Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

Department of Mechanical Engineering

B.Tech. –IV, Mechanical Engineering (As per NEP)

Sr. No.	Subject	Code	Scheme L-T-P	Credits (Min.)	Notional hours of Learning (Approx.)
Seventh Semester (4th year of UG)					
1.	CAD-CAM	ME401	3-1-2	5*	100
2.	Industrial Management Techniques	ME403	3-1-0	4	70
3.	Elective – IV	ME45x	3-0-0	3	55
4.	Elective – V	ME45x	3-0-0	3	55
5.	Elective – VI	ME45x	3-0-0	3	55
			Total	**18**	**335**
6.	Project	ME405	0-0-4	2	70
7.	Minor/Honor	M/HMEXX	3-1-0	4	70
8.	Minor/ Honor – Project	M/HMEXX	0-0-4	2	70
Eighth Semester (4th year of UG)					
1.	Internship	ME402	0-0-40	20	800 (20 x 40)
			Total	**20**	**800**

(List of Elective / Honors / Minors)

Sr. No.	Electives	Code
Elective - IV [Semester - VII]		
1	Computational Machine Design	ME451
2	Design of Material Handling Equipment	ME453
3	Vehicle Dynamics	ME455
4	Design of Heat Exchangers	ME457
5	Energy Efficiency in Industrial Utilities	ME459
6	Fundamentals of Combustion	ME461
7	Sheet Metal Forming	ME463
8	Production and Operations Management	ME465
9	Automation and Process Control for Smart Manufacturing	ME467
Elective - V [Semester - VII]		
1	Theory of Elasticity	ME469
2	Rotor Dynamics	ME471
3	Machine Tool Design	ME473
4	Radiation Heat Transfer	ME475

5	Advanced Refrigeration and -Air-conditioning Systems	ME477
6	Gas Dynamics	ME479
7	Foundry Technology	ME481
8	Manufacturing of Composites	ME483
9	Computer Integrated Manufacturing	ME485
	Elective - VI [Semester - VII]	
1	Design of Pressure Vessels	ME487
2	Theory of Plates and Shells	ME489
3	Continuum Mechanics	ME491
4	Two Phase Flow	ME493
5	Cryogenics Engineering	ME495
6	Design of Solar Thermal Systems	ME497
7	Surface Engineering & Heat Treatment	ME499
8	Hybrid Machining Processes	ME501
9	Project Management	ME503
	Honors	
1	Advanced Vibration	MEHD4
2	Design And Analysis of Rotodynamic Machines	MEHT4
3	Metal Additive Manufacturing	MEHM4
4	Energy Conservation, Management and Audit	MEHE4
	Minors	
1	Industrial Engineering and Management	MEM44

B.Tech. IV (DoME) Semester – 7 CAD-CAM ME401	Scheme	L	T	P	Credit
		3	1	2	05

1. Course Outcomes (COs): At the end of the course, students will be able to	
CO1	Explain the fundamental principles of CAD and learn drafting commands to generate part drawing.
CO2	Apply 2D and 3D transformation concept to find and describe geometry position.
CO3	Demonstrate modelling of parametric curves and procedure of FEA.
CO4	Explain the fundamental principles of CAM and learn CNC programming techniques and APT language to generate the tool paths and tool motion.
CO5	Show computer aided process planning and flexible manufacturing systems and their types.
CO6	Develop the CNC part program for a given part drawing for machining centre.

2.	Syllabus	
	PRINCIPLES OF COMPUTER AIDED DESIGN	**(05 Hours)**
	Computer configuration for CAD applications, Computer peripherals for CAD	
	FUNDAMENTALS OF COMPUTER GRAPHICS	**(15 Hours)**
	Introduction to two-dimensional transformation, Two dimensional transformation of points, lines, parallel & intersecting lines, rotation, reflection, scaling and combined transformations, Rotation about an arbitrary point, reflection about arbitrary line, Homogeneous coordinate system, Three-dimensional transformation-scaling, shearing, rotation, reflection, projections-orthographic, axonometric, foreshortening factor, oblique projection, introduction to perspective projection	
	PLANE CURVES AND SPACES	**(08 Hours)**
	Curve representation, Parametric and non -parametric curves, Parametric presentation of circle, ellipse, parabola, and hyperbola. Cubic spline, Bezier curve and B spline curve	
	INTRODUCTION TO NUMERICAL CONTROL	**(02 Hour)**
	Key terms: CAM, CIM, NC, CNC, and DNC; Need for NC technology and its significance; Comparison of NC and CNC technologies; Advantages and applications of CNC technology;	

	Overview of main components of CNC machine tools; Introduction to machining centers and turning centers	
	FUNDAMENTALS OF CNC TECHNOLOGY	**(03 Hours)**
	Overview of CNC machine components and comparison with conventional machine tools; Working principle and applications of stepper motors; Types of feedback devices: construction, working principles, and numerical examples; Open-loop vs. closed-loop CNC systems: features, advantages, and limitations	
	CNC PROGRAMMING FOR MILLING MACHINE	**(17 Hours)**
	Introduction to G-Codes and M-Codes: Common G-Codes such as G00, G01, G02, G03, G04, G17, G18, G19, G20, G21, G28, G43, G54–G59, G90, G91, G94, G95; Common M-Codes: M00, M01, M02, M03, M04, M05, M06, M08, M09, M30; Introduction to other words: T-word, S-word, H-word, N-word (as per Fanuc controller). Basic and Advanced Part Programming: Calculation of cutter path coordinates; Writing part programs for simple components (e.g., rectangle and triangle contouring); Contouring components with linear and circular elements; Pocket machining (rectangular or circular pockets) with given step-over. Canned Cycles and Associated Codes: Key canned cycles and associated codes: G80, G81, G82, G83, G73, G98, G99; Syntax, working, and programming examples for random holes and hole patterns (rectangular, bolt circle, etc.). Subprograms: Introduction to M98 and M99 codes, applications, and benefits; Writing part programs using subprograms for repetitive patterns (e.g., hole arrays, bolt circles) and identical geometric features. Mirroring Commands: Overview of mirroring commands: applications, advantages, and limitations; Writing part programs using mirror commands. Tool Length Setup Methods: Using a tool presetter; Touch-off method (with and without a master tool); Relevant codes for tool length setup in part programming. Cutter Radius Offset Commands: Introduction to G40, G41, and G42 commands: purpose and usage; Rules and best practices for applying cutter radius offsets; Writing part programs with cutter radius offsets for complex geometries.	
	AUTOMATICALLY PROGRAMMED TOOLS (APT) LANGUAGE	**(05 Hours)**
	Overview of APT as a computer-aided programming language; Key components: Geometry statements, Motion statements, Postprocessor statements, Auxiliary statements; Writing APT programs for drilling holes and hole patterns	
	MANUFACTURING SYSTEMS, GROUP TECHOLOGY, FLEXIBLE MANUFACTURING SYSTEMS AND PROCESS PLANNING	**(05 Hours)**
	Definition and key components and their roles; Classification; Overview of GT and its methodologies; Concept of cellular manufacturing, layout types: inline, loop, rectangular; Overview of FMC and FMS, Components of FMS, Types of FMS cells and layouts, Types of flexibility in FMS; Definition of processes planning and significance in manufacturing; Traditional vs. Computer-Aided Process Planning (CAPP); Advantages and types of CAPP	
		(Total Contact Time: = 60 Hours)

