DEPARTMENT OF MECHANICAL ENGINEERING
M. TECH., THERMAL ENGINEERING
TEACHING SCHEME (2011 ONWARDS)

FIRST SEMESTER

S. No.	Course No.	Course Title	L	T	P	Hours/Week	C
1.	ME - 600	Advanced Thermodynamics	3	0	0	3	3
2.	ME - 601	Fluid Mechanics & Gas Dynamics	3	0	0	3	3
3.	ME - 602	CFD & HT-1	3	0	0	3	3
4.		Programme Elective - 1	3	0	0	3	3
5.		Programme Elective - 2	3	0	0	3	3
6.	ME - 603	Computational Laboratory	0	0	3	3	2
Total			15	0	3	18	17

Programme Elective -1

a. **ME- 700** Gas Turbine & Jet Propulsion
b. **ME- 701** Finite Element Method
c. **ME- 702** Finite Volume Method

Programme Elective -2

a. **ME- 706** Heat Transfer and Fluid Dynamics of Turbomachinery
b. **ME- 707** Data Acquisition System
c. **ME- 708** Modelling and Simulation

SECOND SEMESTER

S. No.	Course No.	Course Title	L	T	P	Hours/Week	C
1.	ME - 604	CFD & HT - II	3	0	0	3	3
2.	MA - 601	Methods of Applied Mathematical Physics	3	0	0	3	3
3.	ME - 606	Experimental Techniques	3	0	0	3	3
4.		Programme Elective - 3	3	0	0	3	3
5.		Open Elective – 1 (from other Deptt.)	3	0	0	3	3
6.	ME - 607	Thermal Engg. Laboratory	0	0	3	3	2
Total			15	0	3	18	17

Programme Elective-3

a. **ME- 711** CFD&HT-III
b. **ME- 712** Simulated Design of Solar Systems
c. **ME- 713** Advanced Heat Transfer
d. **ME- 714** Experimental Techniques In Fluid Flow & Heat Transfer

Open Elective

ME – 750 Introduction To Finite Element Method

THIRD SEMESTER

S. No.	Course No.	Course Title	L	T	P	Hours/Week	C
1.	ME - 799	Self Study				3	2
2.	ME - 800	Seminar			3	3	2
3.	ME - 801	Dissertation (to be continued in IVth Sem)				24	12
Total					3	30	16

FOURTH SEMESTER

S. No.	Course No.	Course Title	L	T	P	Hours/Week	C
1.	ME - 801	Dissertation (continued from IIIrd Sem.)				40	20
Total						40	20

ME-600

ADVANCED THERMODYNAMICS

L	T	P	Cr
3	0	0	3

1. REVIEW OF LAWS:

Thermodynamics laws, Steady flow energy equation, Transient flow analysis, entropy, entropy generation, real gases and mixtures, equation of state.

2. THERMODYNAMIC PROPERTY RELATION:

Residual property function, property of saturation state, Thermodynamic properties of homogeneous mixture, Chemical potential fugacity and fugacity coefficient.

3. EXERGY ANALYSIS:

Concepts, exergy balance, exergy transfer, exergetic efficiency, exergy analysis of power and refrigeration cycles.

4. RECATING SYSTEMS:

Laws of reacting systems, absolute entropy, fuel cells, exergetic efficiency of reacting systems, chemical equilibrium.

BOOKS RECOMMENDED

1. Thermodynamics by Cengel
2. Thermodynamics by Moran & Shapiro
3. Thermodynamics by Van Wylen

ME-601

FLUID MECHANICS AND GAS DYNAMICS

L	T	P	Cr
3	0	0	3

1. CONSERVATION EQUATIONS OF FLUID FLOW:

Conservation of mass, conservation of momentum – stress and strain in fluid flow and their relationship, conservation of energy, work done due to viscous stress.

2. LAMINAR FLOW OF VISCOUS INCOMPRESSIBLE FLUIDS:

Flow between parallel flat plates, couette flow, plane Poiseuille flow, flow between two co-axial cylinders, flow between two concentric rotating cylinder, unsteady motion of a flat plates.

3. BOUNDARY LAYER THEORY:

Boundary layer equation, Blasius solution, shear stress and boundary layer thickness, boundary layer on a surface with pressure gradient, momentum integral theorem for boundary layer, boundary layer for axially symmetric flow, separation and its prevention by boundary layer suction.

