RAJASTHAN TECHNICAL UNIVERSITY, KOTA

Scheme of

POSTGRADUATE DEGREE COURSE

M.Tech. I to IV Semester

Thermal Engineering

(Effective from academic session: 2020-21)

Rajasthan Technical University, Kota
Akelgarh, Rawatbhata Road, Kota-324010

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

M. Tech. Thermal Engineering

Semester - I											
S. No	Course Type	Course Code	Course Name	Contact Hours per Week			Marks				Credits
				L	T	P	Exam Hrs	IA	ETE	Total	
1	PCC	1MTH1-01	Advanced Thermodynamics	3	0	0	3	30	70	100	3
2	PCC	1MTH1-02	Advanced Fluid Mechanics	3	0	0	3	30	70	100	3
3	PEC	1MTH2-11	Equipment Design for Thermal Systems	3	0	0	3	30	70	100	3
4		1MTH2-12	Experimental Methods in Thermal Engineering								
5		1MTH2-13	Numerical Methods in Engineering								
6	PEC	1MTH2-14	Heating, Ventilating and Air-conditioning	3	0	0	3	30	70	100	3
7		1MTH2-15	Gas Dynamics								
8		1MTH2-16	Micro Fluidics								
9	MCC	1MCC3-21	Research Methodology and IPR	2	0	0	2	30	70	100	2
10	PCC	1MTH1-06	Simulation Lab	0	0	4	4	60	40	100	2
11	PCC	1MTH1-07	Advanced Thermal Engineering Lab	0	0	4	4	60	40	100	2
12	SODECA	1MTH5-00	Social Outreach Discipline & Extra Curriculum Activities							100	0.5
			Total							**800**	**18.5**

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Semester - II												
S. No	Course Type	Course Code	Course Name	Contact Hours per Week			Marks				Credits
				L	T	P	Exam Hrs	IA	ETE	Total	
1	PCC	2MTH1-01	Advance Computational Fluid Dynamics	3	0	0	3	30	70	100	3
2	PCC	2MTH1-02	Advanced Heat and Mass Transfer	3	0	0	3	30	70	100	3
3	PEC	2MTH2-11	a. Air-conditioning System Design	3	0	0	3	30	70	100	3
4		2MTH2-12	Design of Heat Exchangers								
5		2MTH2-13	Combustion								
6	PEC	2MTH2-14	Micro-scale Heat Transfer	3	0	0	3	30	70	100	3
7		2MTH2-15	Design of Wind Power Farms								
8		2MTH2-16	Boundary Layer Theory and Turbulence								
9	MCC	2MCC3-XX	Audit Course-I [Minimum 2-credit]								
10	PCC	2MTH1-06	Advanced Heat & Mass Transfer Lab	0	0	4	4	60	40	100	2
11	PCC	2MTH1-07	Computational Fluid Dynamics Lab	0	0	4	4	60	40	100	2
12	REW	2MTH4-50	Mini Project with Seminar	0	0	4	4	60	40	100	2
13	SODECA	2MTH5-00	Social Outreach Discipline & Extra Curriculum Activities							100	0.5
			Total							**800**	**18.5**

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Semester - III

SN	Course Type	Course Code	Course Name	Contact Hours per Week			Marks				Cr
				L	T	P	Exam Hrs	IA	ETE	Total	
1	PEC	3MTH2-11	Optimization Techniques	3	0	0	3	30	70	100	3
2		3MTH2-12	Solar energy engineering and Technology								
3		3MTH2-13	Innovation and Entrepreneurship for Engineers								
4	MCC	3MCC3-XX	Open Elective	3	0	0	3	30	70	100	3
5	MCC	3MCC3-XX	Audit Course-II [Minimum 2-credit]								
6	REW	3MTH4-60	Dissertation-I / Industrial Project	0	0	x		240	160	400	10
			Total							**600**	**16**

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Semester - IV

SN	Course Type	Course Code	Course Name	Contact Hours per Week			Marks				Cr
				L	T	P	Exam Hrs	IA	ETE	Total	
1	REW	4MTH4-70	Dissertation-II	0	0	x		360	240	600	16
			Total							600	16

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

1MTH1-01: Advanced Thermodynamics

Credit: 3 **Max. Marks: 100(IA:30 ETE:70)**

3L+0T+0P **End Term Exam: 3 Hours**

SN	Contents	Hours
1	**RECAPITULATION OF FUNDAMENTALS.** Basic definition and concepts; The basic laws of Thermodynamics, Entropy flow and enropy production, 3rd law of Thermodynamics, Availability in steady flow open system and in a closed system, energy analysis of typical; Irreversibility and effectiveness.	6
2	**PROPERTIES OF PURE SUBSTANCES**. P-V-T surfaces, phase diagram, phase changes, various properties diagram, 1st order phase transition and 2nd order phase transition, Clapeyron's equation, Ehrenfest's equations, Maxwell's equations, equation for internal energy, enthalpy, entropy, specific heat and joule Thompson coefficient.	8
3	**EQUATION OF STATE FOR REAL GASES**. Compressibility factor and generalised compressibility chart, Law of corresponding state, law of pseudo critical pressure and temperature, reduced coordinate, Wander-Walls equation of state and other equation of state.	8
4	**CHEMICAL REACTION**. Fuels and Combustion, First-Law Analysis of Reacting Systems: Steady-Flow Systems and Closed Systems, Entropy Change of Reacting Systems, Second-Law Analysis of Reacting systems.	8
5	**CHEMICAL THERMODYNAMICS**. Gibb's theorem, Gibbs function of mixture of inert ideal gases, Chemical equilibrium, Thermodynamic equation for phase, Degree of reaction, equation of reaction, law of mass action, heat of reaction and Vant Hoff Isober, Phase Equilibrium for a Single-Component System and Multi-Component System	10

TEXT BOOK	
1	Fundamentals of Classical Thermodynamics: English/S.I. Version by Gordon J. Van Wylen and Richard E. Sonntag
2	Thermodynamics: An Engineering Approach - McGraw Hill– Cengel and Boles.
3	Engineering Thermodynamics - P. K. Nag
REFERENCE BOOKS	
SN	**Name of Authors /Books /Publisher**
1	Heat and thermodynamics – M. Zemansky.
2	Concepts of thermodynamics – O.R. Obert
3	Thermodynamics by Enrico Fermi
4	Thermodynamics by Jack P. Holman
5	Treatise on Thermodynamics by Max Planck