3.	Practical
1	Applying drafting commands using drafting software/sketcher mode in packages
2	Creating part drawings based on given sketches as per dimensions
3	Applying programming technique for generating drawings in drafting
4	Applying programming knowledge to design a mechanical part.
5	Applying CAD commands to build 3D models
6	CNC part programming with linear and circular interpolation using a suitable controller
7	CNC part programming for circular and rectangular pocket with a suitable controller
8	CNC part programming for contouring, and bolt circle hole pattern using canned cycles in Cartesian and polar coordinate systems with a suitable controller
9	CNC part programming using mirror and subprogram commands with a suitable controller
10	CNC part programming with tool radius compensation using a suitable controller.

3.	Books Recommended
1	D. F. Rogers and J. A. Adams, "Mathematical Elements for Computer Graphics", McGraw Hill Education, 2017
2	P. N. Rao, "CAD/CAM: Principles and Applications", 3rd Edition, Tata McGraw Hill, 2017
3	M. P. Groover and E. W. Zimmers, "Computer Aided Design and Manufacturing", Prentice Hall India (Pearson Education), 2003
4	S. K. Sinha, "CNC Programming (Fanuc Control)", Galgotia Publications, 2011
5	M. P. Groover, "Automation, production systems, and computer-integrated manufacturing, 4th Edition, Pearson Education India, 2016

B.Tech. IV (DoME) Semester – 7 INDUSTRIAL MANAGEMENT TECHNIQUES ME403	Scheme	L	T	P	Credit
		3	1	0	04

1. Course Outcomes (COs):

At the end of the course, students will be able to

CO1	Develop Linear Programming (LP) models for engineering and management systems, and apply solution techniques and algorithms to solve these problems.
CO2	Solve assignment & transportation models for engineering and management systems, and apply solutions techniques and algorithms to solve these problems.
CO3	Build Network models for engineering and management systems, and apply solution techniques and algorithms to solve these problems
CO4	Formulate Queuing models for engineering and management systems, and apply solution techniques and algorithms to solve these problems
CO5	Apply strategies and payoff to solve game theory problems
CO6	Choose statistical process control tools for designing of products and process controls.

2.	Syllabus	
	LINEAR PROGRAMMING PROBLEMS	**(11 hours)**
	Formulation, Graphical method, Simplex method, Difficulties in Simplex method, Duality.	
	ASSIGNMENT AND TRANSPORTATION MODELS	**(09 hours)**
	Allocations, Problem of imbalance, Hungarian assignment method, Alternate optima, Travelling salesman problem, basic transportation problem, unbalanced transportation problem, Optimal solution, degeneracy, Transhipment and Inventory control problems.	
	NETWORK ANALYSIS	**(08 hours)**
	Project Management, Network analysis, Critical Path Activities, Program Evaluation and Review Techniques (PERT), Crashing analysis, Activity on node analysis and Resource scheduling.	
	STATISTICAL PROCESS CONTROL	**(08 hours)**

	Discrete and continuous probability distributions, Control Charts for variables and attributes, Type I and II errors, Process capability, Acceptance Sampling Plans (single, double and multiple sampling plans).	
	QUEUING THEORY	**(05 hours)**
	Models, Elements, Operating Characteristics and Deterministic queuing models.	
	GAME THEORY	**(04 hours)**
	Two Person Zero Sum Games, Dominance Rule, Application of Linear Programming to game problems.	
	(Total Contact Time: = 45 Hours)	

3.	**Books Recommended**
1	H. A. Taha, Operations research: An Introduction. 10th Edition, Pearson Education, 2019.
2	S. D. Sharma, Operations Research: Theory, Method & Applications, 1st Edition, Kedarnath Ramnath Publishers, 2012
3	P. K. Gupta and D. S. Hira, Operations Research, Revised Edition, S. Chand & Company Ltd., 2017
4	A. Mitra, Fundamentals of Quality Control and Improvement, 3rd Edition, John Wiley & Sons, 2008
5	N. D. Vohra, Quantitative Techniques in Management, 5th Edition, Mc-Graw Hill, 2017

B.Tech. IV (DoME) Semester – 7 COMPUTATIONAL MACHINE DESIGN (ELECTIVE-IV) ME451	Scheme	L	T	P	Credit
		3	0	0	03

1. **Course Outcomes (COs):**

At the end of the course, students will be able to

CO1	Summarize the computer aided aspects of machine design.
CO2	Select numerical techniques for optimization of design.
CO3	Explain the concepts of static analysis methods for machine design.
CO4	Apply finite difference method for transient analysis.
CO5	Describe and apply concepts for dynamic analysis.
CO6	Utilize finite element method to solve spring and truss problems.

2.	**Syllabus**	
	COMPUTER AIDED ASPECTS OF MACHINE DESIGN	**(07 Hours)**
	Introduction to mechanical design, formulation of a specific design problem, computer aided aspects of machine design, failure under dynamic loading.	
	OPTIMIZATION OF DESIGN	**(09 Hours)**
	Conventional design method and Optimum design method, optimum design formulation, gradient vector, hessian matrix, unconstrained minimization of functions, constrained optimization-Lagrange`s multiplier, numerical optimization-Newton`s method, quadratic convergence-Cauchy`s method, Fletcher-Reeves method, optimization using Excel solver	
	STATIC ANALYSIS	**(07 Hours)**
	Determinant and matrices, Static analysis methods-gauss elimination, Gauss-Jordan method, Cholesky`s factorization method, Potter`s method	
	TRANSIENT ANALYSIS	**(07 Hours)**
	Finite difference method – single degree of freedom and multi degree of freedom, explicit schemes, implicit schemes	
	DYNAMIC ANALYSIS	**(06 Hours)**

	Basic concepts of eigenvalue problems, properties of eigen values and vectors, modal matrix, orthogonality, cyclic symmetric structures-free vibration analysis	
	FINITE ELEMENT ANALYSIS	**(09 Hours)**
	Introduction to Finite Element Method, FEM terminology, stiffness matrix-element and global, element equation, displacement function and shape function, spring element, truss element, dynamic analysis of frames	
	(Total Contact Time: = 45 Hours)	

3.	**Books Recommended**
1	R. V. Dukkipati, M. A. Rao and R. Bhat, Computer Aided Analysis and Design of Machine Elements, New Age International Pvt. Ltd., 2015
2	S.S. Rao, Engineering Optimization: Theory and Practice, John Wiley and Sons Inc., 2020
3	R. G. Budynas and K. Nisbett, Shigley's Mechanical Engineering Design, 11th Edition, McGraw Hill, 2020
4	V. Ramamurti, Finite Element Method in Machine Design, Narosa Publishing House Pvt. Ltd., 2009
5	D. L. Logan. A first course in the finite element method. Cengage Learning, 2016

B.Tech. IV (DoME) Semester – 7 DESIGN OF MATERIAL HANDLING EQUIMENT (ELECTIVE-IV) ME453	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs):

At the end of the course, students will be able to

CO1	Understand the fundamentals of material handling equipment.
CO2	Develop a conveyors and selection based on the application.
CO3	Choose of hoists, pulleys and brakes.
CO4	Design of cranes.
CO5	Design of bucket and cage elevator.
CO6	Analyse packaging and storage of bulk materials.

