DEPARTMENT OF MECHANICAL & MANUFACTURING ENGINEERING, MIT Manipal

M.Tech. THERMAL SCIENCES & ENERGY SYSTEMS

Program Structure (Applicable to 2019 admission onwards)

Year	FIRST SEMESTER						SECOND SEMESTER					
	Sub Code	**Subject Name**	**L**	**T**	**P**	**C**	**Sub Code**	**Subject Name**	**L**	**T**	**P**	**C**
I	MAT 5155	Applied Numerical Methods	3	1	0	4	MME 5291	Computational Fluid Dynamics	3	1	0	4
	HUM 5151	Research Methodology and Technical Communication	1	0	3	2	MME 5292	Energy Management, Conservation and Storage	3	1	0	4
	MME 5191	Advanced Fluid Dynamics	3	1	0	4	MME ****	Elective I	3	1	0	4
	MME 5192	Design of Thermal Systems	3	1	0	4	MME ****	Elective II	3	1	0	4
	MME 5193	FEM for Thermal Engineering	3	1	0	4	MME ****	Elective III	3	1	0	4
	MME 5194	Solar Thermal Energy Systems	3	1	0	4	*** ****	Open Elective	3	0	0	3
	MME 5166	FEA Lab on Thermal Systems	0	0	6	2	MME 5269	CFD Lab	0	0	3	1
	MME 5167	Thermal Lab	0	0	3	1	MME 5265	Renewable Energy Lab	0	0	3	1
		Total	**16**	**5**	**12**	**25**		**Total**	**18**	**5**	**6**	**25**
	THIRD AND FOURTH SEMESTER											
II	MME 6098	Project Work							0	0	0	25
								Total	0	0	0	**25**

PROGRAM ELECTIVES			
MME 5019	Advanced Heat Transfer	MME 5022	Refrigeration and Cryogenic Systems
MME 5020	Design of Heat Exchangers	MME 5023	Steam and Gas Turbines
MME 5021	Measurements in Thermal Engineering	MME 5024	Wind Energy Technology

OPEN ELECTIVES			
MME 5053	Corrosion Science	MME 5057	Industrial Safety Engineering
MME 5054	Creativity for Product Design	MME 5058	Lean Manufacturing
MME 5055	Design of Experiments	MME 5059	Renewable Energy Technology

SEMESTER I

MAT 5155 APPLIED NUMERICAL METHODS [3 1 0 4]

Interpolations, Numerical Differentiation and Integration, Solution of linear and nonlinear system of equations: direct methods and iterative methods, Eigen values & Eigen vectors using Power Method. Numerical Solution of Ordinary Differential Equations, Initial Value Problems: Single step methods. Multi step methods, Boundary Value Problems: Finite difference method. Numerical Solution of Partial Differential Equations, Elliptic P.D.E, Parabolic P.D.E, Hyperbolic P.D.E.

References:

1. Atkinson K. E: An Introduction to Numerical Analysis, Edn 3, John Wiley and Sons, 1989.
2. Carnahan, Luther and Wikes: Applied Numerical Methods, TMH, 1969.
3. Hilderband F. B: Introduction to Numerical Analysis, Edn 5, Tata McGraw Hill, New Delhi, 2013.
4. Conte S. D and Be Door: Elementary Numerical Analysis: An Algorithmic Approach, Edn 3, McGraw Hill, 1981.
5. Gerald C.F. and Patrick D. Wheatley: Applied Numerical Analysis, Edn 7, Addison Wesley, 2004.

HUM 5151 RESEARCH METHODOLOGY AND TECHNICAL PRESENTATION [1 0 3 2]

Mechanics of Research Methodology: Basic concepts: Types of research, Significance of research, Research framework, Case study method, Experimental method, Sources of data, Data collection using questionnaire, Interviewing, and experimentation. Research formulation: Components, selection and formulation of a research problem, Objectives of formulation, and Criteria of a good research problem. Research hypothesis: Criterion for hypothesis construction, Nature of hypothesis, need for having a working hypothesis, Characteristics and Types of hypothesis, Procedure for hypothesis testing, Sampling methods- Introduction to various sampling methods and their applications. Data Analysis: Sources of data, Collection of data, Measurement and scaling technique, and Different techniques of Data analysis. Thesis Writing and Journal Publication: thesis writing, journal and conference papers writing, IEEE and Harvard styles of referencing, Effective Presentation, Copyrights, and avoiding plagiarism.

References

1. Ranjit Kumar: Research Methodology: A Step-by-Step Guide for Beginners, SAGE, 2005.
2. Geoffrey R. Marczyk, David DeMatteo & David Festinger: Essentials of Research Design and Methodology, John Wiley & Sons, 2004.
3. John W. Creswel: Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, SAGE, 2004.
4. Suresh C. Sinha and Anil K. Dhiman: Research Methodology, Vedam Books, 2006.
5. C. R. Kothari: Research Methodology: Methods and Techniques, New Age International Publisher, 2008.