4. COMPRESSIBLE FLOW:

Propagation of pressure change, sound velocity, elastic waves, Mach number, Mach cone, isentropic flow relations in terms of sonic velocity and mach number, Stagnation properties, Regions of flow, Energy equation, Effect of Mach number on compressibility, Propagation of infinitesimal waves, Non-steep finite pressure wave and steep finite pressure waves, Expansion waves Isentropic flow with variable area, Mach number variation and its effect on flow through nozzles and diffusers, Area ratio, impulse function, Use of gas/ air tables.

5. SHOCK WAVES:

Development of shock wave, rarefaction wave, governing equations, Prandtle-Meyer relation, Thermodynamic properties across shock, wind tunnels, Fanno curves, Fanno flow equations, Variation of flow properties.

BOOKS SUGGESTED:

1. Fundamental of Fluid Mechanics: S.W.Yuan
2. Viscous Fluid Flow: F.M.White
3. Advanced Fluid Mechanics: Muralidhar & Biswas
4. Fundamental of Gas dynamics: V. Babu

ME-602

COMPUTATIONAL FLUID DYNAMICS & HEAT TRANSFER-I (CFD&HT-1)

L	T	P	Cr
3	0	0	3

1. Review of governing equations of fluid flow and heat transfer, review of numerical methods.

2. DISCRETIZATION:

Introduction to finite differences, difference equations, explicit and implicit approaches: definition and contrasts, errors and analysis of stability.

3. CLASSIFICATION OF PARTIAL DIFFERENTIAL EQUATIONS:

Explicit and Implicit methods, solution of select model equations; Laplace heat and wave equation, laminar boundary layer solution.

4. CFD TECHNIQUES:

The Lax -Wendroff technique, Mac Cormack's technique, Relaxation technique and its use with low speed inviscid flows, aspects of numerical dissipation and dispersion; artificial viscosity, Alternating Direction Implicit (ADI) technique, pressure correction technique with application to incompressible viscous flow.

5. INITIAL AND BOUNDARY VALUE PROBLEMS:

Free falling of a spherical body, two dimensional motions of a body through a fluid radial flow.

6. STEADY STATE CONDUCTION IN RECTANGULAR & CYLINDRICAL GEOMETRY:

transient conduction finite difference applications in convective heat transfer, thermally developing flow inside a circular pipe.

BOOKS RECOMMENDED

1. Computational fluid flow and heat transfer D.A. Anderson et .al
2. Computational Fluid Dynamics -John D. Anderson Jr.
3. Introduction to Computational fluid Mechanics -Chuen –Yen Chow.
4. Computational Fluid Flow and Heat Transfer -K.Muralidhar and T.Sunderrajan, Narosa Publishing House.

ME-604

COMPUTATIONAL FLUID DYNAMICS AND HEAT TRANSFER-II (CFD&HT-II)

L	T	P	Cr
3	0	0	3

1. REVIEW OF SUBSONIC SUPERSONIC ISENTROPIC FLOW, CFD SOLUTION OF SUBSONIC-SUPERSONIC ISENTROPIC NOZZLE FLOW:

Mac Cormack's technique, solution of purely subsonic isentropic nozzle flow, propagation and reflection of a small amplitude wave, propagation of a finite amplitude wave, shock capturing.

2. NUMERICAL SOLUTION OF A TWO DIMENSIONAL SUPERSONIC FLOW:

Introduction to physical problem, Prandtl Meyer expansion wave, numerical solution of Prandtl Meyer expansion wave flow field, method of characteristics.

3. INCOMPRESSIBLE COUETTE FLOW:

Physical problem and its exact analytical solution, the numerical approach: Implicit Crank Nicholsan technique the pressure correction method.

4. SOLUTION OF VISCOUS INCOMPRESSIBLE FLOW BY STREAM FUNCTION VORTICITY FORMULATION -2 D:

Incompressible viscous flow, incorporation of upwind scheme, estimation of discretization error.

5. PANEL METHOD:

Source panel method, flow past a cylinder, flow past an array of two cylinders, calculation of drag, & lift, vortex panel method.

BOOKS RECOMMENDED

1. Computational fluid flow and heat transfer D.A. Anderson et.al
2. Computational Fluid Dynamics -John D. Anderson Jr.
3. Introduction to Computational Fluid Mechanics -Chuen –Yen Chow.
4. Computational Fluid Flow and Heat Transfer -K.Murelidhar & T.Sunderrajan, Narosa Publishing House.