2.	Syllabus	
	Introduction: Objectives of material handling system, Principal groups of materials handling equipment and classification, Scope of Material Handling, Criteria for selection of Material Handling Equipment's, Basic kind of material handling problems, Various methods to analyse material Handling problems. **Conveyor Design:** Introduction to apron conveyors, Pneumatic conveyors, Belt Conveyors, Screw conveyors and vibratory conveyors and their applications, Design of Belt conveyor- Belt selection procedure and calculation of drop energy, Idler design.	**(15 Hours)**
	Design of Bucket Elevator: Introduction, Types of Bucket Elevator, Design of Bucket Elevator- loading and bucket arrangements, Cage elevators, shaft way, guides, counter weights. **Packaging and Storage of Bulk Materials:** Steps for design of packages, protective packaging, testing the physical characteristics of packaging, container testing, types of storage and industrial containers, Automatic guided vehicles, Automatic storage and retrieval system.	**(15 Hours)**
	Design of Bucket Elevator: Introduction, Types of Bucket Elevator, Design of Bucket Elevator- loading and bucket arrangements, Cage elevators, shaft way, guides, counter weights.	**(15 Hours)**

	Packaging and Storage of Bulk Materials: Steps for design of packages, protective packaging, testing the physical characteristics of packaging, container testing, types of storage and industrial containers, Automatic guided vehicles, Automatic storage and retrieval system.	
		(Total Contact Time: = 45 Hours)

3.	**Books Recommended**
1	S. Ray, Introduction to Materials Handling, New Age International Private Limited, 2007.
2	M. P. Stephens, Manufacturing Facilities Design & Material Handling, 6th Edition, Pearson Education Inc., 2019.
3	R. A. Kulwiec, Material Handling Handbook, 2nd Edition, John Wiley and Sons, ASME, USA, 1991.
4	K. C. Arora and V. V. Shinde, Aspects of Materials Handling, Firewall Media, 2007.
5	D. C. Boyd and S. Panigrahi, Design and Selection of Bulk Material Handling Equipment and Systems, Wide Publications, 2012.

B.Tech. IV (DoME) Semester – 7 VEHICLE DYNAMICS (ELECTIVE-IV) ME455	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs):

At the end of the course, students will be able to

CO1	Understand the dynamics of vehicle ride.
CO2	Calculate and refer the loads and forces associated to the vehicles.
CO3	Analysis of steering characteristics and vehicles stability.
CO4	Compare the behaviour of the vehicles under acceleration, ride and braking.
CO5	Formulate tire mechanics and its construction.
CO6	Analyse motorcycle dynamics.

2.	Syllabus	
	Performance Characteristics of Vehicle: SAE vehicle axis system, Forces and moments affecting vehicle, earth fixed coordinate system, dynamic axle loads, equations of motion, transmission characteristics, vehicle performance, power limited and traction limited acceleration, braking performance, brake proportioning, braking efficiency. **Aerodynamics:** Mechanics of air flow around a vehicle, pressure distribution on a vehicle, aerodynamic forces, drag components, aerodynamics aids.	**(15 Hours)**
	Steering Characteristics: Steering linkages, steering system forces and moments, steering system models, steering geometry, steady handling (2 dof steady state model), understeer and oversteer, effect of tire camber and vehicle roll (3 dof steady-state model), transient handling and directional stability (2 dof unsteady model), effect of vehicle roll on transient handling (3 dof unsteady model), steady-state and transient handling of articulated vehicles. **Stability of Vehicles:** Load distribution, calculation of tractive effort and reactions for different drives, stability of a vehicle on a slope, curve and a banked road.	**(15 Hours)**
	Tire Mechanics: Tire construction, size and load rating, terminology and axis system, tractive properties, cornering properties, camber thrust, aligning moment, combined braking and cornering, conicity and ply steer, slip, skid,	**(15 Hours)**

	rolling resistance, elastic band model for longitudinal slip, simple model for lateral slip, combined longitudinal/lateral slip (friction ellipse), taut string model for lateral slip, magic tire formula. **Motorcycle Dynamics:** Kinematic structure of motorcycle, geometry of motorcycles, importance of trail, resistance forces acting on motorcycle, location and height of motor cycle's centre of gravity, moments of inertia on motorcycle, front and rear suspensions of motorcycle.	
	(Total Contact Time: = 45 Hours)	

3.	**Books Recommended**
1	J. Y. Wong, Theory of Ground Vehicles, Wiley, 2008.
2	B. P. Minaker, Fundamentals of Vehicle Dynamics and Modelling, Wiley, 2019.
3	D. J. N. Limebeer and M. Massaro, Dynamics and Optimal Control of Road Vehicles, Oxford University Press, 2018.
4	R. N Jazar, Vehicle Dynamics: Theory and Application, 2nd Ed., Springer, 2013.
5	G. Rill, Road Vehicle Dynamics Fundamentals and Modelling, Taylor & Francis, 2012.

B.Tech. IV (DoME) Semester – 7 DESIGN OF HEAT EXCHANGERS (ELECTIVE-IV) ME457	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs):

At the end of the course, students will be able to

CO1	Summarize the different types of heat exchanger used in application.
CO2	Estimate the performance of shell and tube type heat exchanger.
CO3	Analyze the performance of tube finned heat exchanger.
CO4	Evaluate the performance of plate finned heat exchanger.
CO5	Calculation of pressure drop in compact heat exchanger.
CO6	Design the heat exchanger for the radiation furnace.