MME 5191 ADVANCED FLUID DYNAMICS [3 1 0 4]

Basic Conservation Laws: Continuum concept, Eulerian and Lagrangian concept, material derivative, transport theorem, conservation of mass (continuity equation), Derivation of Navier-Stokes equations: Rotation and shear rate, constitutive equations, viscosity coefficient, Navier-Stokes equations, energy equation, boundary conditions, Flow kinematics and Special forms of the governing equations: Streamlines, pathlines, streaklines, circulation, vorticity, stream tubes, vortex tubes, kinematics of vortex lines, Kelvin's theorem, Bernoulli equation, Crocco's equation, Vorticity equation, Two-dimensional potential flows: Stream function, complex potential, source & sink flow around edges, doublet, circular-cylinder flow with/without circulation, Blasius' integral laws, force and momentum on a circular cylinder, conformal transformations, Joukowski transform, flow around ellipses, Exact solutions: Couette flow, Poiseuille flow, flow between rotating cylinders, Stokes' first problem, Stokes' second problem, pulsating flow between plates, stagnation -point flow, convergent-divergent channel flow, porous-wall flow, Boundary layer in the fluid flow: Concept of boundary layer and its importance, mathematical background of boundary layer theory, mechanism of boundary layer formation, Boundary layer analysis: Boundary layer equations for two-dimensional incompressible flow, flat-plate boundary layer, derivation of Blasius equation, numerical solution of Blasius equation, analysis of boundary layer solution, boundary layer thickness, derivation of the Falkner-Skan equations, flow over a wedge shaped body, exact solutions to the steady 2D boundary layer equations, wake flow after a finite flat plate, wake flow after a 2D body, two dimensional planar jet flow

References:

1. G. Currie: Fundamental Mechanics of Fluids, Marcel Dekker, Inc., 2003.
2. F. M. White: Viscous Fluid Flow, Mc Graw Hill. Inc., 2006.
3. T. C. Papanastasiou, G. C. Georgiou and A. N. Alexandrou: Viscous Fluid Flow, CRC Press LLC, 2000.
4. H. Schlichting: Boundary layer theory, Mc Graw Hill. Inc., 1979.

MME 5192 DESIGN OF THERMAL SYSTEMS [3 1 0 4]

Modeling of Thermal Systems: Types of models, Mathematical modeling, Curve fitting, Linear algebraic systems, Numerical model for a system, System simulation, Methods for numerical simulation. Acceptable Design of a Thermal System: Initial design, Design strategies, Design of systems from different application areas, Additional considerations for large practical systems; Economic Considerations: Calculation of interest, Worth of money as a function of time, Series of payments, Raising capital, Taxes, Economic factor in design, Application to thermal systems. Problem Formulation for Optimization: Optimization methods, Optimization of thermal systems, Practical aspects in optimal design, Lagrange multipliers, Optimization of constrained and unconstrained problems, Applicability to thermal systems; Search methods: Single-variable problem, Multivariable constrained optimization, Examples of thermal systems; Geometric, linear, and dynamic programming and other methods for optimization, Knowledge-based design and additional considerations, Professional ethics.

References:

1. W.F. Stoecker: Design of Thermal Systems, McGraw-Hill, 1971.
2. Y. Jaluria: Design and Optimization of Thermal Systems, CRC Press, 2007.
3. Adrian Bejan, George Tsatsaronis and Michael Moran Thermal Design and Optimization, Wiley, 1996.
4. R. F. Boehm: Developments in the Design of Thermal Systems, Cambridge University Press, 1997.
5. N.V. Suryanarayana: Design & Simulation of Thermal Systems, McGraw-Hill, 2002.

MME 5193 FEM FOR THERMAL ENGINEERING [3 1 0 4]

Brief review of Discrete FEM analysis for simple thermal and fluid systems. Shape function generation methods and Gaussian Integration schemes.The general Galerkin weighted residual formulation and application to different classes of heat and fluid flow systems. The variational finite element formulation and its application to heat and fluid flow problems. Basic extension of the above methods to computational fluid dynamics

.

References:

1. Lewis, Nithiarasu, Seetharamu: Fundamentals of the Finite Element Method for Heat and Fluid Flow, John Wiley & Sons Ltd, UK, 2004.
2. David V Hutton: Fundamentals of Finite Element Analysis, Tata McGraw Hill. India, 2007.
3. Daryl L Logan: A First course in Finite Element Method, Edn 4, Thompson Ltd, India, 2007.
4. P. Seshu: Text Book of Finite Element Analysis, Print 5, Prentice Hall of India, New Delhi, 2012.
5. Chandrupatla, T. R. and Belegundu, A. D: Introduction to Finite Elements in Engineering. Pearson Education. New York, 2001.

