ShriShankaracharya Technical Campus,

ShriShankaracharya Group of Institutions

(An Autonomous Institute affiliated to Chhattisgarh Swami Vivekanand Technical University Bhilai)

SCHEME OF EXAMINATION AND SYLLABUS

SEMESTER 2, MTech, MECHANICAL(THERMAL ENGINEERING)

Effective from the Session 2020-2021

S. No.	Board of Study	Sub. Code	SUBJECT	PERIODS PER WEEK			SCHEME OF EXAM Theory/Practical			TOTAL MARKS	Credit L+(T+P)/ 2
				L	T	P	ESE	CT	TA		
1.	Mechanical Engg	ME229201	Computational Fluid Dynamics	3	2	-	100	20	20	140	4
2.	Mechanical Engg	ME229202	Refrigeration & Air Conditioning System Design	3	2	,	100	20	20	140	4
3.	Mechanical Engg	ME229203	Modeling and Simulation of Thermal Systems	3	2	,	100	20	20	140	4
4.	Mechanical Engg	ME229204	Thermal Measurements and Process Controls	3	2	,	100	20	20	140	4
5	Professional Elective			3	2	,	100	20	20	140	4
6.	Mechanical Engg	ME229291	Computational Fluid Dynamics LAB	,	,	4	75	,	75	150	2
7.	Mechanical Engg	ME229292	Measurement lab	,	,	4	75	,	75	150	2
			Total	**15**	**10**	**8**	**650**	**100**	**250**	**1000**	**24**

L – Lecture, T – Tutorial, P – Practical, ESE, End Semester Exam, CT, Class Test TA – Teacher's Assessment

List of Electives- II

Professional Elective			
S No	**Board of Study**	**Subject Code**	**Subject**
1	Mechanical Engg.	ME229221	Energy Resources, Conversion and Management
2	Mechanical Engg.	ME229222	Hydraulic and Pneumatic control systems
3	Mechanical Engg.	ME229223	Theory of Combustion and emission
4	Mechanical Engg.	ME229224	Advance Gas Dynamics
5	Mechanical Engg.	ME229225	Optimization Techniques & Design of Experiments

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SEMESTER 2, MTech, MECHANICAL(THERMAL ENGINEERING)

Subject Code ME229201	Computational Fluid Dynamics	L = 3	T = 2	P = 0	Credits = 4
Evaluation Scheme	ESE	CT	TA	Total	ESE Duration
	100	20	20	140	3 Hours

Course Objectives	Course Outcomes
1. To develop basic governing equations for fluid and heat flow by examining the physical boundary conditions. 2. To construct finite difference based equations according to the nature (i.e. elliptic, parabolic and hyperbolic) of the flow problem. 3. To decide and implement various implicit and explicit CFD schemes to solve steady and unsteady 1/2/3 dimensional fluid problems. 4. To solve incompressible flow problems with considerations of geometry, mesh, flow physics, physical boundary conditions, turbulence, etc.	**Student will be able to:** **CO1** Develop basic governing equations for fluid and heat flow by examining the physical boundary conditions. **CO2** Construct finite difference based equations according to the nature (i.e. elliptic, parabolic and hyperbolic) of the flow problem. **CO3** Decide and implement various implicit and explicit CFD schemes to solve steady and unsteady 1/2/3 dimensional fluid problems. **CO4** Solve incompressible flow problems with considerations of geometry, mesh, flow physics, physical boundary conditions, turbulence, etc.

Unit I Introduction: Conservation equation mass momentum and energy equations convective forms of the equations and general description. **[7 Hrs.] CO1, CO2**

Unit II Classification and Overview of Numerical Method: Classification into various types of equation parabolic elliptic and hyperbolic boundary and initial conditions over view of numerical methods. **[6 Hrs.] CO2, CO3**

Unit III Finite Difference Formulations: Finite difference methods different means for formulating finite difference equation Taylor series expansion integration over element local function method finite volume methods central upwind and hybrid formulations and comparison for convection-diffusion problem treatment of boundary conditions boundary layer treatment various property interface accuracy of f.d. method. **[7 Hrs.] CO2, CO3**

Unit IV Methods of Solution: Solution of finite difference equations iterative methods matrix inversion methods ADI method operator splitting fast Fourier transforms applications. **[7 Hrs.] CO3**

Unit V Numerical Grid Generation: Numerical grid generation basic ideas transformation and mapping. Finite Element Methods: Finite element methods Rayleigh-Ritz, Galerkin and Least square methods interpolation function one and two dimensional elements applications. **[8 Hrs.] CO4**