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

1MTH1-02: Advanced Fluid Mechanics

Credit: 3 **Max. Marks: 100(IA:30 ETE:70)**

3L+0T+0P **End Term Exam: 3 Hours**

SN	Contents	Hours
1	**INVISCID FLOW OF INCOMPRESSIBLE FLUIDS**: Lagrangian and Eulerain Descriptions of fluid motion- Path lines, Stream lines, Streak lines, stream tubes – velocity of a fluid particle, types of flows, Equations of three dimensional continuity equation- Stream and Velocity potential functions.	3
2	**BASIC LAWS OF FLUID FLOW:** Condition for irrotationality, circulation & vorticity Accelerations in Cartesian systems normal and tangential accelerations, Euler's, Bernouli equations in 3D– Continuity and Momentum Equations.	4
3	**VISCOUS FLOW:** Derivation of Navier-Stoke's Equations for viscous compressible flow – Exact solutions to certain simple cases : Plain Poisoulle flow - Coutte flow with and without pressure gradient - Hagen Poisoulle flow - Blasius solution	5
4	**BOUNDARY LAYER CONCEPTS :**Prandtl's contribution to real fluid flows – Prandtl's boundary layer theory - Boundary layer thickness for flow over a flat plate – Approximate solutions – Creeping motion (Stokes) – Oseen's approximation - Von-Karman momentum integral equation for laminar boundary layer — Expressions for local and mean drag coefficients for different velocity profiles.	6
5	**INTRODUCTION TO TURBULENT FLOW:** Fundamental concept of turbulence – Time Averaged Equations – Boundary Layer Equations - Prandtl Mixing Length Model - Universal Velocity Distribution Law: Van Driest Model –Approximate solutions for drag coefficients – More Refined Turbulence Models – k epsilon model - boundary layer separation and form drag – Karman Vortex Trail, Boundary layer control, lift on circular cylinders	6
6	**INTERNAL FLOW:** Smooth and rough boundaries – Equations for Velocity Distribution and frictional Resistance in smooth rough Pipes – Roughness of Commercial Pipes – Moody's diagram.	4
7	**COMPRESSIBLE FLUID FLOW – I:** Thermodynamic basics –	6

	Equations of continuity, Momentum and Energy - Acoustic Velocity Derivation of Equation for Mach Number – Flow Regimes – Mach Angle–Mach Cone – Stagnation State.	
8	**COMPRESSIBLE FLUID FLOW – II:** Area Variation, Property Relationships in terms of Mach number, Nozzles, Diffusers – Fanno and Releigh Lines, Property Relations – Isothermal Flow in Long Ducts – Normal Compressible Shock, Oblique Shock: Expansion and Compressible Shocks – Supersonic Wave Drag	**6**

TEXT BOOK	
1	Fluid mechanics: F.M. White McGraw Hill
2	Fluid mechanics: Som and Biswas, T.M.H.
3	Hydraulics And Fluid Mechanics Including Hydraulic Machines (In Si Units) by P.N. Modi
REFERENCE BOOKS	
SN	**Name of Authors /Books /Publisher**
1	Fluid Mechanics: Fundamentals and Applications by Yunus A. Cengel
2	Boundary-Layer Theory by Herrmann Schlichting
3	An Album of Fluid Motion by Milton Van Dyke
4	Fluid Mechanics by Pijush K. Kundu
5	Introduction to Fluid Mechanics by Robert W. Fox
6	Turbulence: An Introduction for Scientists and Engineers by Peter A. Davidson
7	Numerical Heat Transfer and Fluid Flow by Suhas V. Patankar

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1MTH2-11: Equipment Design for Thermal Systems

Credit: 3 **Max. Marks: 100(IA:30 ETE:70)**
3L+0T+0P **End Term Exam: 3 Hours**

SN	Contents	Hours
1	**INTRODUCTION TO ENGINEERING DESIGN:** Thermal systems, Basic Considerations in design, Conceptual design, Steps in the design process, Computer-aided design of thermal systems, Material selection, Properties and characteristics for thermal systems.	8
2	**MODELLING OF THERMAL SYSTEMS:** Types of models, Interaction between models, Mathematical modelling, physical modelling and dimensional analysis, Curve fitting.	8
3	**NUMERICAL MODELLING AND SIMULATION:** Solution procedure, Numerical model for a system, System simulation, Methods for numerical simulation. Acceptable design of a thermal system, Design of system from different application	8
4	**ECONOMIC CONSIDERATION:** Introduction, Calculation of interest, Worth of money as a function of time, Series of payments, Raising capital, Economic factor in design, Cost comparision, rate of return, Application to thermal systems.	8
5	**OPTIMIZATION IN DESIGN:** Basic concepts, Mathematical formulation, Optimization methods, Calculus methods, Search methods, Optimization of thermal systems, Optimization of unconstrained problems, Conversion of constrained to unconstrained, Optimization of constrained problems	8

TEXT BOOK	
1	Design and Optimization of Thermal systems – YogeshJaluria – CRC Press
2	Optimization of Engineering Design – Kalyanmoy Deb – PHI
REFERENCE BOOKS	
SN	**Name of Authors /Books /Publisher**
1	Design of thermal systems – W.F. Stoecker -TMH Publication

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

1MTH2-12: Experimental Methods in Thermal Engineering		
Credit: 3		**Max. Marks: 100(IA:30 ETE:70)**
3L+0T+0P		**End Term Exam: 3 Hours**
SN	**Contents**	**Hours**
1	**INSTRUMENT CLASSIFICATION,** static and dynamic characteristics of instruments, experimental error analysis, systematic and random errors, statistical analysis, uncertainty, reliability of instruments, Variable resistance transducers, capacitive transducers, piezoelectric transducers, photoconductive transducers, photovoltaic cells, ionization transducers, Hall effect transducers.	**8**
2	**DYNAMIC RESPONSE CONSIDERATIONS,** Bridgman gauge, McLeod gauge, Pirani thermal conductivity gauge, Knudsen gauge, Alphatron.	**8**
3	**FLOW MEASUREMENT BY DRAG EFFECTS,** hot-wire anemometers, magnetic flow meters, flow visualization methods, interferometer, Laser Doppler anemometer. Temperature measurement by mechanical effect, temperature measurement by radiation, transient response of thermal systems, thermocouple compensation, temperature measurements in high-speed flow.	**8**
4	**THERMAL CONDUCTIVITY MEASUREMENT** of solids, liquids, and gases, measurement of gas diffusion, convection heat transfer measurements, humidity measurements, heat-flux meters. Detection of thermal radiation, measurement of emissivity, reflectivity and transmissivity, solar radiation measurement.	**8**
5	**OPEN AND CLOSED LOOP CONTROL SYSTEMS:** Review of open and closed loop control systems and servo mechanisms, Transfer functions of Mechanical Systems, input and output systems.	**8**

