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

SEMESTER II			M.TECH											
Sr. No	Course Code	Course Name	Teaching Scheme					Exam Scheme						
			L	T	P	C	Hrs/wk	Theory			Practical		Total
								MS	ES	IA	LW	LE/Viva	Marks
1	ME 506T	Experimental Methods	3	0	0	6	3	30	60	10	--	--	100
2	ME 507 T	Advance Heat Transfer	3	0	0	6	3	30	60	10	--	--	100
3	ME 508 T	Computational fluid Dynamics	3	1	0	8	4	30	60	10	--	--	100
4	ME 509P	Thermal Lab-II	0	0	2	2	2	--	--	--	25	25	50
5	ME 5XXT	Elective III	3	0	0	6	3	30	60	10	--	--	100
6	ME 5XXT	Elective IV	3	0	0	6	3	30	60	10	--	--	100
		Total	**15**	**1**	**2**	**34**	**18**						550

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

LW = Laboratory work; LE = Laboratory Exam

Elective I: (i) ME 514 T: Design and Optimization of Thermal Systems (ii) ME 515 T: Advanced Convective Heat Transfer
Elective II: (i) ME 516 T: Solar thermal systems (ii) ME 517T: Turbo machinery (iii) ME 518T: Finite Element Method

ME 506 T: Experimental Methods										
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs/Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
3	**1**	**--**	**8**	**4**	**30**	**60**	**10**	**--**	**--**	**100**

UNIT-I

Strategy of experimentations: Applications of experiment methods, basic principles, design guidelines, statistical design and problems . Experimental design; statistical analysis of data; computerized data acquisition and reduction; experiments on signature analysis, fluid flow, heat transfer, material properties, and vibrations; individual experimental design projects

UNIT-II

Comparative Experiments: Statistical concepts**,** probability, variations, correlations, transformation techniques, central limits, significance, confidence limits, distribution test, analysis of variance, goodness of fit, non parametric methods.

UNIT III

Analysis of sequence of data: Measurements in sequences, interpolation procedures, Markov chains, series of events, runs test, calibration, regression analysis, splines, segmenting sequences, autocorrelation, semi variograms, spectral analysis.

UNIT IV

Spatial analysis: systematic patter search, distribution of points, distributions of lines, analysis of directional data, spherical distributions, fractal analysis, kriging.

UNIT V

Analysis of multivariate data: Multiple regression, discriminant function, cluster analysis, factor analysis, principle component analysis, mode factor analysis, principle coordinate analysis, correspondence analysis, multidimensional scaling, canonical correlation.

Concept to Testing: Research question, hypothesis, defining, gathering, analyzing, concluding, variable, values, observation, scales of measurements, error analysis, hypothesis testing

APPROXIMATE TOTAL 42

Texts and References

1. D.C. Montgomery, Design and Analysis of Experiments, John Wiley, New York, 2001.
2. R. S. Figliola and D. E. Beasley, Theory and Design for Mechanical Measurements, John
3. Wiley Publication.
4. T.G. Beckwith, R. D. Marangoni and J. H. Lienhard N.L., Mechanical Measurements, Pearson Education, 2003.
5. E.O. Doeblin, Measurement Systems, McGraw-Hill, New York, 1986.
6. R.J. Goldstein (Editor), Fluid Mechanics Measurements, Hemisphere Publishing Corporation, New York, 1983; second edition, 1996.
7. C. Tropea, J. Foss and A. Yarin Springer Handbook of Experimental Fluid Mechanics, 2007.
8. J. P. Holman, Experimental Methods for Engineers, Mc Graw Hill, 2007.
9. R.S. Figliola, and D.E. Beasley, Theory and Design for Mechanical Measurements - 2nd Edition, Wiley, 1995

ME 507T Advanced Heat Transfer

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

Conduction: Conservation equations; 1-D, 2-D, and 3-D steady conduction; 1-D unsteady conduction; Solution methods - analytical and numerical; extended surfaces

Convection: conservation equations and boundary conditions; One-dimensional solutions; External and internal flow convection; heat transfer in laminar developed and developing duct flows; Laminar boundary layers: Similarity and integral solutions; Turbulence fundamentals and modeling; Heat transfer in turbulent boundary layers and turbulent duct flows; Fundamentals of boiling and condensation

Radiation: Fundamentals; radiative properties of surfaces; Radiant exchange between surfaces; radiative heat transfer in participating media.