Text Books:

S. No.	Title	Author(s)	Publisher
1	Computational Fluid Mechanics and Heat Transfer	Anderson D.A. Tannehill, J.C. and R.H.	Taylor & Francis.1997

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2	Computational Fluid Dynamics	Roche P.J.	Hermosa New Mexico 1976

Reference Books:

S. No.	Title	Author(s)	Publisher
1.	Fundamentals of Heat and Mass Transfer	Incropera F.P. and Dewitt, D.P.	Wiley N.Y. 1998
2.	Numerical Heat and Fluid Flow	Patankar S.V.	Hemisphere Washington D.C.1980
3.	The Finite Element Method in Engineering Science	Zienkiewicz O.C	McGraw Hill 1971
4.	Numerical Heat Transfer	Shih T.M.	Hemisphere Washington D.C.1984

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SCHEME OF EXAMINATION AND SYLLABUS

SEMESTER 2, MTech, MECHANICAL(THERMAL ENGINEERING)

Subject Code ME229202	Refrigeration & Air Conditioning System Design	L = 3	T = 2	P = 0	Credits = 4
Evaluation Scheme	ESE	CT	TA	Total	ESE Duration
	100	20	20	140	3 Hours

Course Objectives	Course Outcomes
Provide an understanding of working principles and design aspects of refrigeration and air conditioning systems such as HVAC, heat transfer along with different refrigeration cycle and their analysis and system components.	**Student will be able to** **CO1** Perform cooling load calculations considering effect of solar radiation and heat infiltration. **CO2** Analyze general aspects of heat transfer through buildings **CO3** Identify and Select suitable air conditioning system. **CO4** Duct design.

Unit I **Cooling and Heating Load Calculations**: Introduction to cooling and heating load calculations, Solar radiation, Solar geometry, Calculation of direct, diffuse and reflected radiation using ASHRAE solar radiation model, Effect of clouds. Solar Radiation Through Fenestration Ventilation And Infiltration Need for fenestration in buildings and effects of fenestration on air conditioning systems, concepts of Solar Heat Gain Factor (SHGF) and Shading Coefficient, calculation of shaded area of fenestrations, Need for ventilation and recommended ventilation rates, Infiltration and causes for infiltration, Estimation of heat transfer rate due to infiltration and ventilation. **[7 Hrs.] CO1**

Unit II **Heat Transfer Through Buildings**: Fabric Heat Gain/Loss General aspects of heat transfer through buildings, one-dimensional, steady state heat transfer through homogeneous, nonhomogeneous walls, opaque walls and roofs with suitable initial and boundary conditions, semi-empirical methods based on Effective Temperature Difference or Cooling Load Temperature Difference, discuss the physical significance of decrement and time lag factors and present typical tables of CLTD for walls and roof. **[7 Hrs.] CO2**

Unit III **Selection of Air Conditioning Systems:** Introduction to thermal distribution systems and their functions, Selection criteria for air conditioning systems, Classification of air conditioning systems, Working principle, advantages, disadvantages and applications of all air systems, eg. single duct, constant volume, and single/multiple zone system, single duct, dual duct, constant & variable air volume (VAV) systems, outdoor air control in all air systems, advantages/disadvantages & applications of all air systems, working principle, advantages, disadvantages and applications of all water systems, air-water systems, working principle, advantages, disadvantages and applications of unitary refrigerant based systems**[7 Hrs.] CO3**

Unit IV **Transmission of Air in Air Conditioning Ducts**: Air Handling Unit (AHU) and its functions, need for transmission aspects of air in air conditioning, airflow through air conditioning ducts, Bernoulli and modified Bernoulli equations, Static, dynamic, datum and total head, Fan Total Pressure (FTP) and power input to fan, estimation of pressure loss through air conditioning ducts,, Estimation of frictional pressure drop of circular and rectangular ducts using friction charts and equations, Estimation of dynamic pressure drop in various types of fittings, Static regain**[7 Hrs.] CO4**

Unit V **Design of Air Conditioning Ducts**: Important requirements of an air conditioning duct, General rules for duct design, Classification of duct systems, Commonly used duct design methods, Principle of velocity method, Principle of equal friction method, Principle of static regain method, Performance of duct systems, System balancing and optimization, Introduction to fans and fan laws, Interaction between fan and duct system. Ventilation for Cooling Use of ventilated air for cooling of buildings and cooling of occupants, comparison between natural ventilation and mechanical ventilation, characteristics of natural ventilation and estimation of airflow rate due to wind and stack effects, general guidelines for natural ventilation and forced ventilation using electric fans, interior air movement using interior fans, unit ventilators, whole house fans and solar chimneys. **[7 Hrs.] CO4**