2.	Syllabus	
	INTRODUCTION	**(08 hours)**
	Classification of heat exchanger, selection of heat exchanger, overall heat transfer coefficient, LMTD method for heat exchanger analysis for parallel, counter, multi-pass and cross flow heat exchanger, e-NTU method for heat exchanger analysis, fouling, cleanliness factor, percent over surface, techniques to control fouling, additives, rating and sizing problems, heat exchanger design methodology	
	DESIGN OF DOUBLE PIPE HEAT EXCHANGERS	**(12 hours)**
	Thermal and hydraulic design of inner tube and annulus, total pressure drop, Tube – Side heat transfer and pressure loss calculations	
	DESIGN OF SHELL & TUBE HEAT EXCHANGERS	**(12 hours)**
	Basic components, basic design procedure of heat exchanger, approximate sizing of shell & tube heat exchangers, shell – side and tube – side calculations. Design procedure for plain and finned tubes, TEMA code, J-factors, conventional design methods, Bell-Delaware method	
	DESIGN OF COMPACT HEAT EXCHANGERS AND REGENERATORS	**(08 hours)**

	Heat transfer enhancement, plate fin heat exchanger, tube fin heat exchanger, heat transfer and pressure drop, Types of regenerator matrix. Design of coils. Design of automobile radiator.	
	DESIGN OF RADIATION FURNACES AND FOULING MECHANISMS	**(05 hours)**
	Well stirred model and longitudinal model.	
		(Total Contact Time: = 45 Hours)

3.	**Books Recommended**
1	R. K. Shah and D. P. Sekulic, Fundamentals of Heat Exchangers Design, John Wiley & Sons, 2003
2	S. Kakaç, H. Liu, A. Pramuanjaroenkij, Heat Exchangers: Selection, Rating, and Thermal Design, Third Edition, CRC Press, 2012
3	W. M. Kays and A. L. London, Compact Heat Exchangers, McGraw Hill, New York, 1964
4	Saunders E. A. D., Heat Exchangers - Selection, Design and Construction, Longman Scientific & Technical, 1998
5	J.E. Hesselgreaves, R.Law, D. Reay, Compact Heat Exchangers, Selection, Design and Operation, 2nd Edition, Butterworth-Heinemann, 2016

B.Tech. IV (DoME) Semester – 7 ENERGY EFFICIENCY IN INDUSTRIAL UTILITIES (ELECTIVE-IV) ME459	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs): At the end of the course, students will be able to	
CO1	Apply various energy conservation techniques to estimate energy saving potential in boiler, steam and furnace systems.
CO2	Evaluate the performance of a furnace along with general fuel economy measures.
CO3	Analyze and evaluate the thermodynamic performance of cogeneration systems.
CO4	Design and optimize waste heat recovery systems for specific industrial applications.
CO5	Compute various performance parameters of HVAC systems and suggest suitable ways for improving energy efficiency.
CO6	Conclude the performance and efficiency of heat exchangers using theoretical models and practical calculations.

2.	Syllabus	
	ENERGY EFFICIENCY IN BOILER, STEAM AND FURNACE SYSTEM UTILITIES	**(12 Hours)**
	Introduction to Boilers, Performance evaluation of boilers, Energy Conservation opportunities, Introduction to Steam Traps, Steam Distribution, Proper Selection, Operation and Maintenance of Steam Traps, Performance assessment methods for steam traps, efficient Steam Utilization and Energy Saving Opportunities, Introduction to Furnaces, Performance evaluation of a typical fuel fired furnace, General Fuel Economy Measures in Furnaces.	
	COGENERATION	**(10 Hours)**
	Principle of cogeneration, technical options for cogeneration, Factors influencing cogeneration choice, Important technical parameters for cogeneration, Prime movers for Cogeneration, Relative merits of Cogeneration Systems, Case study on savings with and without cogeneration.	
	WASTE HEAT RECOVERY	**(10 Hours)**
	Introduction, Classification and Application, Benefits of Waste Heat Recovery, Development of a Waste Heat Recovery System, Commercial Waste Heat Recovery Devices.	
	ENERGY EFFICIENCY IN HVAC AND REFRIGERATION UNITS	**(08 Hours)**

	Performance assessment of refrigeration units, Factors affecting energy efficiency in refrigeration plants, Energy saving opportunities in cold storage systems, Heat Pumps and Applications, Standards and Labelling of Room Air-conditioners.	
	HEAT EXCHANGERS	**(05 Hours)**
	Introduction, Types, Pinch analysis and Pinch Technology application for process and Energy Efficiency Improvements.	
	(Total Contact Time: = 45 Hours)	

3.	**Books Recommended**
1	General Aspects of Energy Conservation, Management and Audit: Guide Book for Energy Managers and Energy Auditors; Bureau of Energy Efficiency, Ministry of Power, 2015
2	Energy Efficiency in Electrical Utilities: Guide Book for Energy Managers and Energy, 2015
3	Auditors; Bureau of Energy Efficiency, Ministry of Power,2015
4	Energy Efficiency in Thermal Utilities: Guide Book for Energy Managers and Energy Auditors; Bureau of Energy Efficiency, Ministry of Power, 2015
5	S. A. Roosa, Energy Management Handbook, Fairmont Press, 2018

B.Tech. IV (DoME) Semester – 7 FUNDAMENTALS OF COMBUSTION ELECTIVE-IV) ME461	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs):

At the end of the course, students will be able to

CO1	Describe different combustion mechanisms and how these can be efficiently used in engineering applications.
CO2	Evaluate thermodynamics parameters of combustion phenomena.
CO3	Analyse chemical kinetics and physics of combustion process.
CO4	Explain basic concepts of premixed flames; modelling and application to energy systems.
CO5	Outline basic concepts of diffusion flames; modelling and application to energy systems.
CO6	Illustrate different types of pollutants generated in combustion, their effects on health and on the environment.

2.	**Syllabus**	
	INTRODUCTION	**(04 Hours)**
	Introduction to combustion, Applications of combustion, Types of fuel and oxidizers, Characterization of fuel, Various combustion mode, Scope of combustion.	
	THERMODYNAMICS OF COMBUSTION	**(08 Hours)**
	Thermodynamics properties, Laws of thermodynamics, Stoichiometry, Thermochemistry, adiabatic temperature, Chemical equilibrium.	
	COMBUSTION KINETICS	**(08 Hours)**
	Basic Reaction Kinetics, Elementary reactions, Chain reactions, Multistep reactions, Simplification of reaction mechanism, Global kinetics.	
	PHYSICS OF COMBUSTION	**(04 Hours)**
	Fundamental laws of transport phenomena, Conservations Equations	
	PREMIXED FLAME	**(08 Hours)**

	Laminar premixed flame, laminar flame structure, Laminar flame speed, Flame speed measurements, Flame stabilizations.	
	DIFFUSION FLAME	**(08 Hours)**
	Gaseous Jet diffusion flame, Liquid fuel combustion, Atomization, introduction to Spray and Solid fuel combustion	
	COMBUSTION AND ENVIRONMENT	**(05 Hours)**
	Atmosphere, Chemical Emission from combustion, Quantification of emission, Emission control methods.	
	(Total Contact Time: = 45 Hours)	

3.	**Books Recommended**
1	K.K. Kuo, Principles of Combustion, John Wiley and Sons, 2005
2	S.R. Turns, An introduction to combustion, New York: McGraw-Hill, 2017
3	C.K. Law, Combustion physics, Cambridge University Press, 2010
4	D.P. Mishra, Fundamentals of Combustion, Prentice Hall of India, 2010
5	H. S. Mukunda, Understanding combustion, Universities Press, 2009

B.Tech. IV (DoME) Semester – 7 SHEET METAL FORMING (ELECTIVE-IV) ME463	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs): At the end of the course, students will be able to	
CO1	Explain the concept of material yielding and plastic behavior of sheet.
CO2	Summarize the significance of intrinsic material properties used in the sheet metal forming.
CO3	Examine an insight of the sheet deformation processes, load instability and tearing in sheet metal forming.
CO4	Classify various modes of deformation and defects involved in sheet metal forming Processes.
CO5	Analyze principles, capabilities and applications of sheet metal forming processes.
CO6	Evaluate the formability criteria for sheet metal component manufacturing.