MA-601

METHODS OF APPLIED MATHEMATICAL PHYSICS

L	T	P	Cr
3	0	0	3

1. MATRICES AND LINEAR EQUATIONS:

Linear equations; Gauss-Jordan Reduction; matrices & determinants; solvability of linear equations; characteristic value problems; equivalent matrices & transformations; discernments and invariants; co ordinate transformation; numerical solution of characteristic value problem; sturm- Liouville problems.

2. CALCULUS OF VARIATIONS:

maxima & minima; natural boundary and transmition conditions; constraints and lagrangian multipliers; variable end points; Sturm-Liouville problems; Hamilton's principles; Lagrange’s equation; generalized dynamical entities, constraints in dynamical system; small vibration, normal coordinates; variational problem in deformable bodies; elastic plates; Rayleigh-Ritz method.

3. PARTIAL DIFFERENTIAL AND INTEGRAL EQUATIONS:

Introduction, Green's functions; singular integral equations, approximate methods of solutions eg. method of collocation, weighting functions and least squares. Classification of PDE, Solutions Laplace, Diffusion and waves equation and their applications.

4. INTEGRAL TRANSFORMS:

Fourier & Laplace transform; Inverse transforms; rectangle, triangle, exponential, Heaviside's step, sgn, filtering, sine function; impulse symbol; basic theorems similarity, addition, stiff, modulation, convolution Rayleigh, power, derivative theorems; transform of generalized functions; discrete Fourier transform; fast Fourier transform (FFT); applications of FFT.

BOOKS RECOMMENDED

1. Methods of Applied Mathematics -F.B. Hilderbrand, Prentic-Hall of India Ltd. , 1972
2. Partial Differential Equations by J.N.Sharma & Kehar Singh Narosa Publishing House New Delhi-2000
3. The Fourier Transform and its Applications Ronald N. Bracewell, McGraw Hill International Ed. , 1986
4. Theory and Problems of Laplace Transforms Murray R. Spiegel, Schaum's series, McGraw Hill,

ME-606

EXPERIMENTAL TECHNIQUE

L	T	P	Cr
3	0	0	3

1. BASIC COCEPTS:

Definition of terms, Calibration, System response, Important of experimental analysis, Experiment planning.

2. DESIGN OF EXPERIMENT:

Statistical design of experiments, strategy of experimentation, guideline for designing of experiments, Factorial design, concept of two level, Fractional Factorial design, Analysis of variance.

3. ANALYSIS OF EXPERIMENTAL DATA:

Causes and type of experimental errors, Uncertainty analysis, Statistical analysis of experimental data, Distributions, estimators, confidence levels, sample size, test of hypothesis, Goodness-of-fit test Chauvenet's criteria; Regression analysis, co-relations.

4. MEASURING SYSTEMS:

Selection of measuring system, static & dynamic characteristics, Response of general form of instrument, random and transient input, instrument loading under static and dynamic condition, transducer and sensor, measurement of strain, noise, pressure and temperature.

BOOKS RECOMMENDED

1. Experimental methods for Engineers Holman
2. Experiments by Wu and Hamada

Elective 1
ME-700

GAS TURBINES AND JET PROPULSION

L T P Cr
3 0 0 3

1. COMPRESSIBLE FLOW:

Wave propagation and sound velocity; Mach number and compressible flow regimes; basic equations for one-dimensional compressible flow, isentropic flow relations; area-velocity relation; normal shock waves, relation between upstream and downstream flow parameters.

2. GAS TURBINE SYSTEMS AND CYCLES:

System of operation of gas turbines-constant volume and constant pressure gas turbines; thermodynamics of Brayton cycle; regeneration-intercooling, reheating and their combinations; closed cycle and semi-closed cycle gas turbines; gas v/s I.C engines and steam turbines.

3. COMPRESSORS:

Classification-positive displacement and dynamic compressors, Operation of single stage reciprocating compressors; best value of index of compression; isothermal efficiency; effect of clearance and volumetric efficiency; multi-stage compression; air motors. Centrifugal compressors; static and total head values; velocity vector diagrams; slip factor; pressure coefficient and pre-whirl, Axial flow compressors; degree reaction and polytropic efficiency Performance characteristics; surging, choking and stalling.