MME 5194 SOLAR THERMAL ENERGY SYSTEMS [3 1 0 4]

Solar radiation geometry: Radiation on tilted surfaces, Incident angle. Liquid Flat Plate Collectors: Forced and thermosiphon system - Energy balance, H-W-B equation, Transient analysis, ASHRAE test standard and procedure, arrangement of array, Instrumentation, Uncertainty analysis, Load estimation. Evacuated Tube Collectors: Conduction heat transfer phenomena at very low pressure, Thermal analysis, H-W-B constants. Air heaters: Performance analysis of various air heaters, Finned and porous absorbers, Testing procedure and performance curves, Thermal analysis of cabinet drier. Concentrating Collectors: Thermodynamic and optical limit to concentration, Cylindrical parabolic system (PTC), Thermal analysis Heat transfer augmentation techniques, Thermal analysis of solar power plant, Compound parabolic collector, Performance analysis, Paraboloid dish collector, Thermal analysis, Central receiver tower system. Other Systems: Box and dish type cooker, Figure of merit, Desalination, Thermal analysis of single slop system, Fresnel reflector, Solar pond, Solar refrigeration, Adsorption and absorption systems. Energy Storage: Sensible and latent heat storage, Design of storage system, Selection of storage material, Analysis of packed bed system.

References:

1. Duffie J. A and Beckman, W. A: Solar Engineering of Thermal Process, John Wiley, 1991.
2. D. Yogi Goswami: Principles of solar engineering, CRC Press, 2015.
3. Soteris A. Kalogirou: Solar Energy Engineering, Academic Press, 2014.
4. G. N. Tiwari, Solar Energy, Narosa Publications, 2014.
5. S. P. Sukhatme & J.K. Nayak: Solar Energy, Tata McGraw Hill, 2012.

5166 FEA LAB ON THERMAL SYSTEMS [0 0 6 2]

Steady state thermal analysis of one dimensional bar with different boundary conditions, Steady state heat transfer analysis of two dimensional fins of different cross sections [circular, rectangular and tapered], Steady state heat transfer in a composite wall: two dimensional and three dimensional analyses, Two dimensional and three dimensional structural analyses, Unsteady state heat transfer analysis of a heated bar, sphere etc., Thermal stress analyses (2D and 3D), Writing of macros for thermal analysis, Parametric study of thermal components, Design optimization of thermal and structural components, Heat exchanger transient analysis using FLOWNEX, Steady state performance analysis of thermal power plant using FLOWNEX.

Mini-projects related to thermal and structural analysis,

References:

1. Lewis, Nithiarasu, Seetharamu: Fundamentals of the Finite Element Method for Heat and Fluid Flow, John Wiley & Sons Ltd, UK, 2004.
2. ANSYS user manual.
3. FLOWNEX user manual.

MME 5167 THERMAL LAB [0 0 3 1]

Analysis of: (a) Heat Exchangers: Packed bed, Finned tube nanofluid based double pipe and Plate heat exchanger. Cooling tower in forced and natural mode. (b) Energy systems: Air conditioner, Vapor absorption refrigerator, Centrifugal fan, Gas turbine and heat pipe. Computerized C I engine. (c) Other systems: Aerofoil structures using wind tunnel, PCM based thermal energy storage system and transient heat conduction. Calibration of various temperature transducers, Measurement of calorific value of solid/liquid fuel using bomb calorimeter and Dryness fraction of steam using separating and throttling calorimeter.

References:

1. Holman J. P: Experimental methods for Engineers, Mc Graw Hill. Inc, 1994.
2. E. O. Doeblin: Measurement systems: Applications and Design, Tata Mc Graw Hill, 2004.
3. Alan S. Morris: Principles of measurement and instrumentation, Prentice Hall of India, 2002.
4. Sadik Kakac: Heat exchangers: Selection, rating, and thermal design, CRC Press, 2012.

SEMESTER II

MME 5291 COMPUTATIONAL FLUID DYNAMICS [3 1 0 4]

Models of Flow and derivation of governing conservation differential equations for different models for conservation of mass, momentum and Energy. Discussion of characteristics and Boundary and Initial conditions. Basic numerical methods to solve first diffusion related flow physics followed by Convective dominated Diffusion flows. Difficulties and strategies to solve such flows. Algorithmic approach and convergence as well as stability. Turbulence and related closure using turbulence modelling.

References:

1. John D Anderson Jr: Computational Fluid Dynamics- The Basics with Applications, International Edition. McGraw Hill. New York, 1995.
2. Suhas V Patankar: Numerical Heat Transfer and Fluid Flow, Hemisphere / McGraw Hill. New York, 1980.
3. H. K. Versteeg and W. Malalasekera: An Introduction to Computational Fluid Dynamics- The Finite Volume Method, Longman Scientific & Technical. England, 1995.
4. K. Muralidhar and T. Sundararajan: Computational Fluid Flow and Heat Transfer, Narosa Publishing House, New Delhi, 2003.
5. Tennekes H. and Lumley J. L: A First Course in Turbulence, The MIT press, 1972.

