COURSE STRUCTURE FOR M.TECH. MECHANICAL FIRST YEAR (Thermal Engineering)

SEMESTER I			M.TECH										
Sr. No	Course Code	Course Name	Teaching Scheme					Exam Scheme					
			L	T	P	C	Hrs/wk	Theory			Practical		Total Marks
								MS	ES	IA	LW	LE/Viva	
1	MA 501T	Advanced Engineering Mathematics	3	0	0	7	3	30	60	10	--	--	100
2	MA 501P	Advanced Engineering Mathematics	0	0	2	1	2				25	25	50
2	ME 501T	Advanced Fluid Mechanics	3	0	0	6	3	30	60	10	--	--	100
3	ME 502T	Advanced Engineering Thermodynamics	3	0	0	6	3	30	60	10	--	--	100
4	ME 503P	Thermal Lab-I	0	0	2	2	2	--	--	--	25	25	50
5	ME 5XXT	Elective I	3	0	0	6	3	30	60	10	--	--	100
6	ME 5XXT	Elective II	3	0	0	6	3	30	60	10	--	--	100
		Total	**15**	**0**	**4**	**34**	**19**						600

MS = Mid Semester, ES = End Semester; IA = Internal assessment (like quiz, assignments etc)

LW = Laboratory work; LE = Laboratory Exam

Elective I: (i) ME 510T: Heating Ventilation and Air conditioning (ii) ME 511T: Advanced Gas Dynamics
Elective II: (i) ME 505T: Cryogenics (ii) ME 513T: Energy Management

ME 501T ADVANCED FLUID MECHANICS										
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	--	6	3	30	60	10	--	--	100

UNIT I **08**

Introduction: Flow patterns, fluid forces, Solid Vs. Fluid, Physical interpretation of Viscosity, Control volume approach etc.

Derivation of Governing Partial Differential Equations: Derivation of Continuity, Momentum and Energy equation Fluxes in Navier-Stokes Equation, Non dimensional N-S Equation, Initial and Boundary conditions, Integral parameters.

UNIT II **10**

Exact solution of Navier –Stokes Equation: Introduction, flow of two immiscible fluid in plane channel, flow in a pipe, flow between two concentric cylinder, stokes first and second problem, flow over a flat plate with suction,

Vorticity Dynamics: Introduction, vortex lines and tubes, Role of viscosity in Rotational and Irrotational flow ,Kelvin's circulation theorem, Vorticity transport equation, Interaction of Vortices

UNIT III **10**

Laminar Boundary Layers: Ideal and Boundary Layer Theory, Prandtl's Model of boundary layer flow, order of magnitude analysis, flow over flat plate, Blasius solution for flow over flat plate, Boundary layer with non zero pressure gradient, Momentum integral approach,Karman-pohalhausen method for flat plat and duct, Separation and its prevention.

Potential Flow Theory: Incompressible-Inviscid flow, Numerical solution of plane Inviscid flow, Complex variables ,simple potential flows like uniform flow, Irrotational vortex,source,sink,doublet, flow past a half body, cylinder and cylinder with circulation,

UNIT IV

Turbulent Flow: **06**

Concept of linearized stability of parallel viscous flow, transition to turbulent flow, Reynolds equation for turbulent flow, Reynolds stresses, Prandtl's mixing length theory, velocity profile, Turbulent flow in pipes, turbulent boundary layer on flat plate.

Compressible Flow: **04**

Introduction, one dimensional compressible gas flow, flow in nozzle, effect of viscous friction and heat transfer, shocks in supersonic flow, Normal and oblique shocks

Approximate Total : 39 Hrs

Texts and References

1. Advanced Engineering Fluid Mechanics, Muralidhar & Biswas
2. Fluid Mechanics and its Applications, Gupta and Gupta, 1988.
3. Fluid Mechanics, Kundu & Cohen, 2002.
4. Boundary Layer Theory: Schlichting & Gersten, 2000.
5. A first course in Turbulence: Tennekes & Lumley, 1972.

ME 502T ADVANCED THERMODYNAMICS										
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	--	6	3	30	60	10	--	--	100

UNITI: Property relationships for pure substances and Mixtures **12**

Thermodynamic Relations: Some mathematical theorems, Maxwell's equations, Tds equations, Difference in heat capacities, ratio of heat capacities, energy equation, Joule-Thomson effect. Clausius- Clapeyron equation, Evaluation of thermodynamic properties from an equation of state. Helmoltz and Gibbs functions; Maxwell's relations; Enthalpy, entropy, internal energy, and specific heat relations; Clausius-Clapeyron's equation; Applications to ideal and real gases. Joule-Thomson coefficient.