TEXT BOOK	
1	Holman, J.P., "Experimental methods for engineers", Tata McGrawHill, 7th Edition.
REFERENCE BOOKS	
SN	**Name of Authors /Books /Publisher**
1	Prebrashensky V., "Measurement and Instrumentation in Heat Engineering", Vol.1, MIR Publishers.
2	Raman C.S. Sharma G.R., Mani V.S.V., "Instrumentation Devices and Systems", 2nd Edition, Tata McGraw-Hill.
3	Morris A.S, "Principles of Measurements and Instrumentation", 3 rd Edition, Butterworth-Heinemann

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

1MTH2-13: Numerical Methods in Engineering

Credit: 3 **Max. Marks: 100(IA:30 ETE:70)**

3L+0T+0P **End Term Exam: 3 Hours**

SN	Contents	Hours
1	**Introduction:** Objective, scope and outcome of the course.	1
2	Approximations: Accuracy and precision, definitions of round off and truncation errors, error propagation.	4
3	System of LinearEquations: Formulation and solution of linear algebraic equations, Gauss elimination, LU decomposition, iteration methods (Gauss - Siedel); convergence of iteration methods.	8
4	Computations of Eigen-values of a Matrix: Power method for dominant, sub-dominant and smallest eigen-values.	3
5	Interpolation methods: Newton's divided difference, interpolation polynomials.	4
6	Numerical Solution of Ordinary Differential Equations: Initial-value problems: linear multistep methods, Runge-Kutta methods, predictor-corrector Adam- Bashforth, Milne's method. Boundary-value problems: the shooting method, finite difference methods.	10
7	Finite differences: Review of finite difference operators. Finite Difference Methods: Solution of Elliptic PDE usingfive point formulae for Laplacian, replacement for Dirichlet and Neumann's boundary conditions; Solution of Parabolic PDE using Crank-Nicholson, du-Fort and Frankel scheme; Solution of Hyperbolic PDE using finite differences (FD). Problems on application to design, thermal and production engineering will be discussed in different topics of the course.	10
	Total	40

TEXT BOOK	
1	S.S. Sastry, “Introductory Methods of Numerical Analysis”, PHI publication.
REFERENCE BOOKS	
SN	**Name of Authors /Books /Publisher**
1	John H. Mathews, “Numerical Methods Using Matlab, 4/e”, Pearson Education, India.
2	M.K. Jain, S.R.K. Iyengar, and R.K. Jain, "Numerical Methods for Scientific and Engineering Computation", New Age Pvt. Pub, New Delhi.
3	B.S. Grewal, “Numerical Methods in Engineering & Science (with Programs in C,C++ &MATLAB)”, Khanna Publisher, India.

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

1MTH2-14: Heating, Ventilating and Air-conditioning

Credit: 3 **Max. Marks: 100(IA:30 ETE:70)**

3L+0T+0P **End Term Exam: 3 Hours**

SN	Contents	Hours
1	**INTRODUCTION TO HVAC:** Scope, Concepts of air conditioning system, Central air conditioning system, Psychometric chart, Components of AHU and its components	4
2	**COOLING & HEATING LOAD ESTIMATIONS:** Basics of heat transfer in building, Understanding of outdoor & indoor conditions, Sources of heat gain, Heat loss calculations	3
3	**REFRIGERANT:** Types, Evaporating and condensing properties, Refrigerant pipe sizing methods	2
4	**DESIGN OF AIR DISTRIBUTION SYSTEM:** Components of air distributing system	3
5	**DESIGN OF VENTILATION SYSTEM:** Introduction, Restaurant and kitchen ventilation system design	4
6	**CHILLED WATER SYSTEM DESIGN:** Introduction, Classification, Chillar arrangements, cooling tower arrangements, types of cooling tower & expansion tank connections, Pumps required in chilled water system, Chilled water system pipe designing	5
7	**EQUIPMENT SELECTION:** AHU & FCU classification and selection, Package unit selection DX-Chiller, selection, Cooling tower selection mixed air temperature calculation, HRF for open & closed compressor, Expansion tank selection.	6
8	**ERECTION OF EQUIPMENTS:** Detailing & Installation of Chillers, Detailing & Installation of Air handling units, Detailing & Installation of Package units, Detailing & Installation of Fan coil units, Detailing & Installation of Condensing units	4
9	**ESTIMATION OF SYSTEMS:** Understanding the tendering requirements, Quantity take off, Preparing inquiry for	5

	suppliers & finalizing the suppliers, Final billing & quotations finalization	
10	**DRAFTING OF HVAC SYSTEMS:** Introduction, preparation of floor drawings, Load calculation, Duct designing & Equipment selection	**4**

REFERENCE BOOKS	
SN	**Name of Authors /Books /Publisher**
1	F.C. McQuiston and J.D. Parker, Heating, Ventilating, and Air Conditioning Analysis and Design, John Wiley & Sons, Inc.
2.	Refrigeration and Air Conditioning Technology | 9th Edition Eugene Silberstein/Jason Obrzut/John Tomczyk/Bill Whitman/Bill Johnson, Cengage Publications.
3.	HVAC Fundamentals by Samuel C. Sugarman
4.	HVAC Heating Ventilation and Air Conditioning Handbook for Design and Implementation By Ali Vedavarz

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

1MTH2-15: Gas Dynamics

Credit: 3 **Max. Marks: 100(IA:30 ETE:70)**

3L+0T+0P **End Term Exam: 3 Hours**

SN	Contents	Hours
1	REVIEW OF PRELIMINARY CONCEPTS: Ideal Gas, Reversible and irreversible process, First and second laws of thermodynamics, Integral equations for quasi one dimensional flows, isentropic relations, One dimensional flows, normal shock relations, Area velocity relation, flow inside nozzles and diffusers, Fanno flow, Rayleigh flow	8
2	SUPERSONIC STEADY 1-D FLOW: Oblique shock relations, shock polar diagram, Isentropic compression and expansion, Characteristics theory, Riemann invariants for steady flows, Wave interactions, Thin supersonic airfoil theory	8
3	UNSTEADY 1-D FLOW: Review of shock relations, isentropic relations, Moving normal shock, Differential equations for unsteady 1-D flows, Small perturbation approximation, Wave equation, Characteristics, Riemann invariants, Waves interactions	8
4	GOVERNING EQUATIONS FOR INVISCID FLOW: Review on vector analysis, Basic differential equations, Crocco theorem, vorticity, Bernoulli equation (general form), Second order ODE for velocity potential, elliptic and hyperbolic equations, Natural coordinates	8
5	SMALL PERTURBATION THEORY: Linear differential equations and boundary conditions, 2-D supersonic flow, wavy wall solution, Prandtl-Glaurt similarity, Small perturbation theory for lift and drag coefficients	8