Text Books:

S. No.	Title	Author(s)	Publisher
1	Refrigeration And Air Conditioning	Stooker W.F,	Tata McGraw-Hill
2	Refrigeration And Air Conditioning	C.P.Arora,	19th Edition, Tata McGraw Hill, Delhi
3	Principles of Refrigeration	Dossat, R J	4th Edition, Pearson Education (Singapore), India, 2002

Reference Books:

S. No.	Title	Author(s)	Publisher
1	Hand Book of Air Conditioning and Refrigeration	Shan K. Wang	
2	Air conditioning design Hand Book,	Carrier Corporation,	McGraw Hill,

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SCHEME OF EXAMINATION AND SYLLABUS

SEMESTER 2, MTech, MECHANICAL(THERMAL ENGINEERING)

Subject Code ME229203	Modeling and Simulation of Thermal Systems	L = 3	T = 2	P = 0	Credits = 4
Evaluation Scheme	ESE	CT	TA	Total	ESE Duration
	100	20	20	140	3 Hours

Course Objectives	Course Outcomes
1. To make students aware of different types of modelling including mhematical modelling and solve the problem using numerical simulation by choosing the design variables which affects the problem. 2. To make students aware of static as well as dynamic simulation of thermal systems 3. To make students capable of solving optimization problem for single variable and multivariable using the classical optimization techniques.	**After the completion of course student will be able to** **CO 1** Reduce their problem in mathematical modelling and solve the problem using numerical simulation by choosing the design variables which affects the problem. **CO 2** Address static as well as dynamic simulation of thermal systems **CO 3** Understand and solve the optimization problem for single variable and multivariable using the classical optimization technique

Unit I Introduction to Modeling, concept of system, continuous and discrete systems, types of models, steps in simulation study. Mathematical modeling of thermal processes, conservation laws, mass momentum & energy balance. **[7 Hrs.] CO1**

Unit II Dimensional analysis model development for various thermal processes and system. Dynamics of thermo-fluid system. **[7 Hrs.] CO1**

Unit III Simulation of thermal systems, steady state and dynamic simulation. **[7 Hrs.] CO2**

Unit IV Optimization of thermal systems, Introduction to optimization, formulation of objective function, constrained single and multivariable optimization, dynamic integer and geometric programming **[7 Hrs.] CO3**

Unit V Thermodynamic optimization, entropy generation minimization, application to internal and external flows, heat exchangers and other energy-equipment optimization. **[7 Hrs.] CO3**

Text Books:

S. No	Title	Author(s)	Publisher
1	Design and simulation of Thermal System	Suryanarayana N.V. and Arici	McGraw Hill Inc., 2001
2	Design and optimization of Thermal Systems	Jaluria Y.	McGraw Hill Inc., 1997
3	Thermal Design and Optimization	Tsatsaronic G, Moran, M. Bejan	John Wiley & Sons Inc., 1995

Reference Books:

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SEMESTER 2, MTech, MECHANICAL(THERMAL ENGINEERING)

S. No.	Title	Author(s)	Publisher
1	System Simulation	Gorden G	Prentice Hall Inc., 1978
2	System Simulation: the Art & Science	Shannon RE	Prentice Hall Inc., 1990
3	Modeling and Analysis of Dynamic Systems	Close C.M.,Frederick D.K.	John Wiley & Sons Inc.
4	Computational Heat Transfer	Jaluria Y and Torrance K.E	Taylor & Francis, 2002

Subject Code ME229204	**Thermal Measurements and Process Controls**	**L = 3**	**T = 2**	**P = 0**	**Credits = 4**
Evaluation Scheme	**ESE**	**CT**	**TA**	**Total**	**ESE Duration**
	100	**20**	**20**	**140**	**3 Hours**

Course Objectives	Course Outcomes
1. To introduce the basics of experimentation involving the design of experiment & measurement systems. 2. To execute experimental data analysis as well as error/uncertainty analysis.	**CO1** Describe the working principles in the measurement of field and derived quantities **CO2** Understand the concepts of errors in measurements, statistical analysis of data, regression analysis, correlation and estimation of uncertainty **CO3** Interpret International Standards of measurements (ITS-90) and identify internationally accepted measuring standards for measurands. **CO4** Understand role of mechatronics and data acquisition system in the field of thermal measurements.