2.	Syllabus	
	FUNDAMENTALS OF METAL FORMING	**(03 Hours)**
	Introduction, Advantages of metal forming, cold and hot forming, various metal forming processes, Uniaxial Tensile Test - load–extension diagram, engineering stress–strain curve, true stress–strain curve, Anisotropy, Rate sensitivity, Effect of properties on forming.	
	BIAXIAL STRESS TESTING METHODS FOR SHEET METALS	**(03 Hours)**
	Introduction, Geometry of cruciform specimen, method of strain measurement, Biaxial stress strain curve, measurement of yield locus, factors affecting the maximum equivalent plastic strain applicable to gauge area, case studies.	
	SHEET DEFORMATION PROCESSES (PLANE STRESS)	**(09 Hours)**
	Deformation in uniaxial tension, stress and strain ratios, theory of yielding in plain stress condition - Maximum shear stress, Hydrostatic stress, Tresca yield condition, Von Mises yield condition, Levy–Mises flow rule, Relation between the stress and strain ratios, Work of plastic deformation, Work hardening hypothesis, Effective stress and strain functions, Concept of Formability, formability limits and formability diagram. Factors affecting the forming limit curve.	

	LOAD INSTABILITY AND TEARING	**(10 Hours)**
	Uniaxial tension of a perfect strip, Tension of an imperfect strip, Tensile instability in stretching continuous sheet - condition for local necking in uniaxial and biaxial tension.	
	ANALYSIS OF STAMPING AND DEEP DRAWING PROCESS	**(07 Hours)**
	Two-dimensional model of stamping, stretch and draw ratios in a stamping, three-dimensional stamping model, limiting drawing ratio and anisotropy, effect of strain-hardening and friction on drawing stress, redrawing and reverse redrawing of a cylindrical cup, wall ironing of deep-drawn cups, estimation of drawing force.	
	ANALYSIS OF BENDING PROCESS	**(05 Hours)**
	Strain distribution in bending, bending without tension, bending of sheet in v-die, determination of work load, stock length and punch angle, springback and reverse bending, bending line construction.	
	ANALYSIS OF PUNCHING AND BLANKING PROCESS	**(03 Hours)**
	Mode of metal deformation and failure, deformation model and fracture analysis, determination of working force.	
	ANALYSIS OF SHEET HYDROFORMING	**(05 Hours)**
	Free expansion of a cylinder by internal pressure, Forming a cylinder to a square section, Tube forming in a frictionless die, Tube forming with sticking friction (or very high friction), Constant thickness forming, sequential hydroforming	
	(Total Contact Time: = 45 Hours)	

3.	**Books Recommended**
1	R. Hill, The Mathematical Theory of Plasticity, Oxford University Press, London, 2004
2	S.J. Hu, Marciniak Z., J.L. Duncan, Mechanics of Sheet Metal Forming, Butterworth-Heinemann, 2002
3	G. Schuler, Metal forming handbook, Springer Verlag Berlin, Heidelberg, 1998
4	S.P. Timoshenko, Theory of Elasticity, McGraw Hill, 2017
5	A. Ghosh and A. K. Malik, Manufacturing Science, East-West Press Pvt Ltd, 2010

B.Tech. IV (DoME) Semester – 7 PRODUCTION AND OPERATIONS MANAGEMENT (ELECTIVE-IV) ME465	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs):

At the end of the course, students will be able to

CO1	Explain, how the operations and processes have strategic importance and can provide a competitive advantage.
CO2	Evaluate and rank capacity and constraint management by solving the problems.
CO3	Choose and rank aggregate plan and schedule production by solving the problems.
CO4	Develop Material Requirement Planning (MRP) structure.
CO5	Apply various lot sizing techniques to the dependent inventory models.
CO6	Describe the concepts of lean, agile and quick response manufacturing and compare them.

2.	Syllabus	
	OPERATIONS STRATEGY AND PROCESS STRATEGY	**(07 Hours)**
	Operations of goods and services, Developing Mission and strategy, Issues of operations strategy, Strategy development and implementation, Strategic planning, Core competency, Outsourcing, Design and selection of goods and services, Product development Product design issue, Process strategy, process analysis and design.	
	CAPACITY AND CONSTRAINT MANAGEMENT	**(07 Hours)**
	Capacity, Bottleneck analysis and theory, Break -Even Analysis (Single & Multiproduct), Risk Reduction, Capacity Decisions using Expected monetary value, investment analysis.	
	AGGREGATE PLANNING	**(08 Hours)**
	Planning Process, Nature of Planning, Strategies, methods, Aggregate planning in services.	
	MATERIAL REQUIREMENT PLANNING AND ERP	**(09 Hours)**
	Dependent Demand, Dependent inventory model, Material Requirement Planning (MRP) structures, Management, Lot sizing techniques, Extension of MRP, MRP in-services.	

	SHORT TERM SCHEDULING	**(09 Hours)**
	Issues, Scheduling process, Focused facilities, Loading jobs, Sequencing jobs, Finite capacity scheduling, Service scheduling.	
	LEAN, AGILE AND QUICK RESPONSE MANUFACTURING	**(05 Hours)**
	Lean and Just-In-Time, Total Quality Management (TQM), Toyota production System, Lean organization, Lean in Services, Agility, Dimensions of agility, Quick response manufacturing, Manufacturing excellence, Total productive maintenance (TPM)	
	(Total Contact Time: = 45 Hours)	

3.	**Books Recommended**
1	J. Heizer, B. Render, C. Munson and A. Sachan, Operations Management, 12th Edition, Pearson Education, 2017
2	Everett E. Adam, R. J. Ebert, Production and Operations Management: Concepts, Models and Behaviour, 9th Revised Edition, Prentice Hall, 1993
3	E. S. Buffa and R. K. Sarin, Modern Production/ Operations Management, 8th Edition, John Wiley & Sons, 2007
4	S. Eilon, Elements of Production Planning and Control, 3rd Edition, Universal Publishing Corporation, 2022
5	L. J. Krajewski and L. P. Ritzman, Operations Management: Strategy and Analysis, 6th Edition, Pearson Education, 2022

B.Tech. IV (DoME) Semester – 7 AUTOMATION AND PROCESS CONTROL FOR SMART MANUFACTURING (ELECTIVE-IV) ME467	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs):

At the end of the course, students will be able to

CO1	Explain the concepts of automation and IoT for manufacturing process control.
CO2	Apply the knowledge of automation for improvement of existing mechanical engineering systems.
CO3	Distinguish the key elements of the automation systems such as sensors, actuation system, etc.
CO4	Demonstrate programming control strategies and selection controller for manufacturing process control.
CO5	Analyze the key drivers of a smart manufacturing system, internet of things for factory automation.
CO6	Create a pathway for smart factory development.