Ideal Gas Mixtures: Dalton's law of additive pressures, Amagat's law of additive volumes, evaluation of , properties. Analysis of various processes.

Pscychrometry : Atmospheric air and Psychometric properties; Dry bulb temperature, wet bulb temperature, dew point temperature; partial pressures, specific and relative humidity and the relation between the two. Enthalpy and adiabatic saturation temperature. Construction and use of psychrometric chart. Analysis of various processes; heating, cooling, dehumidifying and humidifying. Adiabatic mixing of stream of moist air. Summer and winter air-conditioning.

UNIT II Combustion Thermodynamics **5**

Theoretical (Stoichiometric) air for combustion of fuels. Excess air, mass balance, Exhaust gas analysis, A/F ratio. Energy balance for a chemical reaction, enthalpy of formation, enthalpy and internal energy of combustion. Combustion efficiency. Dissociation and equilibrium, emissions.

UNIT III Thermodynamics Cycles **9**

Gas Power Cycles

Air standard cycles; Carnot, Otto, Diesel, Dual and Stirling cycles, p-v and T -s diagrams, description, efficiencies and mean effective pressures. Comparison of Otto and Diesel cycles. Gas turbine (Brayton) cycle; description and analysis. Regenerative gas turbine cycle. Inter-cooling and reheating in gas turbine cycles.

Vapor Power Cycles

Carnot vapor power cycle, drawbacks as a reference cycle. Simple Rankine cycle; description, T-s diagram, analysis for performance. Comparison of Carnot and Rankine cycles. Effects of pressure and temperature on Rankine cycle performance. Actual vapour power cycles. Ideal and practical regenerative Rankine cycles, open and closed feed water heaters. Reheat Rankine cycle.

Refrigeration Cycles

Vapour compression refrigeration system; description, analysis, refrigerating effect. capacity, power required, units of refrigeration, COP Refrigerants and their desirable properties. Air cycle refrigeration; reversed Carnot cycle, reversed Brayton cycle Vapour absorption refrigeration system. Steam jet refrigeration

UNIT IV Compressible Flows and Steam Nozzles **7**

Compressible Flows:

Velocity of pressure pulse in fluid, stagnation properties, one dimensional steady isentropic flow,

critical properties-choking in isentropic flow, normal shocks, adiabatic flow with friction and without friction, numerical problems.

Steam nozzles:

Flow of steam through nozzles, shape of nozzles, effect of friction, critical pressure ratio, supersaturated flow. .

UNIT V Reciprocating Compressors **5**

Operation of a single stage reciprocating compressors. Work input through p-v diagram and steady state steady flow analysis. Effect of clearance and volumetric efficiency. Adiabatic, isothermal and mechanical efficiencies. Multi-stage compressor, saving in work, optimum intermediate pressure, inter-cooling, minimum work for compression.

Approximate Total : 38 Hrs

Texts and References

1. **Thermodynamics: an Engineering Approach,** Y.A.Cengal and M.A.Boles, McGraw Hill (Fifth edition).
2. A. Bejan, Advanced Engineering Thermodynamics, 3rd edition, John Wiley and sons, 2006.
3. M.J.Moran and H.N.Shapiro, Fundamentals of Engineering Thermodynamics, John Wiley and Sons.
4. T.D. Eastop and A. Mcconkey Applied Thermodynamics for Engineering Technologists (5th Edition), Prentice Hall
5. P.K. Nag, Engineering Thermodynamics, McGraw-Hill Education, 2008

ME 503 P Thermal Engineering -I

Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
--	--	2	1	2	--	--	--	25	25	50

List of Experiments:

1. Performance test of an aerofoil
2. Numerical simulation of aerofoil performance test
3. Heat balance sheet of IC engine.
4. Conductive heat transfer experiment.
5. Software based numerical simulation of conductive heat transfer experiment
6. Software based performance analysis of power plants.

ME 510T HEATING VENTILATION AND AIR CONDITIONING										
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	6	3	30	60	10	--	--	100

UNIT I **08**

Introduction: Overview of Industry and Scope of HVAC, applications of HAVC, definitions and terminology.

Psychrometry: Applied Psychrometry, Psychometric processes using chart - Basic processes such as sensible heating/cooling, humidification/dehumidification and their combinations, steam and adiabatic humidification, adiabatic mixing, etc. - Bypass factor and Sensible heat ratio.