SEMESTER 2, MTech, MECHANICAL(THERMAL ENGINEERING)

Unit I **Significance of Measurement and Instrumentation:** Introduction; generalized configuration and functional stages of measuring systems. The transducer and its environment; an overview; sensing process and physical laws. Dynamic Response of Instruments: Mathematical model of a measuring system, response of general form of instruments to various test inputs; time-domain and frequency domain analysis. Elementary transfer functions and Bode plots of general transfer functions. **[7 Hrs.] CO1**

Unit II **Errors in Measurement and Its analysis:** Causes and type of experimental errors; systematic and random errors. Uncertainty analysis; computation of overall uncertainty; estimation for design and selection for alternative test methods. **[7 Hrs.] CO2**

Unit III **Flow Measurement:** Flow visualization, shadowgraph; schilieren and interferometric techniques; Pitot static tubes; hot wire anemometers; Laser Doppler velometer; flow measurements using Coriolis effect. **[7 Hrs.] CO3**

Unit IV **Temperature and Heat Flux Measurement:** Thermoelectric sensors; electric resistance sensors; thermistors; radiations pyrometers; Temperature measuring problems in flowing fluids, dynamic compensation. **[7 Hrs] CO3**

Unit V **Data Acquisition and Signal Processing:** System for data acquisition and processing; modules and computerized data system; digitization rate; time and frequency domain representation of signals, and Nyquist criterion. A brief description of elements of mechatronics; modular approach to mechatronics and engineering design. **[7 Hrs.] CO4**

Text Books:

S. No.	Title	Author(s)	Publisher
1	Measurements System Application and Design	Marcel Dekker, Doeblin,	5th Ed., McGraw Hill, 2004
2	Transducers in Mechanical and Electronic Design	Trietly, Harry L,	CRC Press, 1986

Reference Books:

S. No.	Title	Author(s)	Publisher
1	Mechanical Measurement by Beckwith	Marrangoni and Lienhard	6th Edn, Prentice Hall, 2006
2	Measurement in Heat Transfer	Eckert and Goldstein	2nd Ed., Sprinter, 1986
3	Fluid Mechanics Measurement	Goldstein R.J.	Hemisphere Publishing Company, 1983

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SCHEME OF EXAMINATION AND SYLLABUS

SEMESTER 2, MTech, MECHANICAL(THERMAL ENGINEERING)

Subject Code ME229221	**Energy Resources, Conversion and Management**	**L = 3**	**T = 2**	**P = 0**	**Credits = 4**
Evaluation Scheme	**ESE**	**CT**	**TA**	**Total**	**ESE Duration**
	100	**20**	**20**	**140**	**3 Hours**

Course Objectives	**Course Outcomes**
1. To develop the basic knowledge of different terms & principles of energy conservation, audit and management. 2. To Evaluate the energy saving & conservation in different mechanical utilities. 3. To develop efficient heat & electricity utilization, saving and recovery in different thermal and electrical system. 4. To prepare energy audit report for different energy conservation instances	After completion of this course. **CO1** The students shall have an understanding of the impact of energy on society, the need for sustainable energy, global and Indian energy policies. **CO2** They would have gained knowledge on various techniques of energy management and conservation. They would also have gained the basic ideas of conducting an energy audit.

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SCHEME OF EXAMINATION AND SYLLABUS

SEMESTER 2, MTech, MECHANICAL(THERMAL ENGINEERING)

Unit – I

Introduction: Energy Scenario, various forms of energy, energy management and its importance, recent trends in energy conservation. Role of Energy manager in each of these organizations. Initiating, Organizing and managing energy management programs. **Energy Auditing and Instrumentation**: Definition and concepts. Types of energy audits, Basic energy concepts, Resources for plant energy studies. Data gathering, Analytical techniques. Energy Conservation: Technologies for energy conservation, Design for conservation of energy materials, Energy flow networks. Role of Instrumentation in Energy Conservation. **[7 Hrs.] CO1**

Unit – II

Energy Economics: Scope, Characterization of an investment project. Types of depreciation, Time value of money. Budget considerations, Risk analysis. Simple payback period, time value of money, IRR NPV, life cycle costing, cost of saved energy, cost of energy generated. **[7 Hrs.] CO1**