MME 5292 ENERGY MANAGEMENT, CONSERVATION AND STORAGE [3 1 0 4]

Energy Management & Audit : Present Energy Scenario, Energy Management Principles, energy audit, insulation, Power factor improvement methods, Electrical lighting and energy conservation methods, Waste heat recovery devices, Cogeneration principles, methods, types and Performance evaluation of cogeneration system, Performance evaluation of Boilers, furnaces diesel Generators, Pumps, Cooling towers. Energy storage: Pumped hydro storage, Compressed gas system: Electrical and magnetic energy storage: Capacitors, electromagnets, Chemical Energy storage,: Solar Ponds for energy storage, stratified storage systems; Rock-bed storage systems, Thermal storage in buildings, Phase Change Materials (PCMs), Selection criteria of PCMs, Energy conservation through LHTES systems, LHTES systems in refrigeration and air-conditioning systems.

References:

1. Paul W. O'Callaghan: Energy Management – A comprehensive guide to reducing costs by efficient energy use, McGraw Hill, England, 1992.
2. W.C Turner: Energy management Handbook, Edn. 7, Fairmont Press, 2007.
3. BEE (Bureau of energy efficiency) Study Material, Energy Management & Energy Audit, (www.bee-india.com)
4. Johannes Jensen Bent Squrensen: Fundamentals of Energy Storage, John Wiley, NY, 1984.
5. Ibrahim Dincer: Thermal Energy Storage: Systems and Applications, Wiley Publications, 2010.

MME 5269 CFD LAB [0 0 3 1]

Introduction to ANSYS Workbench software, Laminar flow and Turbulent Flow in a rectangular duct, Turbulent flow in a cylindrical pipe-Axisymmetric analysis, Turbulent flow in a pipe bend, Simulation of steady state heat transfer for air/water flow through a finned pipe, Transient heat transfer in a bar subjected to annealing process, Periodic flow simulation of a bank of tubes of a heat exchanger, Wind tunnel simulation of flow over a blunt body, Flow over an aero-foil at different angle of incidence, 3D Steady state conductive and convective heat transfer analysis, Simulation of flow and heat transfer through a solar air heater, Simulation of flow through a turbo machine, Simulation of two phase flow through a Convergent-Divergent nozzle.

References:

1. John D Anderson Jr: Computational Fluid Dynamics- The Basics with Applications. International Edition. McGraw Hill. New York, 1995.
2. ANSYS workbench User manual.

MME 5265 RENEWABLE ENERGY LAB [0 0 3 1]

Performance of Solar systems: (a) Water heaters: Flat plate collector in forced and thermosiphon mode with simulated solar radiation / outdoor condition. Evacuated tube collector. (b) Concentrators: Dual axes parabolic trough and Paraboloid type. (c) Cookers: Box and paraboloid type. (d) Others: Flat plate air heater and single slope still. (e) PV systems: Training and research system, grid tied training system and PV emulator. Wind energy: Training system and emulator. Energy Audit: (a) D.G. set and Boiler installed in the campus. (b) Performance assessment of Centrifugal pump.

References:

1. G. N. Tiwari: *Solar Energy*, Narosa Publications, 2014.
2. S. P. Sukhatme and J. K. Nayak: *Solar Energy*, Tata McGraw Hill, 2012.

SECOND YEAR

MME 6098 PROJECT WORK [0 0 0 25]

Students are required to undertake innovative and research oriented projects, which not only reflect their knowledge gained in the previous two semesters but also reflects additional knowledge gained from their own effort. The project work can be carried out in the institution/ industry/ research laboratory or any other competent institutions. The duration of project work should be a minimum of 36 weeks. There will be a mid-term evaluation of the project work done after about 18 weeks. An interim project report is to be submitted to the department during the mid-term evaluation. Each student has to submit to the department a project report in prescribed format after completing the work. The final evaluation and viva-voice will be after submission of the report. Each student has to make a presentation on the work carried out, before the departmental committee for project evaluation. The mid-term & end semester evaluation will be done by the departmental committee including the guides.