4. COMBUSTION SYSTEMS:

Types, combustion process, combustion intensity efficiency and pressure loss.

5. AIR-BREATHING PROPULSION SYSTEMS:

Principle of jet propulsion; analysis and performance characteristics of turbojet, turboprop, ramjet and pulsejet; thrust power and propulsion efficiency.

6. ROCKET PROPULSION:

Operating principle; solid and liquid propellants, performance analysis-calculations for specific impulse and propulsive efficiency.

RECOMMENDED BOOKS

1. Gas Turbine Theory Cohen & Rogers
2. Principle of Jet Propulsion and Gas Turbine Zucrow M J

REFERENCES BOOK
1. Heat Engineering Vasandani V P & Kumar D S

ME-701

FINITE ELEMENT METHODS

L T P Cr
3 0 0 3

1. FUNDAMENTAL CONCEPTS:

Introduction, Historical background, stresses and equilibrium, boundary conditions, strain-displacement relations, stress-strain relations, temperature effects, Rayleigh-Ritz Method, Galerkin's Method, Saint Venant's Principle, Matrix algebra, Gaussian Elimination.

2. FINITE ELEMENT MESHES:

Choice of mesh, mesh data in numerical form, generation of mesh data, mesh modification.

3. ONE -DIMENSIONAL PROBLEMS:

Introduction, Finite element Modeling, Co-ordinates and Shape Functions, Potential energy approach, The Galerkin Approach, Assembly of Global stiffness matrix and load vector, Finite element equations; Treatment of boundary conditions, quadratic shape functions, Temperature effects.

4. TRUSSES:

Introduction, plane trusses, three dimensional trusses, assembly of global stiffness matrix for the banded and skyline solution.

5. TWO- DIMENSIONAL PROBLEMS:

Introduction, finite element modeling, constant strain triangle (CST), Problem modeling and boundary conditions.

6. AXISYMMETRIC SOLIDS SUBJECTED TO AXISYMMETRIC LOADING:

Introduction, Axisymmetric formulation, finite element modeling: Triangular elements, Problem modeling and boundary conditions.

7. TWO -DIMENSIONAL ISOPARAMETRIC ELEMENTS AND NUMERICAL INTEGRATION:

Introduction, The fournode quadrilateral, Numerical Integration, Higher order element, Problem related to beams.

8. BEAMS AND FRAMES:

Introduction, finite element formulation, load vector, boundary considerations, shear force and bending moment beams on elastic supports, plane frames, three dimensional frames.

9. FINITE ELEMENT METHODS IN FLUID FLOW &. HEAT TRANSFER:

1-D Steady heat conduction, 1-D heat conduction in thin fins, 2-D Steady heat conduction, 2-D Fins. 1-D & 2-D heat disfusion, incompressible inviscid flow (potential flow), acoustic flow, and viscous incompressible fluid flow.

RECOMMENDED BOOKS

1. Introduction to Finite Elements in Engineering Tirupathi, R. ,Chandrupatle Ashoka D. Belegundu
2. An Introduction to Finite Element Method J.N. Reddy
3. Finite Element Analysis -Theory and Programming C.S. Krishnamurthy
4. The Finite Element Method in Engineering S.S. Rao
5. Finite Element Methods for Engineers Roger T.Fennee
6. Finite Element Analysis in Engg. Design Rajoebaron

Special assignments and projects/models are to be submitted for evaluation in consultation with the course coordinator

ME-702

FINITE VOLUME METHOD

L T P Cr
3 0 0 3

1. DISCRETIZATION METHODS:

Review of other methods, control volume formulations, four basic rules.

2. HEAT CONDUCTION:

Steady one- dimensional conduction: grid spacing, interface conductivity, non-linearity, source term linearization, boundary conditions, unsteady state one dimensional conduction; explicit, implicit and crank Nicolson scheme, two and three-dimensional conduction, over and under relaxation.

3. CONVECTION AND DIFFUSION:

Steady one- dimensional convection and diffusion, upwind scheme a generalized formulation, discretization equation for two dimensions.

4. FLOW FIELD:

Continuity and momentum equation, pressure correction equations, 6 simple algorithms.

