/Lecture by Industry Expert.
Ref. Books 1. Hand Book of Composite Materials-ed-Lubin. 2. Composite Materials – K.K.Chawla. 3. Composite Materials Science and Applications – Deborah D.L. Chung. 4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	WASTE TO ENERGY	**3**			**3**	

Pre -Requisite:

Course Outcomes: Upon successful completion of this course, students should be able to:

CO1	Identify renewable energy sources and their utilization.
CO2	Understand concepts of Fuel cells and their applications
CO3	Identify methods of energy storage
CO4	Compare energy utilization from wind energy, geothermal energy, biomass, biogas and hydrogen.

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	1			2										
CO2	1	2	2											
CO3	1			2										
CO4	1	2		2										
Avg.														

SYLLABUS

UNIT:1 (16 Hours)

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

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

UNIT:2 (12 Hours)

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

Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs,

Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.
UNIT:3 (14 Hours) Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.
Teaching Methods: Chalk& Board/ PPT/Video Lectures/Lecture by Industry Expert.
Ref. Books 1. . Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 2010. 2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 2013. 3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 2011. 4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 2016.

IV SEMESTER [SECOND YEAR]

Sl. No.	Course Category	Course Code	Course Title	L	T	P	Credits
PRACTICAL / SESSIONAL							
1	ES		Dissertation Phase-II	0	0	32	16
TOTAL				**0**	**0**	**32**	**16**

Total Credits for the programme = 18 + 18 +16 +16 = 68

Audit course 1 & 2

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