UNIT II **11**

Human Comfort: Heat transfer from body, convection, radiation, conduction, evaporation, clothing resistance, activity level - Concept of human comfort – Thermal response - comfort factors – Environmental indices - Indoor air quality

Cooing Load Estimation: External load – solar radiations, wall, roof and glass etc.; internal load – occupancy, lighting, equipments; Ventilation - air quantity; Load estimation methods - Equivalent Temperature Difference Method, Cooling Load Temperature Difference, and Radiance Method, RSHF, GSHF, ESHF, etc.

Heating load estimation: Vapour transfer in wall, vapour barrier, and load estimation basics.

UNIT III **12**

Air Distribution: Ducts, Types of ducts, Fundamentals of air flow in ducts, pressure drop calculations, design ducts by velocity reduction method, equal friction method and static regain method, duct materials and properties, insulating materials, methods of sizing and balancing.

Ventilation: Requirement of ventilation air, various sources of infiltration air, ventilation and infiltration as a part of cooling load, threshold limits of contaminants, estimation of ventilation rates, decay equation, air flow round buildings. Methods of Ventilation - Natural, wind effect, stack effect, combined effect - Mechanical, forced, exhaust, and combined - Displacement ventilation.

Ventilation System Design: Exhaust ducts, filters, blowers, hoods, chimney, etc.

UNIT IV **08**

Air conditioning systems: Classification, design of central and unitary systems, typical air conditioning systems such as automobile, air plane, ships, railway coach air-conditioning, warm air system, hot water systems, heat pump, clean rooms etc.

APPROXIMATE TOTAL 39 Hours

Texts and References

1. ASHRAE Handbook - Fundamentals, American Society of Heating, Refrigerating and Air - Conditioning Engineers Inc., Atlanta, USA, 2009.
2. HVAC Handbook, ISHRAE
3. Refrigeration Handbook, ISHRAE
4. Industrial Ventilation Application Handbook, ISHRAE

5. Air conditioning and ventilation of buildings, Croome, D.J. and Roberts, B.M., Pergamon.
6. Refrigeration and Air Conditioning, Stoecker, W.F., and Jones, J.W., 2nd Edition, Tata McGraw Hill, New Delhi 1982.
7. Refrigeration and Air Conditioning, Arora, C.P., Tata-McGraw- Hill, New Delhi, 2003.
8. Heating, Ventilating and Air Conditioning-Analysis and Design, McQuiston, Faye; Parker, Jerald; Spitler, Jeffrey, 5th ed. John Wiley & Sons, 2000.

ME 511T: Advanced Gas Dynamics										
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	--	6	3	30	60	10	--	--	100

UNIT I

Review of fundamentals: Types of flows, concepts of continuum and control volume, generalized continuity, momentum and energy equations, velocity of sound and its importance, physical difference between incompressible, subsonic and supersonic flows, three reference speeds, dimensionless velocity M*, concepts of static and stagnation parameters.

One dimensional isentropic flow: General features, working equations, choking in Isentropic flow, operation of nozzles and diffusers under varying pressure ratios, performance of real nozzles, applications of isentropic flow.

UNIT-II

Normal shocks: Introductory remarks, governing equations, Rankine–Hugonout, Prandtl's and other relations, weak shocks, thickness of shocks, normal shocks in ducts, performance of convergent-divergent nozzle with shocks, moving shock waves, shocks problems in one dimensional supersonics diffuser, supersonic pilot tube.

UNIT III

Flow in constant area duct with friction: Governing equations, working formulas and tables, choking due to friction, performance of long ducts, isothermal flow in long ducts, flow in constant area duct with heating and cooling.

Generalized one dimensional flow: Working equations, general method of solution, example of combined friction and area change, example of combined friction and heat transfer.

UNIT IV

Multidimensional flow: Equation of continuity, Navier stock equation, potential flow, Method of characteristics.

Dimensional analysis and similitude: Buckingham pai theorem, Van driest theorem, Dimensional analysis, model study, compressible flow of viscous fluids.

Rarefied gas dynamics: Knudsen number, sleep flow, transition and free molecular flow

Forces on submerged bodies: Forces exerted by flowing fluid on a stationary body, drag, lift for different objects like sphere, cylinder, development of lift on a circular cylinder, development of lift on aerofoil.