5. APPLICATIONS:

Developing flow in curved pipe, two-dimensional heat conduction on a non-uniform mesh, heat conduction in cylindrical geometry, an symmetric steady conduction in spherical coordinators.

RECOMMENDED BOOKS

1. Numerical Methods in Heat Transfer & Fluid Flow S.V.Patankar
2. Computational Fluid Flow and Heat Transfer Muralidhar & G. Biswas
3. Computational Fluid Dynamics Vol.1 & 2 Fletcher
4. Computational Fluid Dynamics Date, A. N.

Elective 2

ME-706

HEAT TRANSFER & FLUID DYNAMICS OF TURBOMACHINERY

L	T	P	Cr
3	0	0	3

1. CLASSIFICATION & BASIC CONCEPTS:

Introduction and classification; some basic concepts in fluid dynamics.

2. FUNDAMENTAL PRINCIPLES, ANALYSIS & PERFORMANCE OF TURBOMACHINERY:

Physical process; energy and angular momentum transfer; efficiencies; nondimensional representation; axial flow compressors and fans; propellers; centrifugal compressors and fans; axial & centrifugal pumps; axial flow turbines; radial & fixed flow turbines.

3. CASCADE INVISCID FLOW:

Introduction; aerodynamic forces and governing equations; incompressible inviscid cascade flow theories, subsonic inviscid cascade flows; transonic and supersonic flows.

4. THREE DIMENSIONAL INVISCID AND QUASI-VISCOM FLOW FIELD:

Axisymmetric solutions; quasi three dimensional and three dimensional theories e.q. lifting line & surface theories, passage averaged equations, streamline curvature method, secondary flow theories, tip clearance effects etc.

5. COMPUTATION OF TURBOMACHINE FLOWS:

Governing equation; turbulence modeling for turbomachine flow; numerical techniques; computation of inviscid flows; boundary layer solutions; space marching methods; Enter & N-S solutions e.q. pressure based methods, time marching techniques, pseudo compressibility techniques etc; computational design.

6. TWO AND THREE DIMENSIONAL VISCOUS EFFECTS AND LOSSES:

Nature of real fluid effects; loss mechanism and classification; correlations for losses; secondary flow and end wall effects; losses in centrifugal impellers.

7. TURBINE COOLING AND HEAT TRANSFER:

Basic concepts in Heat transfer; cooling techniques; convective, film and transpiration cooling; aerodynamic losses & efficiency due to cooling; heat transfer computation.

BOOKS RECOMMENDED

1. Fluid Dynamics and Heat Transfer of Turbomachinery B. Lakshminarayana, John Wiley & Sons, 1996.
2. Cascade Aerodynamics -J.P. Gostelow, Pergamon Press, 1984.
3. Aero-Thermodynamics and Flow in Turbomachines-M.H.Vavra; , John Wiley & Sons, 1960.
4. Theory of Turbomachines -G.T.Csanady, McGraw Hill

ME-707

DATA ACQUISITION SYSTEM

L	T	P	Cr
3	0	0	3

1. INTRODUCTION TO DATA ACQUISITION SYSTEMS:

Instrumentation systems, types of instrumentation systems, components of an analog-data acquisition system, uses of data acquisition systems, use of recorders in digital system, Digital recording systems: input conditioning equipment, Digitiser, Multiplexer.

2. REVIEW OF VARIOUS TYPES OF SENSORS AND TRANSDUCERS:

Temperature, pressure, strain, flow, deflection velocity, water level, motion, torque, power Mechanical, Electrical , variable resistance, capacitance, thermoelectric, Photo-electric, Piezo-electric type.

3. SIGNAL CONDITIONING:

Introduction, amplification, instrumentation amplifier, Mechanical, Fluid & Optical amplifiers, A.C.& D.C. amplifiers, Operational amplifier specifications, operational amplifier circuits in instrumentation, Adder, inverter, subtractor, integrator, differentiator, logarithmic converter, Differential amplifier, Modulator, demodulators, filters, types of filters, low pass, band pass, bridges, current sensitive bridge circuit, Voltage sensitive bridge, blast circuits.

4. A/D & D/A CONVERSION TECHNIQUES:

Resolution and Quantization, Aperture time, Sampling, D/A Converters, A/D conversion techniques- successive approximation resistor method, voltage to time A/D converter, Voltage to frequency converter techniques. Dual slope integration technique, Sample ard hold circuit, Analog multiplexer.