Approximate Total : 39 Hrs

Texts and References

1. 1. M N Ozisik, *Heat Conduction*, 2nd ed, John Wiley & Sons, 1993
2. F P Incropera and D P Dewitt, *Introduction to Heat Transfer*, 3rd ed, John Wiley & Sons, 1996
3. V S Arpaci, *Conduction Heat Transfer*, Addison-Wesley, Reading, MA, 1966
4. M F Modest, *Radiative Heat Transfer*, McGraw-Hill, 1993
5. R Siegel and J R Howell, *Thermal Radiation Heat Transfer*, 3rd ed, Taylor & Francis, 1992
6. W. M. Kays and E. M. Crawford, *Convective Heat and Mass Transfer*, Mc Graw Hill,1993.
7. Louis C Burmeister, *Convective Heat Transfer*, John Wiley and Sons, 1993.
8. Adrian Bejan, *Convective Heat Transfer*, John Wiley and Sons, 1995.

ME508T COMPUTATIONAL FLUID DYNAMICS										
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	0	7	4	30	60	10	--	--	100

UNIT I **09**

Introduction to Computational Fluid Dynamics and Principles of Conservation: Computational Fluid Dynamics: What, When, and Why?, CFD Applications, Numerical vs Analytical vs Experimental, Modeling vs Experimentation, Fundamental principles of conservation Mass, momentum and energy equations; Conservative forms of the equations and general description, physical boundary **conditions.**

Numerical Methods: Classification into various types of equations – parabolic, elliptic, hyperbolic and mixed type; Boundary and initial conditions; Overview of numerical methods.

UNIT II **10**

Discretization: Finite Difference Method - explicit, implicit, stability requirement, polynomial fitting, approximation of boundary conditions, applications to heat conduction and convection; Finite Element Method: Variational principle and weighted residual, Rayleigh-Ritz, Galerkin and Least square methods, 1-D and 2-D elements, applications to fluid flow and heat transfer problems; Finite Volume Method **–** finite volume discretization, approximation of surface and volume integrals, interpolation methods - central, upwind and hybrid formulations and comparison.

UNIT III **10**

Methods of Solution: Solution of finite difference equations, iterative methods, matrix inversion methods, ADI technique, SIMPLE algorithm, operator splitting, fast Fourier transform, applications.

Numerical Grid Generation: Grid generation techniques, transformation and mapping, structured and unstructured grid generation, Application of grid generation techniques.

UNIT IV **10**

Introduction and Application of ANSYS Fluent: Geometric modeling-ANSYS Workbench/CFX, mesh generation, boundary and initial conditions, computational approach, analysis.

Case Study: Numerical simulation of steady and un-steady process of fluid transport with and without heat transfer using ANSYS software – use ANSYS Workbench for geometrical modeling and turbulence models (i.e., RNG k-ε model, Standard k-ε model) for comparative analysis.

APPROXIMATE TOTAL 39 Hours

Texts and References

1. Computational Fluid Mechanics and Heat Transfer, Richard Pletcher, John Tannehill and Dale Anderson, CRC Press, 2012.
2. An introduction to computational fluid dynamics: The finite volume method, H.K. Versteeg and W. Malalasekera, Pearson Education, 2007.
3. Numerical Computation of Internal and External Flows, Charles Hirsch, Vol.2 , John Wiley &

Sons, 1990.
4. Computational Methods for Fluid Dynamics, J. H. Fergiger, M. Peric, Springer, 2002.
5. Computational Fluid Dynamics, T. J. Chung, Cambridge University Press, 2010.
6. Computational Techniques for Fluid Dynamics Vol. 1, C. A. J. Fletcher, Springer, 1991.
7. Computational Techniques for Fluid Dynamics Vol. 2, C. A. J. Fletcher, Springer, 1991.
8. Computational Fluid Dynamics, J. D. Anderson Jr., McGraw-Hill International Edition, 1995.
9. Computational Fluid Mechanics and Heat Transfer, John C. Tannehill, Dale A. Anderson and Richard H. Pletcher, Taylor &Francis.
10. Computational Fluid Dynamics, John D. Anderson Jr., McGraw Hill Book Company.
11. Computational Fluid Dynamics: Principles and Applications, J. Blazek, Elsevier.
12. Computational Methods for Fluid Dynamics, Ferziger, J. H. and Peric, M., Third Edition, Springer-Verlag, Berlin, 2003.
13. Introduction to Computational Fluid Dynamics: The Finite Volume Method, Versteeg, H. K. and Malalasekara, W., Second Edition (Indian Reprint) Pearson Education, 2008.

ME 509 P Thermal Engineering –II										
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. Convective heat transfer experiment and modeling.
2. Radiative heat transfer experiment and modeling.
3. Compact heat exchanger performance test.
4. Solar thermal experiment.
5. Developing and fully developed flow simulation.
6. Flow visualization and velocity field determination using PIV.