TEXT BOOK	
1	Anderson, J.D., "Modern Compressible Flow With Historical Perspective, Mc Graw• Hill, 2nd edition, 2003.
REFERENCE BOOKS	
SN	**Name of Authors /Books /Publisher**
1	Lipmann, H.W., Roshko, A., Elements of gas dynamics, John Wiley• & Sons Inc. (1957), Dover Publications (2002).
2	Thompson, P. A., Compressible fluid dynamics, Mc Graw Hill, 1972.•

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

1MTH2-16: Micro Fluidics

Credit: 3 **Max. Marks: 100(IA:30 ETE:70)**

3L+0T+0P **End Term Exam: 3 Hours**

SN	Contents	Hours
1	**REVIEW OF ESSENTIALS IN MACROFLUIDICS:** Fluids, micro-fluids, application areas	8
2	**FUNDAMENTALS OF MICROFLUIDICS**: Micro-scale fluidic mechanics, Scaling effect, Surface forces, Electrokinetics and electrophoresis	8
3	**MICROFABRICATION TECHNIQUES:** Introduction, Techniques	8
4	**MICROFLUIDIC DEVICES:** Micropumps, Micromixing, Actuators and other components	8
5	**APPLICATIONS:** Analytical bio/chemistry: Point-of-care devices and lab-on-chips, Biomolecule separation and particle sorting, Droplet microfluidics, hysiology: Blood flow in the microvasculature and related instrumentation	8

TEXT BOOK	
1	Introduction to Microfluidics, by Patrick Tabeling, Oxford University Press.
REFERENCE BOOKS	
SN	**Name of Authors /Books /Publisher**
1	Micro- and Nanoscale Fluid Mechanics: Transport in Microfluidic Devices, by Brain Kirby, Cambridge University Press.

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

1MTH1-06: Simulation Lab

Credit: 2 **Max. Marks: 100(IA:60, ETE:40)**

0L+0T+4P **End Term Exam: 4 Hours**

SN	List of Experiments
A: by using Commercial packages such as ANSYS/CFX etc	
1	Introduction to the software employed in modeling and simulation
2	Solution of the governing equations (software development).
3	Numerical simulation of the following flow problems using commercial software packages: a. Flow over an airfoil. b. Supersonic flow over a wedge. c. Flat plate boundary layer. d. Laminar flow through pipe. e. Flow past a cylinder
4	Mitigation of dangerous wake vortices shed from aircraft and high-speed trains
5	Aerodynamic shape design using deep learning
6	Shape optimization using morphing, Bayesian Optimization
7	Numerical simulation of Flow over an airfoil using commercial software
8	Numerical simulation of Supersonic flow over a wedge using commercial software packages
9	Numerical simulation of Flat plate boundary layer using commercial software packages
10	Numerical simulation of Laminar flow through pipe using commercial software packages
11	Numerical simulation of Flow past cylinder using commercial software packages
B: Project work	
Each student will undertake a project in which geometric modelling, meshing, analysis and post processing of a mechanical system (involving fluid and heat transfer) are to be carried out. The animation of the system is to be demonstrated. The weightage of the project shall be 30% of IA component.	

Note: The above list is suggestive. Experiments/case studies may be added relevant to the theory courses taught in the semester.

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1MTH1-07: Advanced Thermal Engineering Lab

Credit: 2 **Max. Marks: 100(IA:60, ETE:40)**

0L+0T+4P **End Term Exam: 4 Hours**

SN	List of Experiments
1	Performance analysis of four stroke S.I. Engine- Determination of indicated and brake thermal efficiency, specific fuel consumption at different loads, Energy Balance.
2	Performance analysis of four stroke C.I. Engine- Determination of indicated and brake thermal efficiency, specific fuel consumption at different loads, Energy Balance
3	Performance analysis of an alternate fuel on computerized IC Engine test rig.
4	Calculation of thermal conductivity of metal rods.
5	Experiment on Pin fin Apparatus (free and force convection heat transfer).
6	COP calculation on air conditioning test rig apparatus
7	COP calculation on simple vapour compression refrigeration test rig.
8	Performance test and analysis of exhaust gases of an I.C. Engine.
9	Dryness fraction estimation of steam
10	Compressibility factor measurement of different real gases.

Note: The above list is suggestive. Experiments/case studies may be added relevant to the theory courses taught in the semester.

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

2MTH1-01: Advanced Computational Fluid Dynamics

Credit: 3 **Max. Marks: 100(IA:30 ETE:70)**

3L+0T+0P **End Term Exam: 3 Hours**

SN	Contents	Hours
1	**CONSERVATION EQUATIONS:** Classification of equations, Idealisation and approximation in flow/transport phenomenon, Theory of Visualisation, Method of Discretization, Boundry conditions, Components and properties of numerical solution methods, Turbulence modelling, Briefing.	**8**
2	**SOLUTION OF GENERALISED TRANSPORT EQUATION:** Method for steady diffusion and convection- diffusion problems, Various differencing schemes, Implementation of different boundary conditions, Algebraic equation systems, example.	**8**
3	**METHOD FOR UNSTEADY PROBLEMS:** Implicit, Explicit and semi explicit formulation, examples	**8**
4	**METHOD OF FLOW FIELD CALCULATION:** Necessity, Solution of inviscid flow, Simple viscous flow, Boundary layer flow and Navier stroke equation, Variable grid arrangements, Pressure calculation, Vorticity based methods, Simple, Simple and SIMPLEC algorithm, Fractional time steps method and artificial compressibility method, examples.	**8**
5	**ALGEBRAIC EQUATION SYSTEM SOLUTION METHODS:** Direct methods, Indirect methods, Coupled equations and its solutions, Convergence criteria and types of solvers, Problem with mesh independence, Post processing of results, Iteration errors analysis and estimation, Recommended practices in CFD	**8**

TEXT BOOK	
1	S.V. Patankar- Numerical heat transfer and fluid flow, hemisphere publishimng company,1980.
2	Malalashekhara and Versteeg: An introduction of computational fluid dynamics (finite volume method)
REFERENCE BOOKS	
SN	**Name of Authors /Books /Publisher**
1	J.N. Reddy and D.K. Gartling: The finite element method in heat transfer and fluid dynamics, CRC Press,1994.
2	A.I. Haker: Finite elements computational fluid mechanics, hemisphere publishing company, 1983.
3	P.S. Ghoshdrstidar, Computer simulation of flow and heat transfer, TMH publishing company Ltd, New Delhi,1998.
4	Computational fluid dynamics/ T. J.Chung/ Cambridge University press,2002.
5	Text book of fluid dynamics/ Frank Choriton/ CBS Publishers & distributors, 1985
6	Computational Fluid Flow and Heat Transfer/ Muralidaran/ Narosa Publications
7	Computational Fluid Dynamics: Basics with applications/John D. Anderson/ Mc Graw Hill.
8	Fundamentals of Computational Fluid Dynamics/Tapan K. Sengupta / Universities Press.
9	Introduction to Theoretical and Computational Fluid Dynamics/C. Pozrikidis /Oxford University Press/2nd Edition.
10	Farrashkhalvat and Miles: Basic structured grid generation