5. INTRODUCTION TO MICROPROCESSOR:

Introduction to microprocessors 8086, 80286. 80386, 80486 and Pentium series, internal architecture of 8086- execution unit, bus interface unit addressing Schemes- immediate addressing mode, resistor addressing-mode, direct addressing mode and in-direct addressing mode, segmentation, pin configuration of 8086, Assembly language programming- Instruction set, assembly language programmes like addition, multiplication & division. Microprocessor other chips-8284 A clock generator, 8288 bus controller, Interfacing- 8212 input/output, I/O code and programmable 8255 peripheral interface, 8253 programmable timer, programmable communication interface, Direct memory access.

6. APPLICATION OF MICROPROCESSOR TO DAS: -

Microprocessor based measurement, control and display of temperature, pressure, flow, speed, velocity, strain, water level etc.

BOOKS RECOMMENDED

1. Measurement systems- Application and design by E.O. Doebelin
2. Electronic measurement and instrumentation by Oliver & Cage.
3. Microprocessors & Interfacing by Douglas V.Hall TATA Mc Graw Hill.
4. Operational amplifier circuits by R.F. Coughlin & Driscoll. PHI
5. Microcomputer Systems: The 8086/8088 family by YU-Cheng liu & Glenn A Gibson. Prentice Hall of India.
6. Microprocessors with Applications in process Control by S.I. Ahson, Tata McGraw Hill New Delhi.

ME-713

ADVANCED HEAT TRANSFER

L	T	P	Cr
3	0	0	3

1. Conduction:

Review of governing equation, One dimensional steady state conduction with and without heat sources, Fins of non-uniform cross-sectional area, Two dimensional steady state conduction-method of separation of variables, graphical method-construction of flux plots, determination of heat transfer rate, conduction shape factor.

2. Transient Heat Conduction:

General Lumped capacitance analysis, spatial effects, plane wall with convection, Transient heat flow in semi infinite solid-const, Multidimensional systems, use of Heisler chart, heat conduction with moving boundary – heat conduction in melting and solidification, moving heat source.

3. Forced-Convection:

General review, Laminar Flow: a similarity solution, Turbulent flow, mixed boundary layer conditions, flow across cylinders and spheres, tube banks – inline and staggered arrangement, packed beds, introduction to compact heat exchangers, convection heat and mass transfer.

4. Free-Convection:

Inclined and horizontal plates – the flow pattern and heat transfer, heat transfer from upper and lower surfaces of heated or cooled palates, tubes, vertical and inclined channels, enclosures, combined free and forced convection.

5. Radiation:

Review of fundamental concepts and laws, radiation exchange between surfaces: shape factors, determination of shape factors, view factor algebra, radiosity, irradiation, radiation shields, black body radiation exchange, radiation exchange between diffuse, gray surfaces, gaseous emission and absorption.

TEXT BOOKS

1. Heat Transfer - Incroperra & Dewitt.
2. Heat & Mass Transfer – Eckert & Drake.
3. Analysis of Heat & Mass Transfer – Eckert & Drake.

REFERENCE:

1. Convective Heat & Mass Transfer – Kays & Crawford.
2. Radiative Heat Transfer -- Siegel &Howell

ME-711

COMPUTATIONAL FLUID DYNAMICS & HEAT TRANSFER-III (CFD&HT-III)

L	T	P	Cr
3	0	0	3

1. Grids with appropriate Transformations, general transformation of equations, matrices and Jacobians, stretched grids, boundary fitted coordinate systems: elliptic grid generation.

2. Solution of N-S equations for incompressible Flows using MAC & SIMPLE 'algorithms, staggered grids, MAC formulation, boundary conditions, numerical stability considerations, higher order upwind differencing, solution of energy equation, retention of dissipation. SIMPLE formulation: discretization of one dimensional convection-diffusion equation, various differencing schemes, formulation of flow problem, momentum equation, pressure correction equation, two dimensional systems of equations and line by line TDMA Inviscid flow.

3. Advanced topics in CFD:
Additional considerations for implicit methods: Linearisation of equations, the multidimensional problem, block tridiagonal matrix. Upwind scheme: flux vector splitting, Godunov approach second order Upwind scheme.