APPROXIMATE TOTAL 42

Texts and References

1. Fundamentals of Compressible Flow by S.M. Yahya, New Age
2. Gas Dynamics by Ali Campbell & Lenning
3. Gas Dynamics by Radha Krishnan , PHI

ME 505 T: Cryogenics										
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	--	6	3	30	60	10	--	--	100

UNIT I

Introduction to properties of engineering materials at cryogenic temperatures, mechanical properties, thermal properties, electric & magnetic properties, super conducting materials, thermo electric materials, composite materials, properties of cryogenic fluids, super fluidity of He3 & He 4.

Cryogenic insulation – expanded foams, gas filled & fibrous insulation, vacuum insulation, evacuated powder & fibrous insulation, opacified powder insulation, multilayer insulation, comparison of performance of various insulations .

UNIT-II

Applications of cryogenic systems: Super conductive devices such as bearings, motors, cryotrons, magnets, D.C. transformers, tunnel diodes, space technology, space simulation, cryogenics in biology and medicine, food preservation and industrial applications, nuclear propulsions , chemical propulsions.

Cryogenic Refrigeration System: Ideal isothermal and reversible isobaric source refrigeration cycles, Joule Thomson system, cascade or pre-cooled joule–Thomson refrigeration systems, expansion engine and cold gas refrigeration systems,

UNIT III

Advanced Cry coolers: Philips refrigerators, Importance of regenerator effectiveness for the Philips

refrigerators, Gifford single volume refrigerator, Gifford double volume refrigerators analysis, COP, FOM, regenerators, pulse tube refrigerators, various types of pulse tube refrigerator.

Refrigerators using solids as working media: Magnetic cooling, magnetic refrigeration systems, thermal; valves, nuclear demagnetization.

UNIT IV

Gas liquefaction systems: Introduction, thermodynamically ideal systems, Joule Thomson effect, liquefaction systems such as Linde Hampton, precooled Linde Hampson, Linde dual pressure,

cascade, claude, kapitza, heyland systems using expanders, comparison of liquefaction systems.

APPROXIMATE TOTAL 42

Texts and References

1. Cryogenic process engineering, Thomas M Flynn, Informa Health Care, 2004
2. Miniature refrigerators for cryogenic sensors and cold electronics, Graham Walker,
3. Clarendon Press, 1989
4. Cryogenic technology & applications, A R Jha, Butterworth-Heinemann, 2006,
5. Cryocooler, Fundamentals Part I &II, Graham Walker, Plenum Press, New York
6. Cryogenic Regenerative Heat Exchangers, R.A. Ackermann, Springer, 1997
7. Cryogenic systems, R F Barron, Oxford University Press,
8. Cryogenic heat transfer, R F Barron, Taylor & Francis Group
9. Cryogenics: A Text Book, S. S. Thipse, Alpha Science Intl Ltd
10. Fundamentals Of Cryogenic Engineering, Mamata Mukhopadhyay, PHI
11. Fundamentals of Vacuum Engineering, Pipkov, Mir Publication.

ME 513T: Renewable Energy & Energy Management

Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	--	6	3	30	60	10	--	--	100

Solar energy: Devices for thermal collection, solar energy applications

Wind energy: analysis of wind speeds, different types of wind turbines, Wind date, factors for site selection, performance characteristics

Bio Energy: Biomass gasifies, types, design and construction of biogas plants, scope and future

Tidal, wave and ocean thermal energy conversion plants, geothermal plants

Energy Management: Its importance, Steam Systems: Boiler efficiency testing, excess air control, Steam distribution, condensate recovery, flash steam utilization, Thermal Insulation Energy conservation in Pumps, Fans, Compressed Air Systems, Refrigeration & Air conditioning systems

Waste heat recovery: Recuperates, heat pipes, heat pumps, Cogeneration - concept, options (steam/gas turbines/diesel engine based), selection criteria, control strategy

Heat exchanger networking: concept of pinch, target setting, problem table approach, composite curves. Demand side management, financing energy conservation

APPROXIMATE TOTAL 42

Texts and References

1. Solar Energy by S P Sukhatme and J K Nayak
2. Solar Engineering of Thermal Processes by Duffie and Backman
3. Energy Management and Conservation Frank Kreith and D Yogi Goswami Handbook CRC press
4. TERI hand book on Energy Conservation
5.Industrial Energy Conservation Manuals, MIT Press
6. Heat Exchanger Network Synthesis- Process Optimisation by Energy and Resource Analysis by Uday V Shenoy, Gulf Publ. Company