Unit-III

Financial Management & Monitoring and Targeting: Investment-need, appraisal and criteria, financial analysis techniques simple payback period, return on investment, net present value, internal rate of return, cash flows, risk and sensitivity analysis; Defining monitoring and targeting, elements of monitoring and targeting, data and information, analysis techniques, energy consumption, production, cumulative sum of difference. **[7 Hrs.] CO2**

Unit-IV

Energy Efficiency in Thermal Utilities & Energy and environment, Climate Change: Boilers, steam systems, furnaces insulation and refractories, FBC boilers, cogeneration, waste heat recovery. United Nations Framework Convention on Climate Change (UNFCC), sustainable development, Kyoto Protocol, Conference of Parties (COP), Clean Development Mechanism (CDM), CDM Procedures case of CDM – Bachat Lamp Yojna and industry; Prototype Carbon Fund (PCF). **[7 Hrs.] CO2**

Unit-V

Alternative Energy Sources: Solar Energy: Types of devices for solar energy collections, Thermal storage system, Control systems. Wind Energy, Availability, Wind Devices, Wind Characteristics, performance of turbines and systems. **[7 Hrs.] CO2**

Text Books:

S. No.	Title	Author(s)	Publisher
1.	Industrial Energy Management and Utilization	Witte L.C., Schmidt P.S., Brown D.R	Springer
2.	Industrial Energy Conservation Manuals,	Gyftopoulos E.P.,	MIT Press
3.	The Efficient Use of Energy, 2nd Ed.,	Dryden IGC	Butterworth Heinemann
4.	Energy Management	W. R. Murthy,G. Mc. Kay	BS Publication
5.	Financial Management	S. C. Kuchhal	Chaitanya Publishing House

Reference Books:

S. No.	Title	Author(s)	Publisher
1.	Energy Management Handbook	Capehart B.L, Turner W.C., Kennedy W.J	John Wiley and Sons

2.	Economics of Solar Energy & Conservation Systems, Vol. I & II	F. Krieth & RE West	CRC Press
3.	Industrial Energy Recovery	D.A. Reay,	Wiley
4.	Energy Management Principles	CB Smith	Pergamon Press
5.	Management of Energy Environment Systems.	W.K.Foell	John Wiley and Sons

Subject Code ME229222	Hydraulic and Pneumatic control systems	L = 3	T = 2	P = 0	Credits = 4

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SEMESTER 2, MTech, MECHANICAL(THERMAL ENGINEERING)

Evaluation Scheme	ESE	CT	TA	Total	ESE Duration
	100	20	20	140	3 Hours

Course Objectives	Course Outcomes
1. To provide student with knowledge on the application of fluid power in process, construction and manufacturing Industries. 2. To provide students with an understanding of the fluids and components utilized in modern industrial fluid power system. 3. To develop a measurable degree of competence in the design, construction and operation of fluid power circuits. 4. To understand construction and working and performance of various Turbines	**Students will be able to:** **CO1** Explain the Fluid power and operation of different types of pumps. **CO2** Summarize the features and functions of Hydraulic motors, actuators and Flow control valves. **CO3** Explain the different types of Hydraulic circuits and systems. **CO4** Explain the working of different pneumatic circuits and systems. **CO5** Explain the working operation of various hydraulic Turbines.

UNIT I Fluid Power Principle and Hydraulic Pumps

Introduction to Fluid power – Advantages and Applications – Fluid power systems – Types of fluids – Properties of fluids and selection – Basics of Hydraulics – Pascal's Law – Principles of flow – Friction loss – Work, Power and Torque Problems, Sources of Hydraulic power : Pumping Theory

Pump Classification — Construction, Working, Design, Advantages, Disadvantages, Performance, Selection criteria of Linear and Rotary — Fixed and Variable displacement pumps — Problems**. [8 Hrs.] CO1**

UNIT II Hydraulic Actuators and Control Components

Hydraulic Actuators: Cylinders — Types and construction, Application, Hydraulic cushioning — Hydraulic motors — Control Components: Direction Control, Flow control and pressure control valves — Types, Construction and Operation — Servo and Proportional valves — Applications — Accessories: Reservoirs, Pressure Switches — Applications — Fluid Power ANSI Symbols — Problems. **[6 Hrs.] CO2**

UNIT III Hydraulic Circuits and Systems

Accumulators, Intensifiers, Industrial hydraulic circuits — Regenerative, Pump Unloading, Double- Pump, Pressure Intensifier, Air-over oil, Sequence, Reciprocation, Synchronization, Fail-Safe, Speed Control, Hydrostatic transmission, Electro hydraulic circuits, Mechanical hydraulic servo systems. **[7 Hrs.] CO3**