BOOKS RECOMMENDED

1. Computational fluid flow and heat transfer D.A. Anderson et .al
2. Computational Fluid Dynamics -John D. Anderson Jr.
3. Introduction to Computational Fluid Mechanics -Chuen –Yen Chow.
4. Computational Fluid Flow and Heat Transfer -K.Murelidhar & T.Sunderrajan, Narosa Publishing House.

ME-714

EXPERIMENTAL TECHNIQUES IN FLUID FLOW & HEAT TRANSFER

L	T	P	Cr
3	0	0	3

1. WHAT DO WE MEASURE, AND WHY:

Introduction, the need for flow measurements, what do we need to know?, examples of fluid mechanics measurements, measurement of sediment load in a stream, wind-tunnel studies, propeller vibration, aeroacoustics, turbulent mixing layer, summery, outline of the theory of fluid mechanics, inviscid flow, viscous flow and turbulence, spatial and temporal resolution in measurements, correlation of data and signal analysis, classification of deterministic data, random data and signal analysis.

2. PHYSICAL LAWS OF FLUID MECHANICS AND THEIR APPLICATION TO MEASUREMENT TECHNIQUES:

Introduction, similarity analysis, inviscid, incompressible fluids, inviscid, compressible fluids, viscous fluids.

3. DIFFERENTIAL PRESSURE MEASUREMENT:

Introduction, uses of differential pressure measurements, principles involved in measuring velocities with differential pressure, pitot-static and impact pressure tubes, multidimensional mean-velocity measurement, physical errors in the measurement of steady pressure, types of transducers for measuring unsteady pressure, condenser microphones, Piezoelectric transducers, strain-gage transducers, mechanical transduction of time-varying press sure signals, physical errors in the measurement of unsteady pressures, spatial -resolution errors, aerodynamic interference, acoustic reflection, special techniques with microphone arrays.

4. THERMAL ANEMOMETERS:

Introduction, strengths, limitations, and comparisons with laser velocimeters, hot wire sensors, probe supports and mounting, control circuit, calibration of a hot-wire anemometer, heat transfer from fine wires, high speed flow, conduction to walls, conduction to the supports, angle sensitivity and support interference, measuring mean velocity, velocity components, and temperature, one component using a single hot wire, two components using an X probe, three components, multipositiion measurements, nonisothermal flows, dynamics of the constant temperature hot-wire anemometer, frequency response of a constant temperature hot wire anemometer, optimization and electronic testing of the dynamics of the hot wire anemometer, large velocity fluctuations, dynamic effects of conduction losses to the supports, attenuation of heat waves across the thermal boundary layer of the sensor, finite resolution due to finite sensor size, noise in constant temperature thermal anemometry, film sensors, cylindrical film sensors, noncylindrical film sensors, constant current operation, other measurement techniques and applications using the constant temperature anemometer, aspirating probe, pressure measurements, total flow, split film sensors, conclusion.

5. LASER VELOCIMETRY:

Introduction, basic principles, doppler shift of light scattered by small particles, optical heterodyne detection, basic optical systems, the dual beam LDV, practical dual-beam optics, characteristics of the dual-beam signal, the reference beam LDV, multivelocity component systems, photodetectors, detector characteristics, photoemission statistics, shot noise signal to noise ratio effects, scatters particles, properties of the random light flux, signal representation random doppler light flux, statistical properties of g (x, t, D), correlation and power spectrum, burst density, high burst density signals (N 1), signal processors, amplitude correlators, photon correlators, spectrum analysis, frequency trackers, frequency counters, selection of signal processors, data process, processing data from time-averaging processors, processing data from time-resolving signal processors, fringe biasing.

6. VOLUME FLOW MEASUREMENTS:

Introduction, classification of metering devices, selected meter performance characteristics, orifice meters, venturi tubes and flow nozzles, elbow meters, pitot tubes, laminar flowmeters, turbine meters, rotameters, target meters, thermal flowmeters, weirs and flumes, magnetic flowmeters, acoustic flowmeters, vortex-shedding meters, laser flowmeters, coriolis-acceleration flowmeters, flow conditioning devices, proving-primary and secondary standards, liquid flow; static weighing procedure, liquid flow; dynamic weighing procedure, gas flow: static gas flow: dynamic procedure, ballistic calibrators. NBS facilities and secondary standards, traceability to National flow standards-measurement assurance programs for flow, static traceability, dynamic traceability, measurement assurance programs, the role of flow conditioning in the Artifact package, test program, data analysis.