PROGRAM ELECTIVES

MME 5019 ADVANCED HEAT TRANSFER [3 1 0 4]

Steady state heat conduction: Energy balance for solid, concept of generation and storage, types of boundary conditions. steady state heat conduction through plane, cylindrical and spherical walls, formulation of steady combined conduction, convection problems and their analytical solutions – heat transfer characteristics of straight, annular, and pin-fins of uniform and non-uniform cross sections. formulation of steady two-dimensional heat conduction problems in rectangular, and cylindrical geometries and their analytical solutions, method of separation of variables, homogeneous and nonhomogeneous problems, partial solutions, variation of parameters, principle of superposition, Transient heat conduction: Formulation and solution of unsteady heat conduction problems, initial conditions, multidimensional transients, lumped system analysis, Convection heat transfer: Conservation principles, derivation of continuity, momentum and energy equations, Concept of viscous and thermal boundary layer, Prandtl number, differential equations for the laminar and turbulent boundary layers, laminar internal flow and heat transfer; concept of fully developed velocity and temperature profile, solutions for constant heat flux and constant wall temperature boundary conditions. solution of entry length problem for constant heat flux and constant wall temperature boundary conditions, Laminar external boundary layers; momentum transfer, heat transfer, turbulent boundary layer and heat transfer, convective heat transfer with body forces

References:

1. Myers G. E., Analytical Methods in Conduction Heat Transfer, McGraw-Hill, 1998.
2. Kays W., Crawford M., Weigand B., Convective Heat and Mass Transfer, McGraw-Hill, 2005.
3. Bejan A, Convection Heat Transfer, Wiley, 2013.
4. Cengel Y. A., Heat and Mass Transfer, McGraw-Hill, 2007.

MME 5020 DESIGN OF HEAT EXCHANGERS [3 1 0 4]

Heat exchangers: Design methods and calculation, convection correlations, pressure drop and pumping power calculations, fouling of heat exchangers. Micro and nano heat transfer: Flow in micro channels, Convective heat transfer with nano-fluids and analysis. Double pipe heat exchangers: Thermal and hydraulic analysis, bare and finned tube analysis, parallel – series arrangements. Shell and tube heat exchangers: Types, basic components, layout and geometry, stream allocation, design procedure, Kern and Bell-Delaware method. Design of condensers and evaporators: Condensation in horizontal and vertical tubes, Thermal design of shell and tube condensers, horizontal and vertical condensers with tube side and shell side condensation, flow boiling correlations, Thermal design of evaporators. Compact heat exchangers: Heat transfer and pressure drop calculations. Plate heat exchangers, Thermal performance. Fired process heaters and furnaces: Types, fundamentals of combustion, heat transfer and heat balance in fired heaters, furnace heat transfer, Cooling towers: Classification, concept of psychrometry, energy balance, design and analysis. Testing of Heat Exchangers: Performance evaluation and testing procedures.

References:

1. Sadik Kakac: Heat exchangers: Selection, rating, and thermal design, CRC Press, 2012.
2. Robert W Serth: Process Heat Transfer: Principles, Applications and Rules of Thumb, Academic Press, 2014.
3. Donald Q Kern: Process heat transfer, McGraw Hill Publication, 1997.
4. Kays W. M. and London A.L: Compact Heat Exchangers, McGraw-Hill, 1998.
5. Ramesh K Shah: Fundamentals of heat exchanger design, John Wiley and sons, 2003.

MME 5021 MEASUREMENTS IN THERMAL ENGINEERING [3 1 0 4]

Planning of Experimental Investigation: Theoretical and experimental approaches, Uncertainty analysis, Use of softwares in regression analysis. Temperature and Heat flux measurement: Thermal expansion methods Electrical methods, Thermocouple classification and coding, Cold junction compensation, Data acquisition and processing, Measurement in high speed flow, Radiation methods, Calibration of temperature measuring devices, Heat flux and heat transfer coefficient measurement. Pressure Measurement: Balancing liquid column, Elastic deformation, Electrical methods, Pressure switches, Calibration, Digital transducers, Selection criteria. Flow Measurement: Variable head meters, Compressible flow measurement, Uncertainty analysis, Variable area meters, Measurement and calibration of flow measuring devices for compressible and incompressible fluids, other types of flow measuring devices, Selection criteria. Measurement of Velocity: Pitot tube, Compressible and Incompressible flow, Hot wire anemometer, Time of flight velocimeter, Ultrasonic doppler.

References:

1. Holman J. P: Experimental methods for Engineers, Mc Graw Hill. Inc, 1994.
2. E. O. Doeblin: Measurement systems: Applications and Design, Tata Mc Graw Hill, 2004.
3. Alan S. Morris: Principles of measurement and instrumentation, Prentice Hall of India, 2002.
4. S. P. Venkateshan: Mechanical measurements, Ane Books India, 2008.
5. Beckwith: Mechanical Measurements, Peasrson Education, India, 2005

MME 5022 REFRIGERATION AND CRYOGENIC SYSTEMS [3 1 0 4]