UNIT IV Pneumatic and Electro Pneumatic Systems

Properties of air Perfect Gas Laws Compressor Filters, Regulator, Lubricator, Muffler, Air control Valves, Quick Exhaust Valves, Pneumatic actuators, Design of Pneumatic circuit — Cascade method — Electro Pneumatic System Elements Ladder diagram Problems, Introduction to fluidics and pneumatic logic circuits. **[7 Hrs.] CO4**

UNIT V Hydraulic Turbines

Impulse Turbine: Classification of turbine, impulse turbine, Pelton wheel, Construction working, work done, head efficiency and Design aspects, Governing of impulse turbine. Reaction Turbine: Radial flow reaction turbine, Francis turbine: construction, working, work done, efficiency, design aspect, advantages & disadvantages over Pelton wheel. **[7 Hrs.] CO5**

SEMESTER 2, MTech, MECHANICAL(THERMAL ENGINEERING)

Text Books:

S. No.	Title	Author(s)	Publisher
1	Fluid Power with Applications	Anthony Esposito	Pearson Education 2005
2	Oil Hydraulics Systems- Principles and Maintenance	Majumdar S.R	Tata McGraw- Hill, 2001
3	Fluid Mechanics & Hydraulics Machines	R.K.Bansal	Laxmi Publications, Delhi

Reference Books:

S. No.	Title	Author(s)	Publisher
1	Fluid Power Systems	A.B. Goodinain	McMillan Press Ltd
2	The Control of Fluid Powe	McCloy & Martin	Longman Publications
3	Hydraulics and Fluid Mechanics Including Hydraulic Machine	PN Modi, & SM Seth	Standard, Delhi
4	Introduction to Fluid Mechanics and Fluid Machines	S.K. Som and G. Biswas	TMH, Delhi

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SCHEME OF EXAMINATION AND SYLLABUS

SEMESTER 2, MTech, MECHANICAL(THERMAL ENGINEERING)

Subject Code ME229223	Theory of Combustion and emission	L = 3	T = 2	P = 0	Credits = 4
Evaluation Scheme	ESE	CT	TA	Total	ESE Duration
	100	20	20	140	3 Hours

Course Objectives	Course Outcomes
Make students aware of types, sources and effects of combustion generated air pollution and their control technology.	**CO1** Become aware of different types and sources of air pollution and their effects on man, material and vegetation. **CO2** Understand the fundamental knowledge of thermodynamics and chemical kinetics of combustion **CO3** Analyze the formation mechanisms of ic engine combustion-generated air pollutants **CO4** Understand and select appropriate methods for air pollution measurement and control

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SCHEME OF EXAMINATION AND SYLLABUS

SEMESTER 2, MTech, MECHANICAL(THERMAL ENGINEERING)

Unit I Generation and nature of pollutants from various combustion sources, classification of pollutants, primary and secondary pollutants, Stationary and mobile sources, Significance of natural and artificial pollutants, Properties of major air pollutants **[7 Hrs.] CO1**

UNIT II Effect of combustion pollution on man, material and vegetation, Study of air pollution disasters of world, acid rains, ozone holes. **[7 Hrs.] CO1**

UNIT III Thermo chemistry of pollutant formation, stiochiometry, chemical thermodynamics, kinetics. Formation of CO, SOx, NOx, Thermodynamics of combustion, combustion of coal, oil, and natural gas. **[7 Hrs.] CO2**

UNIT IV Combustion pollution from IC Engines, Nature and extent of problem, Nitrogen Oxides, Kinetics of NO formation, Nox formation in SI and CI Engines, Carbon monoxides, unburned hydrocarbons emissions. Particulate emissions exhaust gas treatment, catalytic converters, three way catalysts, particulate traps. **[7 Hrs.] CO3**

UNIT V Control technology for particulate, for gaseous pollutants, for Sox, for Nox, for odour pollution, Meteorology and dispersion of pollutants, instruments for pollutant measurement and monitoring. Legislation and emission standards. **[7 Hrs.] CO4**

Text Books:

S. No.	Title	Author(s)	Publisher
1	Combustion Fundamentals	Strehlow	McGraw Hill
2	Combustion	Glassman	Academic Press
3	Air Polution and Control	K.V.S.G Murli Krishna	Kaushal and Co. Kakinada
4	Environmental Engineering	Howard S Peavy	McGraw Hill, Singapore

Reference Books:

S. No.	Title	Author(s)	Publisher
1	Pollution control in process Industries	S P Mahajan,	Tata McGraw Hill
2	Internal Combustion Engine Fundamentals	Heywood	McG rawHill
3	Internal Combustion Engine Fundamentals	Ferguson	Jhon Wiley

Subject Code ME229224	Advance Gas Dynamics	L = 3	T = 2	P = 0	Credits = 4
Evaluation Scheme	ESE	CT	TA	Total	ESE Duration
	100	20	20	140	3 Hours

Course Objectives	Course Outcomes

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SCHEME OF EXAMINATION AND SYLLABUS

SEMESTER 2, MTech, MECHANICAL(THERMAL ENGINEERING)

1. To understand the compressible flow fundamentals 2. To study the compressible flow with friction and heat transfer. 3. To know the application of normal shock & their governing equations. 4. To understand the construction and operation of various jet and rocket engine. 5. To analyze jet engine and rocket engine from fluid and thermodynamic principle.	**Students will be able to:** **CO1 To** distinguish between various flows regime. **CO2** To analyse the flow under different flow conditions. **CO3** To assess the flow behaviour and consequent loads due to flow. **CO4** Demonstrate a basic understanding of jet and rocket engine design, function and performance. **CO5** Acquire knowledge and hands-on competence in the design and development of mechanical systems

UNIT I - Supersonic Flow

Normal Shocks - Governing equations, Rankine Huguenot, Prandtl and other relations, weak shocks, thickness of shocks, normal shocks in ducts, performance of convergent divergent nozzle with shocks, moving shock waves, shock problems in one dimensional supersonic diffuser, supersonic pitot tube. **[7 Hrs.] CO1, CO3**

UNIT II - Flow in Constant Area Duct under different conditions

Flow in Constant Area Duct with Friction: Governing equations, working formulas and tables, choking due to friction, performance of long ducts, and Isothermal flow in long ducts. Flow in Constant Area Duct with Heating and Cooling: Governing equations, working formula and tables, choice of end states, choking effects, shock waves with changes in stagnation temperature. **[8 Hrs.] CO1, CO2, CO3**

UNIT III - Space Propulsion

Types of rocket engines – Propellants-feeding systems – Ignition and combustion – Theory of rocket propulsion – Performance study – Staging – Terminal and characteristic velocity – Applications – space flights. **[6 Hrs.] CO1, CO5**

UNIT IV - Oblique shock

Governing physical equations and general relations, shock polar diagram and auxiliary diagrams, strong and weak shocks, detached shock, interaction and reflection of shocks. **[7 Hrs.] CO3**

UNIT V- Jet Propulsion

Theory of jet propulsion – Thrust equation – Thrust power and propulsive efficiency – Operating principle, cycle analysis and use of stagnation state performance of ram jet, turbojet, turbofan and turbo prop engines. **[7 Hrs.] CO4, CO5**

Text Books:

S. No.	Title	Author(s)	Publisher
1	Modern Compressible flow	Anderson, J.D	3rd Edition, McGraw Hill
2	Fundamentals of Compressible Flow	Yahya, S.M	New Age International (P) Ltd., New Delhi
3	Gas Dynamics	E. Rathakrishnan	Prentice-Hall of India, New Delhi

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SEMESTER 2, MTech, MECHANICAL(THERMAL ENGINEERING)

Reference Books:

S. No.	Title	Author(s)	Publisher
1	Compressible Fluid Flow	M.A. Saad	Prentice-Hall, New Jersey, 1985
2	The Dynamics and thermodynamics of Compressible Fluid Flow (2 Volumes)	A. H. Shapiro	The Ronald Press, New York, 1953.
3	Gas Turbine Theory & Jet Propulsion	J.K. Jain	Khanna Publishers, Delhi

Subject Code ME229225	**Optimization Techniques & Design of Experiments**	**L = 3**	**T = 2**	**P = 0**	**Credits = 4**
Evaluation Scheme	**ESE**	**CT**	**TA**	**Total**	**ESE Duration**
	100	**20**	**20**	**140**	**3 Hours**

Course Objectives	**Course Outcomes**

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SCHEME OF EXAMINATION AND SYLLABUS

SEMESTER 2, MTech, MECHANICAL(THERMAL ENGINEERING)

1. To develop basic governing equations for fluid and heat flow by examining the physical boundary conditions. 2. To construct finite difference based equations according to the nature (i.e. elliptic, parabolic and hyperbolic) of the flow problem. 3. To decide and implement various implicit and explicit CFD schemes to solve steady and unsteady 1/2/3 dimensional fluid problems. 4. To solve incompressible flow problems with considerations of geometry, mesh, flow physics, physical boundary conditions, turbulence, etc.	**Student will be able to:** **CO1** Develop basic governing equations for fluid and heat flow by examining the physical boundary conditions. **CO2** Construct finite difference based equations according to the nature (i.e. elliptic, parabolic and hyperbolic) of the flow problem. **CO3** Decide and implement various implicit and explicit CFD schemes to solve steady and unsteady 1/2/3 dimensional fluid problems. **CO4** Solve incompressible flow problems with considerations of geometry, mesh, flow physics, physical boundary conditions, turbulence, etc.