2.	Syllabus	
	Automation	**(15 Hours)**
	Introduction to automation of different manufacturing processes. Levels of automation, types of automation system. Automation principles and strategies: the USA principle, strategies for automation and process improvement, and automation migration strategy. Manufacturing operations; Production facilities; Automatic control in manufacturing: Introduction to transducing, actuating, signal conditioning, data conversion devices, microprocessor-based controllers and applications, process control and controllers, machine vision, programmable logic controllers-system interfacing, programming, and applications; numerical control of machine tools, control of robotic manipulators, supervisory control and data acquisition (SCADA), inspection for quality control.	
	SENSING AND MOTION CONTROL SYSTEMS	**(10 Hours)**
	Brief overview of measurement systems, classification, characteristics and calibration of different sensors. Sensing of displacement, position, speed, acceleration, strain gauge, force, torque, pressure, flow, level, light, humidity, temperature, pH. Smart sensors. Principles and structures of modern micro sensors. Selection and mechanism of actuating devices: switching devices, solenoid-type devices, actuating cylinders and process control valves, motors and	

	drives, piezoelectric actuators. Basics of motion control, Mechanically and electronically coordinated motion, component of motion control system.	
	SMART MANUFACTURING TECHNOLOGIES-I	**(10 Hours)**
	Introduction to smart manufacturing, key drivers, role of 3D Printing technologies in smart manufacturing, smart materials in manufacturing, 4D Printing, artificial intelligence in manufacturing.	
	SMART MANUFACTURING TECHNOLOGIES-II	**(10 Hours)**
	The concept of Industry 4.0/5.0 and smart factories, components. Introduction to the concept of dark factories, big data analysis, internet of things (IoT) for factory automation.	
	(Total Contact Time: = 45 Hours)	

3.	**Books Recommended**
1	M. P. Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, 4th Edition, Pearson, 2015
2	C D Johnson, Process Control Instrumentation Technology, 8th Edition, Prentice Hall India, 2006
3	Beno Benhabib, Manufacturing: Design, Production, Automation, and Integration, Marcel Dekker, Inc., USA, 2003
4	D. Shetty, A. R. Kolk, Mechatronic System Design, 2nd Edition, PWS Publicity Boston, 2010
5	D. Serpanos, M. Wolf, Internet-of-Things (IoT) Systems: Architectures, Algorithms, Methodologies, Springer International Publishing, 2018

B.Tech. IV (DoME) Semester – 7 THEORY OF ELASTICITY (ELECTIVE-V) ME469	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs):

At the end of the course, students will be able to

CO1	Utilize principles of elasticity theory to estimate stresses and strains in isotropic and non-isotropic materials using a tentorial approach.
CO2	Formulate and solve boundary value problems in solid continua using stress and displacement based solution Strategies.
CO3	Apply Airy stress function in rectangular and polar co-ordinates.
CO4	Solve specific three-dimensional problems like torsion.
CO5	Assume bending of non-circular prismatic bar and membrane analogy.
CO6	Analyse simple plate bending problems.

2.	**Syllabus**	
	Analysis of Stress and Strain: Stress at a point; stress tensor; stress transformations; principal stresses; octahedral stress; geometrical representation of stress at a point; equations of equilibrium. Infinitesimal affine transformation for deformation; strain tensor; principal strains; strain-displacement relations for finite and infinitesimal strains; compatibility conditions. Constitutive Equations: General theory; generalized Hooke's law for anisotropic and isotropic materials.	**(15 Hours)**
	Equations of Elasticity: Common equations of elasticity theory like Mitchel-Beltrami and Navier equations, formulation of the general elasticity problem; boundary conditions.	**(15 Hours)**
	Solution of Some Special Boundary Value Problems: Simplifications; two-dimensional problems in rectangular and polar coordinates; Airy's stress function; a few problems like stress concentration around a circular hole and Boussinesq problem. A few representative three-dimensional problems; torsion and bending of non – circular prismatic bars (Saint- Venant's solution); membrane analogy, Simple Plate bending.	**(15 Hours)**
		(Total Contact Time: = 45 Hours)

3.	Books Recommended
1	L. S. Srinath, Advance Mechanics of Solids, McGraw Hill Education, 3rd Edition, 2009.
2	A. C. Ugural and S. K . Fenster, Advanced Mechanics of Materials and Applied Elasticity, Pearson Education, 5th Edition 2011.
3	H. J. Helena, Theory of Elasticity and Plasticity, PHI Learning Pvt. Ltd., 2017.
4	S. Singh, Theory of Elasticity, Khanna Publishers, 2015.
5	S. Timoshenko, Theory of Elasticity, McGraw Hill Education, 3rd Edition, 2017.

B.Tech. IV (DoME) Semester – 7 ROTOR DYNAMICS(ELECTIVE-V) ME471	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs): At the end of the course, students will be able to	
CO1	Understand the concept of simple rotor systems.
CO2	Conceptualize the rotordynamic design of bearings and seals.
CO3	Formulate the concept of transverse vibrations in rotor systems.
CO4	Evaluate the instability in rotor systems.
CO5	Analyze the transfer matrix method to rotor dynamic systems and understand the vibration measurements.

2.	Syllabus	
	History of Rotor Systems and Recent Trends. **Transverse Vibrations of Simple Rotor Systems:** Single-DOF Undamped Rotor Model, Jeffcott Rotor Model, Jeffcott Rotor Model with an Offset Disc, Effect of Cross-Coupling Stiffness on Critical Speeds, Gyroscopic Moments in Rotating Systems, Synchronous Motion of Rotors. **Transverse Vibrations of Simple Rotor-Bearing-Foundation Systems:** Symmetrical Long Rigid Shaft on Flexible Anisotropic Undamped Bearings, Symmetrical Long Rigid Shaft on Anisotropic Bearings, A Symmetrical Flexible Shaft on Anisotropic Bearings.	**(15 Hours)**
	Rotordynamic Parameters of Bearings and Seals: Hydrodynamic Fluid-Lubricated Journal Bearings, Rolling Element Bearings, Dynamic Seals. **Torsional Vibrations of Rotor Systems by the Direct Analytical and Transfer Matrix Methods:** Torsional Rotor System with a Single Disc, Two-Disc Torsional Rotor System, Three-Disc Torsional Rotor System, Direct Approach and Transfer Matrix Methods.	**(15 Hours)**
	Instability Analysis of Simple Rotor Systems: Self-Excited Vibrations, Phenomenon of the Oil Whirl, Instability Analysis with Bearing Fluid-Film Force Linearity and Nonlinearity, Rotor System with Variable Stiffness Characteristics.	**(15 Hours)**