Principles of Refrigeration: Vapour compression cycle, Actual vapour compression cycle, Multistage systems, Cascade system, Gas cycle refrigeration for Aircraft applications: thermal load Estimation, Selection and matching of components, capacity control, requirements of refrigerants and Lubricants, Secondary and Mixed refrigerants. Theory of Mixtures: Enthalpy composition diagrams, principle of Absorption system, Aqua ammonia systems, LiBr water system, three fluid absorption systems, solar refrigeration system. Cryogenic Systems: Introduction, Insight on Cryogenics, Properties of Cryogenic fluids, Material properties at Cryogenic Temperatures. Carnot Liquefaction Cycle, F.O.M. and Yield of Liquefaction; Cycles. Inversion Curve, Joule Thomson Effect, Liquefaction Cycles: Linde Hampson Cycle, Pre-cooled Linde-Hampson Cycle, Claudes Cycle, Dual Cycle, Helium Refrigerated Hydrogen Liquefaction Systems. Critical components in Liquefaction Systems. Cryogenic Refrigerators: J.T.Cryo-coolers, Sterling Cycle Refrigerators, G.M.Cryo-coolers, Pulse Tube Refrigerators, Regenerators used in Cryogenic Refrigerators, Magnetic Refrigerators Applications: Applications of Cryogenics in Space programs, Superconductivity, Cryo Metallurgy, Medical applications.

References:

1. Manohar Prasad: Refrigeration and Air Conditioning, New age international Publishers, 2015.
2. W.F Stocker and J.W. Jones: Refrigeration and Air-conditioning Data, McGraw Hill, 1985.
3. K. D. Timmerhaus and T.M. Flynn: Cryogenic Process Engineering, Plenum Press, 1989.
4. R. F. Barron: Cryogenic Systems, McGraw Hill, 1985.

MME 5023 STEAM AND GAS TURBINES [3 1 0 4]

Nozzles and diffusers: Equation of continuity and momentum, Parameters affecting the performance of nozzles. Impulse steam turbines: Compounding of Impulse turbine, Impulse–Reaction turbine, Combination turbines, Stage efficiency, Efficiency of multistage impulse turbine. Flow of Steam through Impulse-Reaction Turbine Blades: Velocity diagram, Degree of reaction, State Point Locus Reheat Factor and design, Reheat factor for different work condition, Correction of reheat factor for finite number of stages, Design procedure of impulse and impulse- reaction turbines. Axial Flow and Centrifugal Compressors: Compressibility effects, Degree of reaction, Design process and blade design. Shaft power cycles and gas turbine cycles for air-craft propulsion, Turbo fan engine, Turbo prop engine, Thrust augmentation. Axial and Radial Flow Gas Turbines and Prediction of Performance: Vortex theory, Estimation of blade performance, Off-design operation, Methods of displacing the equilibrium running line, Incorporation of variable pressure losses. Jet and Rocket Propulsion: Different jet engines, Thrust equation, Principles of rocket propulsion, Ideal chemical rocket, Free radical propulsion, Nuclear propulsion, Electro dynamics propulsion, Photon propulsion.

References:

1. R. Yadav: Steam and Gas Turbines, Central Publishing House, Allahabad, 2009.
2. H.I.H. Saravanamuttoo, G.F.C. Rogers & H Cohen: Gas Turbine Theory, Edn 6, Pearson Education, 2008.
3. V. Ganesan: Gas Turbines, Edn 3, Tata McGraw-Hill Publications, 2010.

MME 5024 WIND ENERGY TECHNOLOGY [3 1 0 4]

Wind Energy Conversion: Power, torque and speed characteristics, Wind data analysis. Wind Characteristics: Wind speed variation with height, Wind speed statistics, Weibull statistics, Weibull parameters, Rayleigh and normal distribution. Wind measurements: Wind speed and direction measurement, Rotational and other anemometers. WECS Design: Aerodynamic theories, Rotor characteristics, Maximum power coefficient; Prandlt's tip loss correction. Design of Wind Turbine: Theoretical simulation of wind turbine characteristics, Test methods, Power output from practical turbines, Transmission and generation efficiency. Wind turbine connected to electrical network: Methods of generating synchronous power, Synchronous generator, Induction machine, Asynchronous Electric Generators. Wind Energy Application: Performance analysis, design concept and testing of piston water pumps, Centrifugal pumps, Paddle wheel heaters, Batteries. Economics of wind energy utilization: Capital costs, Economic revenues requirements, value of wind generated electricity, Wind energy in India, Case studies.

References:

1. Johnson G L: Wind Energy Systems, Prentice Hall Inc, New Jersey, 1985.
2. Spera David A: Wind Turbine Technology: Fundamental Concepts of Wind Turbine Engineering, American Society of Mechanical Engineers, 1994.
3. Desire L Gouriers: Wind Power Plants: Theory and Design, Pergamon Press, 1982.
4. Paul Gipe , Karen Perez: Wind Energy Basics: A Guide to Small and Micro Wind Systems, Chelsea Green Publishing Company, 1999.
5. Hau Erich: Wind Turbines: Fundamentals, Technologies, Application and Economics, Springer Verlag, 2000.