BOOKS RECOMMENDED

1. Aerodynamic Measurement -MIT Press -Edited by R.C.Din
2. Fluid Mechanics Measurement -Edidted by R.J.Goldstein Hemisphere Pub.Corporation.

ME-712

SIMULATED DESIGN OF SOLAR SYSTEMS

L	T	P	Cr
3	**0**	**0**	**3**

1. SOLAR HEAT SYSTEMS:
General System, solar collectors, solar DHW systems; liquid based and air based solar space heating systems; solar radiation collection.

2. PROGRAMMING, SCHEMATIC DESIGN AND ITS DEVELOPMENT:
Programming phase and checklist; schematic design and checklist; Solar collector operational consideration; thermal storage for solar heating systems and its design; design of heat exchangers; selection of pumps, fluids and tubes; design of fans and ducts; solar energy cost equation and its constituents.

3. SIMULATIONS IN SOLAR PROCESS DESIGN:
Simulation programs; the utility of simulations; information from simulations; TRNSYS, a thermal process simulation program; simulations and experiments, metrological data limitations of simulations.

4. DESIGN OF ACTIVE SYSTEMS BY F-CHART:
Review of design methods; the f-chart methods, the f-chart for liquid systems; the f-chart for air systems; service water heating systems; f-chart results; parallel solar energy-heat pump systems.

5. DESIGN OF ACTIVE SYSTEMS BY UTILIZABILITY METHODS:
Hourly utilizability, daily utilizability; the phi-bar f-chart method.

6. DESIGN OF PASSIVE AND HVBRID HEATING SYSTEMS:
Approaches to passive design; the solar-load ratio method; the utilizability design method: direct gain; the -utilizability design method: collector-storage walls; hybrid systems: active collection with passive storage.

BOOKS RECOMMENDED

1. Solar Energy Engineering by A.A.M.Sayigh; Academic Press.
2. Solar Engineering of thermal process by Duffie & Beckman; Wiley
3. The Solar Heating Design process by Kreider; MGH
4. Applied Solar Energy by Meinel & Meinel ; Addison
5. Solar Heating and Cooling by Kreider & Kreith; MGHME

Open Elective

ME-750

INTRODUCTION TO FINITE ELEMENT METHOD

L T P Cr
3 0 0 3

1. FUNDAMENTAL CONCEPTS:
Introduction, boundary conditions, strain-displacement relations, stress-strain relations, temperature effects, Rayleigh-Ritz Method, Galerkin's Method, Saint Venant's Principle, Matrix algebra, Gaussian Elimination.

2. FINITE ELEMENT MESHES:
Choice of mesh, mesh data in numerical form, generation of mesh data, mesh modification.

3. ONE -DIMENSIONAL PROBLEMS: Introduction, Finite element Modeling, Co-ordinates and Shape Functions, Potential energy approach, The Galerkin Approach, Assembly of Global stiffness matrix and load vector, Finite element equations; Treatment of boundary conditions, quadratic shape functions, Temperature effects.

4. TRUSSES: Introduction, plane trusses, three dimensional trusses, assembly of global stiffness matrix for the banded and skyline solution.

5. TWO- DIMENSIONAL PROBLEMS: Introduction, finite element modeling, constant strain triangle (CST), Problem modeling and boundary conditions.

6. AXISYMMETRIC SOLIDS SUBJECTED TO AXISYMMETRIC LOADING: Introduction, Axisymmetric formulation, finite element modeling: Triangular elements, Problem modeling and boundary conditions.

7. TWO -DIMENSIONAL ISOPARAMETRIC ELEMENTS AND NUMERICAL INTEGRATION:
Introduction, The fournode quadrilateral, Numerical Integration, Higher order element, Problem related to beams.

8. BEAMS AND FRAMES: Introduction, finite element formulation, load vector, boundary considerations, shear force and bending moment beams on elastic supports, plane frames, three dimensional frames.

RECOMMENDED BOOKS

1. Introduction to Finite Elements in Engineering Tirupathi, R. ,Chandrupatle Ashoka D. Belegundu
2. An Introduction to Finite Element Method J.N. Reddy
3. Finite Element Analysis -Theory and Programming C.S. Krishnamurthy
4. The Finite Element Method in Engineering S.S. Rao