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

2MTH1-02: Advanced Heat and Mass Transfer

Credit: 3 **Max. Marks: 100(IA:30 ETE:70)**

3L+0T+0P **End Term Exam: 3 Hours**

SN	Contents	Hours
1	**BRIEF INTRODUCTION OF HEAT TRANSFER:** Conduction: General heat Conduction equation-initial and boundary conditions. Transient heat conduction: Lumped system analysis-Heisler charts-semi infinite solid-use of shape factors in conduction-2D transient heat conduction-product solutions.	8
2	**FINITE DIFFERENCE METHODS FOR CONDUCTION:** ID & 2D steady state and simple transient heat conduction problems-implicit and explicit methods. Forced Convection: Equations of fluid flow-concepts of continuity, momentum equations. Derivation of energy equation-methods to determine heat transfer coefficient: Analyticalmethods-dimensional analysis and concept of exact solution. Approximate method-integral analysis.	6
3	**EXTERNAL FLOWS:** Flow over a flat plate: integral method for laminar heat transfer coefficient for different velocity and temperature profiles. Application of empirical relations to variation geometries for laminar and turbulent flows.	6
4	**INTERNAL FLOWS:** Fully developed flow: integral analysis for laminar heat transfer coefficient types of flow-constant wall temperature and constant heat flux boundary conditionshydrodynamic & thermal entry lengths; use of empirical correlations.	6
5	**FREE CONVECTION:** Approximate analysis on laminar free convective heat transfer boussinesque approximation-different geometries-combined free and forced convection.	6
6	**BOILING AND CONDENSATION:** Boiling curve-correlations-Nusselts theory of film condensation on a vertical plate-assumptions & correlations of film condensation for different geometries.	4
7	**RADIATION HEAT TRANSFER:** Radiant heat exchange in grey, non-grey bodies, with transmitting. Reflecting and absorbing	4

	media, specular surfaces, gas radiation-radiation from flames.	

TEXT BOOK	
1	Fundamentals of Heat and Mass Transfer by Frank P. Incropera
2	Heat and Mass Transfer Data Bookby C.P. Kothandaraman
REFERENCE BOOKS	
SN	**Name of Authors /Books /Publisher**
1	Heat and Mass Transfer by Yunus A. Cengel
2	Heat and Mass Transfer by Frank M. White
3	Fundamentals of Heat and Mass Transfer by C.P. Kothandaraman
4	Elements of Heat Transfer/E. Radha Krishna/CRC Press
5	Heat Tranfer/ Hollman J. P./ McGraw-Hill Education
6	Heat Transfer / NecatiOzisik / TMH
7	Heat Transfer / Nellis& Klein / Cambridge University Press
8	Heat Transfer/ P.S. Ghoshdastidar/ Oxford Press
9	Introduction to Heat Transfer/SK Som/PHI

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

2MTH2-11: Air-conditioning System Design

Credit: 3 **Max. Marks: 100(IA:30 ETE:70)**
3L+0T+0P **End Term Exam: 3 Hours**

SN	Contents	Hours
1	**COOLING AND HEATING LOAD CALCULATION – I: ESTIMATION OF SOLAR RADIATION**. Introduction, solar radiation, constant and irradiation geometry and various related basic and derived angle ,angle of incident for horizontal, vertical and tilted surfaces, calculation of direct, diffuse and reflected radiation using ASHRAE solar radiation model including effect of clouds	**8**
2	**COOLING AND HEATING LOAD CALCULATION – II: SOLAR RADIATION FENESTRATION, VENTILATION AND INFILTERATION**. Fenestration, need, effect on air conditioning systems, estimation, concepts, SHGF, shading coefficient, external shading, calculation of shaded area, windows with overhang, infiltration and ventilation, causes, estimation of heat transfer rate.	**8**
3	COOLING AND HEATION LOAD CALCULATION – III: HEAT TRANSFER THROUGH BUILDING, FABRIC HEAT GAIN/LOSS. Heat transfer through buildings, 1-D, steady state and unsteady state heat transfer through homogeneous, non homogeneous walls, air spaces, composite walls, opaque walls, roofs. The analytical and in brief numerical methods used to solve the 1-D transient heat transfer problem, semi-emperical methods, physical significance of decrement and time lag factor, typical tables of CLTD for walls and roofs.	**8**
4	SELECTION OF AIR CONDITIONING SYSTEMS. Introduction to thermal distribution systems, there functions, selection criteria and there classification of air conditioning systems, working principal, advantages, disadvantages and its application for various air/water flow systems.	**8**
5	TRANSMISSION OF AIR IN AIR CONDITIONING DUCTS. Describe an air handling unit(AHU) its functions, need for studying transmission , air flow through ducts, Bernoulli and modified Bernoulli equation, static, dynamic, datum and total head, fan total pressure(FTP) and power input to fan, estimation of pressure loss through ducts, estimation of dynamic pressure drop in various types of heatings.	**8**

TEXT BOOK	
1	Refrigeration and air conditioning by Stooker W.F.
2	Refrigeration and air conditioning by C.P. Arora, Tata McGraw Hill.

REFERENCE BOOKS	
SN	**Name of Authors /Books /Publisher**
1	Refrigeration and air conditioning by Ahmad ul Ameen, PHI publication.
2	Handbook of air conditioning and Refrigeration by Shan K. Wang,Tata McGraw Hill.