Unit I Single variable non-linear unconstrained optimization: One dimensional Optimization methods, Uni-modal function, elimination method, Fibonacci method, golden section method, interpolation methods- quadratic & cubic interpolation methods. **[8 Hrs.] CO1**

Unit II Multi Variable Non-Linear Unconstrained Optimization: Direct search method –Univariant Method – pattern search methods – Powell's – Hook – Jeeves, Rosenbrock search methods–gradient methods, gradient of function, steepest decent method, Fletcher reeves method. Variable metric method. **[7 Hrs.] CO2**

Unit III Geometric Programming: Polynomials –arithmetic –geometric inequality –unconstrained G.P–constrained G.P
Dynamic Programming: Multistage decision process, principles of optimality, examples, conversion of final problem to an initial value problem, application of dynamic programming, production inventory. Allocation, scheduling replacement. **[6 Hrs.] CO3**

Unit IV Linear Programming: Formulation – Sensitivity analysis. Change in the constraints, cost coefficients, coefficients of the constraints, addition and deletion of variable, constraints. Simulation: Introduction – Types – Steps – application – inventory – queuing – thermal system. **[7 Hrs.] CO4**

Unit V Integer Programming: Introduction – formulation – Gomory cutting plane algorithm – Zero or one algorithm, branch and bound method.
Stochastic Programming: Basic concepts of probability theory, random variables – distributions – mean, variance, Correlation, co variance, joint probability distribution – stochastic linear, dynamic programming. **[7 Hrs.] CO1 , CO4**

Text Books:

No.	Title	Author(s)	Publisher
1	Optimization theory & Applications	S.S Rao	New Age International

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2	Optimization Techniques theory and practice	M.C Joshi, K.M Moudgalya	Narosa Publications

Reference Books:

S. No.	Title	Author(s)	Publisher
1.	Introductory to operation research	Kasan & Kumar	Springer
2.	Operation Research	H.A. Taha	TMH
3.	Optimization in operations research	R.L Rardin	
4.	Optimization Techniques	Benugundu & Chandraputla	Pearson Asia

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SCHEME OF EXAMINATION AND SYLLABUS

SEMESTER 2, MTech, MECHANICAL(THERMAL ENGINEERING)

Subject Code ME229291	**Computational Fluid Dynamics LAB**	**L = 0**	**T = 0**	**P = 4**	**Credits = 2**
Evaluation Scheme	**ESE**	**CT**	**TA**	**Total**	**ESE Duration**
	75	**0**	**75**	**150**	

Course Objectives	**Course Outcomes**
1. To provide students with the necessary skills to use commercial CFD packages 2. To carry out research in the area of Computational Fluid Dynamics. 3. To solve a variety of flow situations and heat transfer tutorials.	At the end of the course student will attain proficiency in using commercial CFD software to solve at least basic thermal problems.

The set of tutorials designed to provide the student with the necessary tools for using sophisticated commercial ANSYS fluent CFD software. A set of laboratory tasks will take the student through a series of increasingly complex flow and heat transfer simulations, requiring an understanding of the basic theory of computational fluid dynamics (CFD).

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SCHEME OF EXAMINATION AND SYLLABUS

SEMESTER 2, MTech, MECHANICAL(THERMAL ENGINEERING)

Subject Code ME229292	Measurement lab	L = 0	T = 0	P = 4	Credits = 2
Evaluation Scheme	ESE	CT	TA	Total	ESE Duration
	75	0	75	150	

Course Objectives	Course Outcomes
1. To introduce the basics of experimentation involving the design of experiment & measurement systems 2. To execute experimental data analysis as well as error/uncertainty analysis	Upon successful completion of the course, the students will be gain confidence in executing experimental investigations & measurement.

Experiments utilizing various methods of measuring different thermal parameters viz. Temperature, Pressure, Air velocity, flow etc.

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