	Vibration-Based Condition Monitoring in Rotating Machinery: Unbalances in Rotor Systems, Misalignment, Rub, Slackness of Rotor Elements, Rolling Bearing Defects, Faults in Gears.	
		(Total Contact Time: = 45 Hours)

3.	**Books Recommended**
1	J. Vance, F. Zeidan, and B. T. Murphy, Machinery Vibration and Rotor Dynamics, John Wiley & Sons, 2010.
2	M. Goodwin, The Dynamics of Rotor Bearing Systems, Springer-Netherlands, 1989.
3	G. Genta, Dynamics of Rotating Systems, Springer, 2005.
4	M. I. Friswell, J. E. T. Penny, S. D. Garvey and A. W. Lees, Dynamics of Rotating Machines, Cambridge University Press, 2010.
5	J. S. Rao, Rotor Dynamics, 3rd Edition, New Age International, 1996.

B.Tech. IV (DoME) Semester – 7 MACHINE TOOL DESIGN (ELECTIVE-V) ME473	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs): At the end of the course, students will be able to	
CO1	Outline the general requirements of machine tools.
CO2	Design mechanical and hydraulic transmission elements.
CO3	Analyze the kinematics of machine elements
CO4	Explain machine tool control systems.
CO5	Choose the column, table and guide ways of machine tools.
CO6	Develop and develop control systems for machine tools

2.	Syllabus	
	INTRODUCTION	**(05 Hours)**
	General requirements to machine tools, Machine tool design recommendations, Classification of motions to shape surface, Machine tool drives for rectilinear motion, Periodic motion, reversing motion etc.	
	KINEMATICS OF MACHINE TOOLS	**(05 Hours)**
	Kinematics or gearing diagram of Lathe, Drilling Machine, Milling Machine etc. machine tool drive, principles specification of machine tool	
	DESIGN OF KINEMATICS	**(05 Hours)**
	Methods to determine transmission ratios for drives, Mechanical transmission and its elements, hydraulic transmission and its elements	
	SPEED AND FEED BOXES	**(05 Hours)**
	General requirement, Design of gear trains, speed box es types, speed changing devices, feed boxes, characteristics of feed mechanism, types of rapid traverse mechanisms, variable devices	
	SPINDLE DESIGN AND SPINDLE BEARING	**(08 Hours)**

	Main requirement, Materials and details of spindle design, Spindle bearings, bearings, types of bearings and their selections, Bearing Materials.	
	COLUMNS, TABLES AND WAYS	**(08 Hours)**
	Materials, typical constructions and design, basic design procedure of machine tool structure, design of columns, function and types of guide ways, design criteria and calculation of slide ways	
	MACHINE TOOLS CONTROL SYSTEMS	**(09 Hours)**
	Requirement of control system selection and construction of control systems Mechanical control system, predilection control, remote control safety devices	
	(Total Contact Time: = 45 Hours)	

3.	**Books Recommended**
1	N. K. Mehta, Machine Tool Design, 3re Edition, Tata McGraw Hill, 2017
2	S. K. Basu and D. K. Pal, Design of Machine Tools, 5th Edition, Ox ford and IBH, 2005
3	N. Achertan, Machine Tool Design, University Press of the Pacific, 2000
4	F. Koenigsberger, Design Principles of Metal Cutting Machine Tools, Pergamon Press, 2013
5	G. C. Sen and A. Bhattacharyya, Principles of Machine Tools, 2nd Edition, New Central Book Agency,2009

B.Tech. IV (DoME) Semester – 7 RADIATION HEAT TRANSFER (ELECTIVE-V) ME475	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs):

At the end of the course, students will be able to

CO1	Describes the basic laws of radiation heat transfer
CO2	Calculate radiation heat transfer for black and gray body surfaces
CO3	Develop solutions for surface-to-surface radiation heat transfer with and without participating media
CO4	Analyze problems involving gas radiation heat transfer
CO5	Estimate the radiation parameters using inverse method
CO6	Investigate radiation heat transfer in biological tissue and atmosphere

2.	**Syllabus**	
	RADIATION	**(02 hours)**
	Importance of thermal radiation, Nature of Radiation.	
	BLACKBODY AND ITS CHARACTERISTICS	**(05 hours)**
	Key attributes of a black body, Solid angle, Spectral or Monochromatic radiation intensity, Spectral hemispherical emissive power, Relationship between intensity and temperature, Candidate blackbody distribution function, Planck's blackbody radiation distribution function, Wein's displacement law, universal blackbody function, Problems.	
	RADIATIVE PROPERTIES OF NON-BLACK SURFACES	**(05 hours)**
	Why do we need a gray body model, Spectral directional emissivity, Hemispherical spectral emissivity, Directional total emissivity, Hemispherical total emissivity, Kirchoff law, Absorptivity, Spectral directional absorptivity, Directional total absorptivity, Hemispherical total absorptivity, Reflectivity, Transmissivity, Spectral transmissivity, Optical pyrometry, Problems	
	RADIATIVE HEAT TRANSFER BETWEEN SURFACES	**(07 hours)**
	Enclosure theory, View factor, View factor algebra, View factors from direct integration, Enclosure analysis – Gray surface, Enclosure analysis – Non gray surface, Problems	

	RADIATION IN PARTICIPATING MEDIA	**(12 hours)**
	Principal difficulties in studying gas radiation, Important properties for study of gas radiation, Equation of transfer or Radiative transfer equation, Solution to the Radiative transfer equation, Concept of mean beam length, Enclosure analysis in the presence of absorbing/emitting gas, Emissivity and absorptivity of gas mixture, Radiation Combined with Conduction and Convection, Problems.	
	INVERSE PROBLEMS IN RADIATION	**(07 hours)**
	Introduction to inverse problems, Parameter estimation by least squares minimizations, Problems.	
	SPECIAL TOPICS ON RADIATION HEAT TRANSFER	**(07 hours)**
	Atmospheric and solar radiation, Radiation Transfer in Tissue, Numerical modeling of Radiative Transfer equation (RTE)	
	(Total Contact Time: = 45 Hours)	

3.	**Books Recommended**
1	R. Siegel and J.R. Howell, Thermal Radiation Heat Transfer, Taylor & Francis, 2015.
2	M.F. Modest, Radiative Heat Transfer, McGraw Hill, 2013
3	C. Balaji, Essentials of Radiation Heat Transfer. John Wiley & Sons, 2014
4	M.N. Ozisik, Inverse Heat Transfer: Fundamentals and Applications. CRC Press, 2000
5	F.P. Incropera, A.S. Lavine, T.L. Bergman, and D.P. DeWitt, Fundamentals of Heat and Mass Transfer. John Wiley & Sons Inc., 2011