OPEN ELECTIVES

MME 5053 CORROSION SCIENCE [3 0 0 3]

Importance of corrosion study: Factors affecting corrosion, Economical aspects of corrosion. Fundamental aspects of corrosion: Formation of a corrosion Cell, Cathodic and anodic corrosion reactions and characteristics, Hydrogen and Calomel electrode, Pourbaix diagram for metal-water system. Principles of corrosion: Nernst's Equation, Electro-chemical corrosion in aqueous medium, Faradays' laws of electrolysis, Corrosion potential, Corrosion current density, Factors affecting corrosion rate. Types of corrosion: Characteristic features, causes and control measures for different types of corrosion, Introduction to high temperature corrosion, Corrosion/Chemical degradation of non-metallic materials. Polarization: Thermodynamics and Kinetics of Electrode Processes, Gibb's free energy of adsorption, Equilibrium constant, Activation energy, Physical & chemical adsorption. Corrosion control: Material selection, Design considerations, Control of environment including Inhibitors and Passivators, Cathodic and anodic protection, Coatings, Electroplating and other techniques, Case studies on Corroison control. Corrosion Monitoring: Accelerated chemical tests for studying different forms of corrosion. Electrochemical methods of corrosion rate measurements by Gravimetric, Tafel polarization, Linear polarization, Cyclic polarization, Impedance spectroscopy, NDT techniques - Ultrasonic, Radiography and Eddy current method, Case studies on corrosion monitoring.

References:

1. Mars G. Fontana: Corrosion Engineering, Edn 3, Tata McGraw Hill, New Delhi, 2008.
2. Zaki Ahmed: Principles of Corrosion Engineering and Corrosion Control, Elsevier Science and Technology Books, 2006.
3. Trethewey K. R. and Chamberlain Longman J: Corrosion for students of science and engineering, Scientific & Technical New York, USA, 1988.
4. Philip A Schweitzer: Fundamentals of corrosion-Mechanisms, Causes and preventive methods, CRC Press, Taylor and Francis Group, Boca Raton, 2010.
5. Uhlig H.H. and Revie R. W: Corrosion and Corrosion Control, Wiley, NY, 1985.

MME 5054 CREATIVITY FOR PRODUCT DESIGN [3 0 0 3]

Product Design: Process, 3 S's, strength considerations in product design. Tools for design: Different tools, Taguchi technique for robust design, Design for Manufacture, Rapid prototyping, Role of concurrent engineering, reverse engineering. Creative thinking: The five dimensions of creativity. Basic Probability concepts: Central Limit Theorem and sampling distributions, probability density function. Reliability of Components and Systems: Reliability, Factor of safety and reliability theory, Reliability management, history of reliability engineering; failure modes, failure data analysis, failure rate, time curve, reliability and hazard functions, hazard models, estimation of failure rate, mean time before failure, system reliability, complex systems, reliability enhancement, maintainability and availability, repairable systems, reliability allocation, event-tree and fault-tree analyses, reliability testing.

References:

1. Ulrich Karl T. and Eppinger Steven D: Product Design and Development, McGraw Hill International Edition, 1999.
2. Rosenthal Stephen: Effective Product Design and Development, Business One Orwin Homewood, 1992.
3. Dieter: Engineering Design, McGraw Hill International Edition, 1990.
4. Day Ronald G: Quality Function Deployment, Tata McGraw Hill, 1990.
5. Goldenberg and Mazursky: Creativity in Product Innovation, Cambridge University Press, 1996.

MME 5055 DESIGN OF EXPERIMENTS [3 0 0 3]

Understanding basic design principles, Working in simple comparative experimental contexts, introduction to R language and its applications in DOE problems, Working with single factors or one-way ANOVA in completely randomized experimental design contexts, Implementing randomized blocks, Latin square designs and extensions of these, Understanding factorial design contexts, Working with two level, 2*k*, designs, Implementing confounding and blocking in 2*k* designs, Working with 2-level fractional factorial designs, Working with 3-level and mixed-level factorials and fractional factorial designs, Simple linear regression models, Understanding and implementing response surface methodologies, Understanding robust parameter designs, Working with random and mixed effects models, Design of computer experiments and the applications in industrial engineering problems.

References

1. Montgomery, D. C: Design and Analysis of Experiments, John Wiley & Sons. Inc., 2001.
2. Dean, A. M. and Voss, D. T: Design and Analysis of Experiments (Springer text in Statistics), Springer Science + Business Media, 1999.
3. Box, G. E. P., Hunter, W. G., and Hunter, J. S: Statistics for Experimenters: An Introduction to Design, Data Analysis, and Model Building, John Wiley & Sons, 1978.
4. Diamond, W. J: Practical Experiment Designs for Engineers and Scientists, John Wiley & Sons, 2001.
5. Jeff Wu, C. E. and Hamada, M. I: Experiments: Planning, Analysis, and Parameter Design Optimization, John Wiley & Sons, 2000.