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

2MTH2-12: Design of Heat Exchangers

Credit: 3 **Max. Marks: 100(IA:30 ETE:70)**

3L+0T+0P **End Term Exam: 3 Hours**

SN	Contents	Hours
1	CLASSIFICATION OF HEAT EXCHANGERS: Introduction, Recuperation & regeneration, Tabular heat exchangers, Double pipe, shell & tube heat exchanger, Plate heat Exchangers, Gasketed plate heat exchanger. Spiral plate heat exchanger, Lamella heat exchanger, Extended surface heat exchanger, Plate fin and Tabular fin. Basic Design Methods of Heat Exchanger: Introduction, Basic equations in design, Overall heat transfer coefficient, LMTD method for heat exchanger analysis, Parallel flow, Counter flow. Multipass, cross flow heat exchanger design calculations	6
2	DOUBLE PIPE HEAT EXCHANGER: Film coefficient for fluids in annulus, fouling factors, Calorific temperature, Average fluid temperature, The calculation of double pipe exchanger, Double pipe exchangers in series parallel arrangements.	4
3	Shell & Tube Heat Exchangers: Tube layouts for exchangers, Baffle heat exchangers, Calculation of shell and tube heat exchangers, Shell side film coefficients, Shell side equivalent diameter, The true temperature difference in a 1 -2 heat exchanger. Influence of approach temperature on correction factor. Shell side pressure drop, Tube side pressure drop, Analysis of performance of 1 -2 heat exchanger and design of shell & tube heat exchangers, Flow arrangements for increased heat recovery, the calculation of 2-4 exchangers.	8
4	CONDENSATION OF SINGLE VAPOURS: Calculation of horizontal condenser, Vertical condenser, De-Super heater condenser, Vertical condenser-sub-Cooler, Horizontal Condenser- Sub cooler, Vertical reflux type condenser. Condensation of steam.	6
5	VAPORIZERS, EVAPORATORS AND REBOILERS: Vaporizing processes, Forced circulation vaporizing exchanger, Natural circulation vaporizing exchangers, Calculations of a reboiler. Extended Surfaces: Longitudinal fins. Weighted fin efficiency curve, Calculation of a Double pipe fin efficiency curve. Calculationof a double pipe finned exchanger, Calculation of a longitudinal fin shell	8

	and tube exchanger.	
6	DIRECT CONTACT HEAT EXCHANGER: Cooling towers, relation between wet bulb & dew point temperatures, The Lewis number and Classification of cooling towers, Cooling tower internals and the roll of fill, Heat Balance. Heat Transfer by simultaneous diffusion and convection, Analysis of cooling tower requirements, Deign of cooling towers, Determination of the number of diffusion units, Calculation of cooling tower performance.	**8**

TEXT BOOK	
1	Process Heat Transfer/D.Q.Kern/ TMH
REFERENCE BOOKS	
SN	**Name of Authors /Books /Publisher**
1	Heat Exchanger Design/ A.P.Fraas and M.N.Ozisicj/ John Wiely& sons, New York.
2	Cooling Towers / J.D.Gurney and I.A. Cotter/ Maclaren

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

2MTH2-13: Combustion

Credit: 3 **Max. Marks: 100(IA:30 ETE:70)**

3L+0T+0P **End Term Exam: 3 Hours**

SN	Contents	Hours
1	INTRODUCTION; review of chemical equilibrium, heat of combustion, adiabatic flame temperature, kinetics. Review of Reynolds transport theorem and conservation equations.	8
2	NON-PREMIXED FLAMES: mixture fraction, coupling functions. Burke Schumann flame and droplet combustion	8
3	PREMIXED FLAMES: Thermodynamical considerations - Rankine Hugoniot relations: deflagration and detonation, flame speed and thickness phenomenology. Adiabatic flame speed and flame speed with heat loss. Flame stretch, flame speed with stretch, experimental techniques to determine laminar flame speed. Chemical structure of a premixed flame.	8
4	INTRODUCTION TO TURBULENT COMBUSTION: RANS equations, Favre averaging, length scales, energy spectra, mixing, intermittency	8
5	TURBULENT PREMIXED FLAMES: Regime Diagrams, Turbulent flame speed. Turbulent Non-Premixed Flames: Mixing, scalar dissipation rates, extinction. Introduction to Combustion Instabilities.	8

TEXT BOOK	
1	Fundamentals of Combustion by Mishra D P
REFERENCE BOOKS	
SN	**Name of Authors /Books /Publisher**
1	An Intro to Combustion: Concepts & Applications, 3rd Edition, by Stephen Turns, McGraw-Hill
2	Combustion 4th Edition by Irvin Glassman and Richard A. Yetter

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2MTH2-14: Micro-scale Heat Transfer		
Credit: 3		**Max. Marks: 100(IA:30 ETE:70)**
3L+0T+0P		**End Term Exam: 3 Hours**
SN	**Contents**	**Hours**
1	INTRODUCTION: Introduction to micro/nano scale transport phenomena, Material waves and energy quantization, Energy states in Solids, Statistical Thermodynamics and Thermal Energy Storage.	**12**
2	ENERGY TRANSFER: Energy Transfer by waves, Particle description of transport process: Classical laws, Boltzmann transport equation, Classical size effects, Energy conversion and couple transport process, Coupled nonequilibrium electron-phonon transport.	**12**
3	APPLICATIONS: Applications of micro/nanoscale heat transfer - nanoparticles and nanofluids, Thermoelectric devices, Short pulse laser heating of metals, microheat pipes, microelectronics, superconducting films	**16**

TEXT BOOK	
1	Nanoscale Energy Transfer and Conversion: A Parallel Treatment of Electrons, Molecules, Phonons, and Photons, by G Chen, Oxford Press.
REFERENCE BOOKS	
SN	**Name of Authors /Books /Publisher**
1	Nano/Microscale Heat Transfer, by Z Zhang, Mcgraw Hill.
2	Microscale and Nanoscale Heat Transfer: Fundamentals and Applications, by C B Sobhan and G P Peterson, CRC Press Taylor and Francis Group.
3	Microscale and Nanoscale Heat Transfer, Sebastian Volz, Springer-Verlag Berlin.
4	Statistical Thermodynamics and Microscale Heat Transfer, Van P. Carey, Cambridge Univ. Press.

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

2MTH2-15: Design of Wind Power Farms

Credit: 3 **Max. Marks: 100(IA:30 ETE:70)**
3L+0T+0P **End Term Exam: 3 Hours**

SN	Contents	Hours
1	INTRODUCTION TO WIND: Introduction and Status of Wind Energy Technology	4
2	TECHNOLOGY AND COMPONENTS: Overview of Wind Turbine Components, Design aspects of Wind Turbine, The Aerodynamics of Wind Turbine, Wind Turbine Blade Manufacture, Role of Non Crimp fabric in Blade Manufacturing, Drive Train Concepts of Wind Turbine, Wind Turbine Gear Box, Wind Turbine Generator, Control and Protection System in Wind Turbine, Wind Turbine Tower, Wind Turbine Foundation	8
3	WIND RESOURCE ASSESSMENT: Wind Resource Assessment and Techniques, Guidelines for Wind Measurements, Wind Measurements by Remote Sensing Instruments, Wind Data Measurements and Analysis, Design and Layout if Wind Farms, Indian Wind Atlas: A Case Study, Forecasting of Wind and Energy Production	4
4	WIND TURBINE TESTING & CERTIFICATION: Type Certification of wind turbine and overview of Design Requirements as per IEC 61400, Wind Turbine Testing & Measurement Techniques, Instrumentation for Wind Turbine Testing, Safety and Function Testing, Power Curve Measurements, Quality aspects of Wind turbines	8
5	WIND TURBINE PRE AND POST INSTALLATION: Wind Farm Developments and Related Issues, Economic Analysis of Wind Power Development, Installation and Commissioning of Wind Turbine, Grid Integration of Wind Turbine, Wind Power Evacuation, Operation and Maintenance of Wind Farms, Wind Farm Management using SCADA, Wind Turbine Condition Monitoring, Power Quality Characteristics of Wind Farms, Power System Studies for Renewable Integration	8
6	SMALL WIND TURBINE: Small Wind Turbine Testing and Hybrid System	3