<table>
<tr><th colspan="11">ME 514T: Design and Optimization of Thermal Systems</th></tr>
<tr><th colspan="5">Teaching Scheme</th><th colspan="6">Examination Scheme</th></tr>
<tr><th rowspan="2">L</th><th rowspan="2">T</th><th rowspan="2">P</th><th rowspan="2">C</th><th rowspan="2">Hrs/Week</th><th colspan="3">Theory</th><th colspan="2">Practical</th><th rowspan="2">Total Marks</th></tr>
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<tr><td>3</td><td>0</td><td>--</td><td>6</td><td>3</td><td>30</td><td>60</td><td>10</td><td>--</td><td>--</td><td>100</td></tr>
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Basic considerations in Design: Engineering design, Integrated approach, formulation of the design problem, steps in design process, conceptual and acceptable design.

Modeling of Thermal systems: features of modeling, types of models, Mathematical modeling and validation, Physical modeling, curve fitting, numerical modeling.

System simulation: Principles of numerical modeling and simulation, multivariable simulation methods with wide range of applications, economic considerations.

Optimization: Basic concepts, optimization methods; Calculus and search methods; Linear, dynamic and Geometric programming; Multi-objective optimization, knowledge based design and additional considerations

Application of softwares for design and optimization of thermal systems

APPROXIMATE TOTAL 39

Texts and References

Books:

1. Design and Optimization of Thermal Systems by Yogesh Jaluria, CRC press.
2. Design of Thermal Systems by W.F. Stoecker, McGraw Hill
3. Optimization theory and applications by S.S. Rao, Wiley Eastern

ME 515T Advanced Convective Heat Transfer										
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

Introduction, Conservation Principles, Fluid Stresses and Flux Laws
Laminar Boundary Layer, Integral Equations for the Boundary Layer
Laminar Internal Flows: Momentum Transfer & heat transfer
Laminar External Boundary Layers: Momentum Transfer & heat transfer
Differential Equations for the Turbulent Boundary Layer
Turbulent External Boundary Layers: Momentum Transfer & heat transfer
Turbulent Internal Flows: Momentum Transfer & heat transfer
Influence of Temperature-Dependent Fluid Properties
Convective Heat Transfer at High Velocities
Convective Heat Transfer with Body Forces

References:

1. William M. Kays, M. Crawford and B. Weigand, *Convective heat and mass transfer*, 4th Ed., McGraw Hill
2. Louis C. Burmeister, *Convective Heat Transfer*, John Wiley and Sons, 1993.
3. Adrian Bejan, *Convective Heat Transfer*, John Wiley and Sons, 1995.

ME 516T SOLAR THERMAL SYSTEMS										
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	--	6	3	50	100	10	--	--	100

UNITI: Basics of Solar Energy and Low Temperature Solar Thermal Systems **10**

Solar geometry and solar resource assessment, Active and passive low temperature solar thermal systems. Solar water heaters with natural and forced circulations. Components: Flat plate and Evacuated tube collector, energy storage, auxiliaries. Solar water heater performance, efficiency.

UNIT II Space drying, Cooling and Thermal storage **7**

Solar drying, technology for drying, Thermal energy storage: sensible and latent heat storage, Solar vapor absorption and space cooling.

UNIT III Process Heating Generation **7**

Solar Cooking: Methods and technology, Solar distillation: methods and technology, Solar systems for process heat production.

UNIT IV Solar Thermal Electric Power Plants **7**

Types of solar thermal electric power plants based on parabolic trough, solar tower, parabolic dish and Linear Fresnel lenses.

UNIT V Solar Thermal System Design and Economics **7**

Fundamentals of design calculations and analysis of solar thermal systems. Solar plant installation, economics.

Approximate Total : 38 Hrs

Texts and References

1. Kalogirou S. A. Solar Energy Engineering: Process and systems, Academy Press, 2009
2. Duffie J. A, Beckman W. A., Solar Engineering of Thermal Processes, Wiley, 3rd ed, 2006
3. Sukhatme S. P., Nayak, J. K., Solar Energy-Principles of Thermal Collection and Storage, Tata McGraw Hill, 3rd ed, 2008
4. Dr. Felix A. Peuser & et al, Solar thermal systems- successful planning and construction, Solarpraxis AG, 2002
5. German Solar Energy Society, Planning and Installing Solar Thermal Systems- a guide for installers, architects and engineers, 2nd ed, 2010.

ME 517 T: Turbo machinery										
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

Rotodynamic machines: Pump and turbine parameters, similarities of Rotodynamic machines, non dimensional parameters, Specific speed based classification, different types, ranges of, operation. Testing of pumps: Test rigs, standard instrumentation, Operational characteristics, Testing of model turbines: test rigs, universal characteristics, separation of losses, cavitations characteristics.