MME 5057 INDUSTRIAL SAFETY ENGINEERING [3 0 0 3]

Basics: Accidents & their effects; Cost of accidents; Theories of accident causation, Management failures in accident causation, Accident investigation and reporting. Industrial Hazards: Various Hazards, Blood borne pathogens in the workplace. National Safety Council of India (NSCI) and Industrial Safety Acts: Mission and Vision, Hazard and operational (HAZOP) studies, Document preparation, Various acts. Industrial Safety Analysis and Management: Hazard analysis, Human error analysis (HEA), Technic of operation review (TOR), Fault tree analysis, Applying and evaluating safety and health instruction; Training supervisors; Training new and transferred employees. Environmental Safety: Safety, health and environment; Legislation and Regulation; Types of environment, Hazards of the environment; OSHA hazardous waste standard; Environmental management system (EMS); ISO 14000 series of standards; Ethics and safety.

References:
1. David L. Goetsch: Occupational Safety and Health for Technologists, Engineers and Managers, Edn 5, Pearson-Prentice Hall, 2005.
2. Frank R. Spellman and Nancy E. Whiting: The Handbook of Safety Engineering: Principles and Applications, The Scarecrow Press Inc., 2010
3. Amit Kumar Gupta: Industrial Safety and Environment, Laxmi Publications (P) Ltd., 2006
4. National Safety Council India, "NSC," [Online]. Available: http://nsc.org.in/.
5. Ministry of Labour and Employment, "Ministry of Labour and Employment," [Online]. Available: http://nsc.org.in/.

MME 5058 LEAN MANUFACTURING [3 0 0 3]

Introduction: The production system, Types, Inception & necessity of lean production system, lean revolution in Toyota, Basic image of lean production, Principles& Characteristics of Lean Manufacturing, MUDA(waste) and Types. Lean Manufacturing Tools and Techniques: Cellular Manufacturing, Continuous Improvement, Just-In-Time, Production Smoothing, Total Productive Maintenance, 5S system, Standardization of Work, Elements of standardized work, Charts to define standardized work, man power reduction, Overall Equipment Efficiency, Standardized work and KAIZEN, Case study. Standardization of operations: Multi-function workers and job rotation, Improvement activities to reduce work force and increase worker morale foundation for improvements. Just In Time Principles of JIT, JIT system, Kanban and its rules, Expanded role of conveyance, production leveling, Pull systems, Value stream mapping, Case study. Shortening of production lead times: Reduction of setup times, practical procedures for reducing setup time. Jidoka concept – Poka-yoke systems, Inspection systems and zone control, types and use of poka-yoke systems, Implementation of jidoka, Case studies.

References:
1. Chasel Aquilino: Productions and Operations Management, Dreamtech, 2005.
2. Yasuhiro Monden: Toyoto Production System -An integrated approach to Just in Time, Institute of Industrial Engineers Norcross Georgia, 1983.
3. James P Womack, Daniel T Jones and Daniel Roos: The Machine that changed the World. The Story of Lean Production - -Harper Perennial -edition published, 1991.
4. James Womack and Daniel T Jones: Lean Thinking, Edn 2, 2003.
5. Richard Schourberger, Japanese Manufacturing Techniques. The Nine Hidden Lessons by simplicity - ASQC Press, 1991.

MME 5059 RENEWABLE ENERGY TECHNOLOGY [3 0 0 3]

Solar energy: Sun-Earth angles, Measuring techniques and estimation of solar radiation, Applications of Solar energy. Energy from biomass: Sources of biomass, Conversion of biomass into fuels, Properties of biomass, Types of biogas plants, Design and operation. Wind energy: Principles of wind energy conversion, Site selection considerations, Wind power plant design, Types of wind power conversion systems, Operation, maintenance and economics. Fuel Cell: Components of fuel cells, Principle, Performance characteristics of fuel cells, Efficiency, Fuel cell power plant. Geothermal and Ocean energy: Geothermal fields, Energy conversion technologies, Ocean energy, Scope and economics, Introduction to integrated energy systems.

References:
1. J.A. Duffie and W.A. Beckman: Solar Energy Thermal Processes, J. Wiley, 1994.
2. A.A.M. Saigh (Ed): Solar Energy Engineering, Academic Press, 1977.
3. F. Kreith and J.F. Kreider: Principles of Solar Engineering, McGraw Hill, 1978.
4. G.N. Tiwari: Solar Energy-Fundamentals, Design, Modelling and Applications, Narosa Publishers, 2002.
5. H.P. Garg, S.C. Mullick and A.K. Bhargava: Solar Thermal Energy Storage, 1985.