7	ADVANCED TOPICS: Role of NIWE in India Wind Energy Development, Wind Energy Development in India, ,Offshore Wind Energy: An Overview, Water Pumping Wind Mill and RE for Rural Development, Environmental Aspects of Wind Turbine Technology, Integration of Wind energy with other renewable sources– A Case Study, Social Acceptance of Wind Power Projects, Carbon Credit – Opportunity for Wind Power, Solar Radiation Resource Assessment	**5**

TEXT BOOK	
1	T. Burton, N. Jenkins, D. Sharpe and E. Bossanyi, Wind Energy Handbook, Chichester: John Wiley and Sons.
2	M. O. Hansen, Aerodynamics of wind turbines, London: Routledge.
REFERENCE BOOKS	
SN	**Name of Authors /Books /Publisher**
1	J. W. Manwell, J. G. McGowan and A. L. Rogers, Wind Energy Explained, Theory, Design and Application. 2nd edition, Wiley-Blackwell, Oxford.
2	National Institute of Wind Energy (NIWE) Guidelines

2MTH2-16: Boundary Layer Theory and Turbulence

Credit: 3 **Max. Marks: 100(IA:30 ETE:70)**

3L+0T+0P **End Term Exam: 3 Hours**

SN	Contents	Hours
1	FUNDAMENTALS BOUNDARY LAYER THEORY: Boundary Layer Concept, Laminar Boundary Layer on a Flat Plate at zero incidences, Turbulent Boundary Layer on a Flat plate at zero incidence, Fully Developed Turbulent Flow in a pipe, Boundary Layer on an airfoil, Boundary Layer separation.	12
2	TURBULENT BOUNDARY LAYERS: Internal Flows, Couette flow, Two-Layer Structure of the velocity Field, Universal Law of the wall, Friction law, fully developed Internal flows, Chennel Flow, Couettee – Poiseuille flows, Pipe Flow.	12
3	TURBULENCE AND TURBULENCE MODELS: Nature of turbulence, Averaging Procedures, Characteristics of Turbulent Flows, Types of Turbulent Flows, Scales of Turbulence, Prandtl's Mixing length, Two-Equation Models, Low Reynolds Number Models, Large Eddy Simulation	16

TEXT BOOK	
1	H. Schlichting and Klaus Gersten, Boundary Layer Theory, Springer. R.J. Garde, Turbulent Flow, New Age International (p) Limited, Publishers
REFERENCE BOOKS	
SN	**Name of Authors /Books /Publisher**
1	G. Biswas and E. Eswaran, Turbulent Flows, Fundamentals, Experiments and Modelling, Narosa Publishing House.

2MTH1-06: Advanced Heat & Mass Transfer Lab

Credit: 2 **Max. Marks: 100(IA:60, ETE:40)**

0L+0T+4P **End Term Exam: 4 Hours**

SN	List of Experiments
1	Determination of Stefan Boltzman Constant.
2	Determination of LMDT and Effectiveness in a Parallel Flow and Counter Flow Heat Exchangers
3	Experiments on Boiling of Liquid and Condensation of Vapour
4	Experiment on Transient Conduction Heat Transfer
5	Determination of Thermal Conductivity of a Metal Rod
6	Determination of Overall Heat Transfer Coefficient of a Composite wall
7	Determination of Effectiveness on a Metallic fin
8	Determination of Heat Transfer Coefficient in a free Convection on a vertical tube
9	Determination of Heat Transfer Coefficient in a Forced Convention Flow through a Pipe
10	Determination of Emissivity of a Surface

Note: The above list is suggestive. Experiments/case studies may be added relevant to the theory courses taught in the semester.

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2MTH1-07: Computational Fluid Dynamics Lab

Credit: 2 **Max. Marks: 100(IA:60, ETE:40)**

0L+0T+4P **End Term Exam: 4 Hours**

SN	List of Experiments
A: Performing CFD simulations using commercial packages	
1	Introduction to CFD Lab
2	Generation of structured and unstructured mesh over simple objects
3	Boundary layer resolution and grid independence test
4	Flow over flat plate and use of transition models
5	Inviscid and viscous flow over circular cylinder at different Reynolds number
6	Laminar and turbulent flow in a pipe
7	Flow over airfoil at high Reynolds number and use of different turbulence models
8	Supersonic flow past wedge and cone
9	Transonic flow over subsonic and supercritical airfoils
10	Flow over finite wing and effect of aspect ratio and taper ratio
11	Flow in nozzles and diffusers
12	Writing codes in C/ C++/ MATLAB for simple flow fields
B: Project work	
Each student will undertake a project in which geometric modelling, meshing, analysis (using UDF (User Defined Functions)) and post processing of a mechanical system (involving fluid and heat transfer) are to be carried out. The animation of the system is to be demonstrated. The weightage of the project shall be 30% of IA.	

Note: The above list is suggestive. Experiments/case studies may be added relevant to the theory courses taught in the semester.

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III Semester

3MTH2-11: Optimization Techniques

Credit: 3 **Max. Marks: 100(IA:30 ETE:70)**
3L+0T+0P **End Term Exam: 3 Hours**

SN	Contents	Hours
1	**Introduction:** Objective, scope and outcome of the course.	1
2	**Optimal Problem Formulation:** Design Variables, Constraints, Objective Function, Variable Bounds. Engineering Optimization Problems. Classification.	3
3	**Single Variable Optimization Problems:** Optimality Criterion, Bracketing Methods, Region Elimination Methods, Successive Quadratic Estimation Method. Gradient Based Methods: Newton-Raphson Method, Bisection Method, Secant Method. Application to Root finding.	10
4	**Multivariable Optimization Algorithms:** Optimality Criteria, Unidirectional Search, Direct Search Methods: Hooke-Jeeves pattern search method, Powell's Conjugate Direction Method. Gradient Based Methods: Cauchy's Steepest Descent Method, Newton's method, Marquardt's Method.	12
5	**Constrained Optimization Algorithms:** Kuhn Tucker conditions, Transformation Methods: Penalty Function Method, Method of Multipliers. Sensitivity analysis.	10
6	**Specialized Algorithms:** Integer Programming: Penalty Function Method, Branch and Bound Method. Problems on application to design, thermal and production engineering will be discussed in different topics of the course.	4
	Total	40

TEXT BOOK	
1	Kalyanmoy Deb, Optimization for Engineering Design: Algorithms and Examples, Prentice Hall of India.
REFERENCE BOOKS	
SN	**Name of Authors /Books /Publisher**
1	S. S. Rao, Engineering Optimization: Theory and Practice, John Wiley & Sons.
2	Jasbir Arora, Introduction to Optimum Design, McGraw Hill.
3	Ranjan Ganguli, Engineering Optimization: A Modern Approach, Universities Press.
4	G.V. Reklaites, A. Ravindran and K.M. Rogsdeth, Optimization, Wiley.
5	D E Goldberg, Genetic Algorithm in Search, Optimization and Machine Learning , Addison Wesley.