UNIT-II

Centrifugal pumps: Radial and mixed flow, constructional details, Inlet, passage, Suction spiral, impeller, recuperator, vane diffuser, multi stage pumps, return passage, internal leakage
Wearing ring, axial thrust, balancing devices, Self priming arrangements, bearings and seals, Basic theory, number and shape of blades, blade loading, Head slip, Correction factors, pre rotation, off design performance, flow in the volute, flow in, the diffuser and return passage, losses, hydraulic losses, volumetric losses, disc friction, mechanical losses, estimation of axial thrust, pump characteristics, stable operation, parallel operation of pumps, pumps in pipe systems, cavitations, NPSH.

UNIT III

Axial flow pumps: Constructional details,, pump casing, guide system, impeller, blade adjusting mechanism, diffuser, bearings, blade profiles, aerofoil theory, estimation of blade lift and pump head losses, performance characteristics, cavitations.

UNIT IV

Hydraulic turbines: Basic parameters, principles of similarity, model turbines, Unit quantities and specific speed classification range of utilization, Constructional details of water turbines, Reaction turbines, propeller, Kaplan, bulb and Francis turbines, Inlet passage, Spiral casing, speed ring guide apparatus, casing, draft tube, Pelton wheel, distributor, nozzle, needle regulator, deflector, bucket, braking jet.

UNIT V

Basic theory of reaction turbine: Velocity triangles and their correction, aerofoil theory. flow through different flow passages, volute, guide, apparatus, runner and draft tube, hydraulic, volumetric and mechanical, losses, energy balance, regulation of discharge, off design performance, Forces and moments of guide vanes and adjustable blades of runner, axial thrust, cavitation in turbines, Thoma's coefficient, Location of turbine, above the tail race.

Theory of pelton wheel: Action of jet on the buckets, flow on bucket, surfaces, Hydrodynamic forces and torque on the runner losses energy balance.

APPROXIMATE TOTAL 42

Texts and References

1. Stepanoff A.J., Centrifugal and axial flow pumps, John Wiley 1962.
2. Lazarkieniz and Torskolanski, Impeller pumps, Pergamon Press,1965.
3. Brown JG. , Hydroelectric engineering practice, Vol.II, 1958.
4. Addison, H., A treatise on applied hydraulics, Chapman and Hall,1954.
5. Nechlepa, M., Hydraulic Turbines, Constable and Co., 1957
6. V. Kadambi and Manohar Prasad, An Introduction to energy conversion, Volume III – Turbo machinery, New Age International Publishers (P) Ltd.
7. S. M. Yahya, Turbines, Compressors & Fans, Tata-McGraw Hill Co., 2nd Edition (2002).
8. D. G. Shepherd, Principles of Turbo Machinery, The Macmillan Company (1964)
9. William W Perg, Fundamentals of Turbomachinery: John Wiley & Sons, Inc. 2008

ME 518T FINITE ELEMENT METHODS										
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 12

Introduction: Introduction to Finite Element Method. Difference between FEM,FDM and FVM .Basic Steps in FEM Formulation, General Applicability of the Method

Weighted Residual Methods: Collocation, Method of Least squares, Galerkin's method, Element of Calculus of Variations , Ritz Method, Equivalence of Ritz and Galerkin method for some cases.

UNIT II 12

Linear and Quadratic 1D Elements: Linear, quadratic and higher order elements. Application to solutions of ODE. Assembly and solution of banded system.

Finite Element to 2D problems: Introduction, Difference between 1D and 2D approach, types of 2D elements, Local coordinates, Global coordinates. Triangular elements: linear and quadratic elements with area coordinates Rectangular elements: General Quadrilateral elements, serendipity elements, linear and higher order shape functions

UNITIII **12**

Assembly of element equations, Solution of equations Application to flow and heat transfer problems, Discussion over higher order differential equations

Meshless Finite Element Methods: Introduction to Meshless Galerkin methods: Difference between Meshfree and FEM methods, Choice of approach, and interpolating polynomials, Variational Formulation, Application to some simple problem.

UNITIV **3**

Computer implementation: Pre-processor, Processor, Post-processor.

Approximate Total : 39 Hrs

Texts and References

1. J.N. Reddy, An Introduction to Finite Element Method, McGraw Hill Publication(2003)
2. L.S. Segerlind, Applied Finite Element Analysis, John Wiley & Sons
3. S.S. Rao, The Finite Element Method in Engineering, Pergamon
4. Bathe, K. J. *Finite Element Procedures*. Cambridge, MA: Klaus-Jorgen Bathe, 2007.
5. O. C. Zienkiewicz, R. L. Taylor, The Finite Element Method, Elsevier Butterworth-Heinemann