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

3MTH2-12: Solar Energy Engineering and Technology

MOOC COURSE

https://swayam.gov.in/nd1_noc20_ph14/preview

Credit: 3 **Max. Marks: 100(IA:30 ETE:70)**
3L+0T+0P **End Term Exam: 3 Hours**

SN	Contents	Hours
1	Energy Scenario, overview of solar energy conversion devices and applications, physics of propagation of solar radiation from the sun to earth Sun-Earth Geometry, Extra-Terrestrial and Terrestrial Radiation, Solar energy measuring instruments Estimation of solar radiation under different climatic conditions, Estimation of total radiation	8
2	Fundamentals of solar PV cells, principles and performance analysis, modules, arrays, theoretical maximum power generation from PV cells. PV standalone system components, Standalone PV-system design. Components of grid-connected PV system, solar power plant design and performance analysis	8
3	Fundamentals of solar collectors, Snails law, Bougers law, Physical significance of Transmissivity – absorptivity product. Performance anlaysis of Liquid flat plate collectors and testing	8
4	Performance anlaysis of Solar Air heaters and testing Solar thermal power generation (Solar concentrators).	8
5	Thermal Energy Storage (sensible, latent and thermochemical) and solar pond Applications: Solar Refrigeration, Passive architecture,solar distillation, and ermeging technologies	8

TEXT BOOK	
1	H. P. Garg and J. Prakash, Solar Energy: Fundamentals and Applications, Tata McGraw Hill, 1997
REFERENCE BOOK	
SN	
1	S. P. Sukhatme and J. K. Nayak, Solar Energy: Principles of Thermal Collection and Storage, Tata McGraw Hill, 2006
2	J. A. Duffie and W. A. Beckman, Solar Engineering of Thermal Processes, John Wiley, 2006.

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3MTH2-13: INNOVATION AND ENTREPRENEURSHIP FOR ENGINEERS

SN	Contents	Hours
1.	**Introduction:** Objective, scope and outcomes of the course.	1
2.	**Entrepreneurship:** Concept and Definitions; Entrepreneurship and Economic Development; Types of Entrepreneurs; Factor Affecting Entrepreneurial Growth – Economic, Non-Economic Factors; EDP Programmes; Entrepreneurial Training; Traits/Qualities of an Entrepreneurs; Manager Vs. Entrepreneur, types of entrepreneurships, Entrepreneurial myths.	5
3.	**Opportunity Identification and Product Selection:** Entrepreneurial Opportunity Search and Identification; Criteria to Select a Product; Conducting Feasibility Studies; Sources of business ideas, launching a new product; export marketing, Methods of Project Appraisal, Project Report Preparation; Project Planning and Scheduling. Sources of finance for entrepreneurs. Procedure for Export and Import. Handicraft business opportunities in India.	8
4.	**Support Institutions and Management of Small Business:** MSME- Definition and significance in Indian economy, Registration, NOC from Pollution Board; Major problems faced by MSME; MSME Schemes, Challenges and Difficulties in availing MSME Schemes, Development Commissioner (MSME); Department of Industrial Policy and Promotion (DIPP); Director of Industries (DIC); KVIC, Coir Board; SIDBI; RIICO, SIDCO; NSIC, RSIC; Entrepreneurship development institutes: NIESBUD, IIE, NIMSME, EDI etc; State Financial Corporation SFC; Venture Capital: Concept, venture capital financing schemes offered by various financial institutions in India, Legal issues related to forming business entity, Requirements for formation of a Private/Public Limited Company. Steps in registration of firms and partnership.	10
5.	**Introduction to IPR and patents:** Basic concept of intellectual property Rights: Patents, design, trademark, GI, Copyright. Indian patent system and salient features of patent Act 1970. WTO-TRIPS agreement: Development of TRIPS Complied Regime in India. Patent Databases & Patent Information System: WIPO, IPINDIA, USPTO, Google Patents etc. Novelty searches. Subject matters of patentable and non-patentable in India. Procedure of patent filing, PCT application, provisional application, date of priority.	8
6.	**Startup**: Stages in transforming idea to a startup, Idea – Create, develop and validation. Prototype testing, Developing the product, developing the team, creating traction for the product, pitching	8

	the startup, Sources for funding of a startup, Pre Seed funding – Business angles, accelerators, Seed Funding - Angles, venture capitalists, crowd funding, syndicate investing, SME lending, grants, Accelerator funding. Mergers and acquisition.	
	TOTAL	**40**

TEXTBOOK	
1	Entrepreneurship development small business enterprises, Poornima M Charantimath, Pearson.
2	Understanding Patent Law, Vishnu S. Warrier, LexisNexis.
REFERENCE BOOKS	
1	Entrepreneurship, Roy Rajiv, Oxford University Press.
2	Innovation and Entrepreneurship, Drucker. F, Peter, Harper Business.
3	Entrepreneurship, Robert D. Hisrich, Mathew J. Manimala, Michael P Peters and Dean A. Shepherd, Tata Mc-Graw Hill Publishing Co. Ltd.
4	Enterpreneurship Development, S.S.Khanka, S.Chand & Co.
5	Small-Scale Industries and Entrepreneurship, Vasant Desai, Himalaya Publishing House.
6	Entrepreneurship Management, Cynthia, Kaulgud, Aruna, Vikas Publ
7	Entrepreneurship: Ideas in Action, Cynthia L. Greene, Thomson Asia Pvt.
8	Patent Law in India, M. B. Rao , Manjula Guru, Kluwer Law International
9	Intellectual Property Law, P Narayan, Eastern Law House
10	Intellectual Property Rights: Drafting, Interpretation of Patent Specifications and Claims, N.S. Rathore, New India Publishing Agency
11	Handbook on Patent Law - The Patents Act, 1970, LexCampus