B.Tech. IV (DoME) Semester – 7 ADVANCED REFRIGERATION AND AIR-CONDITIONING SYSTEMS (ELECTIVE-V) ME477	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs):

At the end of the course, students will be able to

CO1	Outline the properties of refrigeration systems.
CO2	Evaluate the performance of compound vapour compression refrigeration systems for various applications
CO3	Describe vapour absorption system for large cooling load application and evaluate its performance
CO4	Explain working principles of non-conventional refrigeration systems and evaluate the performance of steam jet refrigeration system.
CO5	Compute cooling/heating loads for designing air conditioning systems for residential and commercial building
CO6	Design the air duct systems for large commercial buildings

2.	Syllabus	
	VAPOUR COMPRESSION REFRIGERATION SYSTEM	**(06 hours)**
	Refrigerants – properties, applications, selection, mixed refrigerants, retrofit study, standard rating cycle for domestic refrigerator, methods of defrosting. refrigeration system components: compressors, condensers, expansion devices, evaporators, Next generation refrigerants.	
	COMPOUND VAPOUR COMPRESSION REFRIGERATION SYSTEMS	**(08 hours)**
	Multi stage compression with water intercooler, liquid sub cooler, flash chamber, flash intercoolers and multiple expansion valves, multi evaporator systems, cascade refrigeration system	
	VAPOUR ABSORPTION SYSTEMS	**(05 hours)**
	Temperature concentration and enthalpy concentration diagrams, enthalpy balance for various components of aqua ammonia systems, vapour absorption system- Electrolux refrigerator	
	NON - CONVENTIONAL REFRIGERATION SYSTEMS	**(06 hours)**

	Steam jet refrigeration system, Performance analysis of steam jet refrigeration system, thermo electric refrigeration system, vortex tube refrigeration, pulse tube refrigeration, vapour adsorption refrigeration system	
	AIR CONDITIONING	**(12 hours)**
	Review of air conditioning processes, summer and winter load calculations, internal and external heat gains, cooling coils, bypass factor, effective sensible heat factor, design consideration for cooling coils, high latent heat load, design of evaporative cooling system, comfort air conditioning, thermodynamics of human body, comfort charts, room air-conditioning, split air-conditioning, package air-conditioning	
	AIR HANDLING UNIT	**(08 hours)**
	Central air conditioning system, components of Air handling unit, principle of room air distributions, fluid flow and pressure losses, Duct design: Principle of duct design, equivalent diameter of ducts, duct materials, friction chart and its use, methods of duct design	
	(Total Contact Time: = 45 Hours)	

3.	**Books Recommended**
1	W. F. Stoeaker, Refrigeration and Air Conditioning, McGraw Hill, 2004
2	R.J Dossat, Principles of Refrigeration, John Wiley & Sons, 2000
3	C.P. Arora, Refrigeration and Air Conditioning, Tata McGraw Hill, 2008
4	S.C. Arora and S. Domkundwar, A Course in Refrigeration and Air Conditioning, Dhanpat Rai & Sons, 2018
5	P. Manohar, Refrigeration and Air Conditioning, New Age International, 2011

B.Tech. IV (DoME) Semester – 7 GAS DYNAMICS (ELECTIVE-V) ME479	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs):

At the end of the course, students will be able to

CO1	Predict the effect of compressibility and flow behaviour in the field of gas dynamics.
CO2	Describe the various possible 1-D duct mechanisms and develop duct flow equations.
CO3	Solve 1-D design problems based on Isentropic, Fanno and Rayleigh flow
CO4	Evaluate the different possible conditions for flow without chocking in 1-D duct with variable area, friction and heat transfer.
CO5	Estimate the position and effect of shock within the 1-D duct.
CO6	Explore the shock phenomenon and learn to use shock polar diagram for 2-D flows

2.	**Syllabus**	
	INTRODUCTION	**(05 hours)**
	Thermodynamics of compressible flow, Perfect Gas, General effect of compressibility, Wave Motion, Propagation of Infinitesimal waves, Mach number, Pressure disturbances in a Compressible flow, Stagnation condition.	
	1-DIMENSIONAL, STEADY, ISENTROPIC FLOW IN VARIABLE AREA PASSAGES	**(10 hours)**
	Introduction, governing equations, Effect of area change in the fluid properties, Equations for Isentropic flow, Maximum mass flow rate, Flow through nozzle & diffuser, Numerical.	
	FLOW IN CONSTANT AREA DUCT WITH FRICTION	**(06 hours)**
	Introduction, governing equations, Fanno flow equations, Variation of Mach number with duct length, Numerical.	
	FLOW IN CONSTANT AREA DUCT WITH HEAT TRANSFER	**(06 hours)**
	Introduction, governing equations, Slope of Rayleigh line on p-v diagram, Fundamental equation of Rayleigh line, Maximum heat transfer, Numerical	
	NORMAL SHOCK	**(10 hours)**

	Introduction, classification of shock, Physical equations of Normal shock, Rankine Hugoniot Relations, Prandtle equation, Numerical	
	OBLIQUE SHOCK	**(08 hours)**
	Introduction, governing equations, Rankine–Huguenot Relations, Prandtle Equations, θ-β-M relation, Shock polar diagram & Hodograph method for the solution of 2- D flows.	
	(Total Contact Time: = 45 Hours)	

3.	**Books Recommended**
1	S. M. Yahya, Fundamental of Compressible Flow with Aircraft & Rocket Propulsion, New Age International Ltd., 2016
2	E. Rathakrishnan, Gas Dynamics, PHI Learning Pvt. Ltd., 2017
3	A. H. Shapiro, Compressible Fluid Flow, Ronald Press Company, 1953
4	M. J Zucrow and J.D. Hoffman, Gas Dynamics, John Wiley & Sons, 1976
5	R. D. Zucker and Oscar Biblarz, Fundamental of Gas Dynamics, Wiley, 2019

B.Tech. IV (DoME) Semester – 7 FOUNDRY TECHNOLOGY (ELECTIVE-V) ME481	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs):

At the end of the course, students will be able to

CO1	Demonstrate science of liquid metal solidifying metal and related phenomenon.
CO2	Explain about flow and heat transfer of molten metal and correlate the effects of the same on resultant structure-properties of cast metals.
CO3	Describe the design of patterns and mold parts and explain procedures of testing of core and mold materials.
CO4	Solve the size of gating system elements and pouring time for sand castings.
CO5	Calculate the size and determine the shape and location of risers and describe effects of feeding aids for achieving directional solidification.
CO6	Describe and compare procedures of casting various ferrous and non-ferrous metals and alloys.

2.	**Syllabus**	
	SCIENCE OF SOLIDIFYING METAL	**(08 hours)**
	Metal flow analysis - pressure, velocity and losses, turbulence & fluidity of molten metals, gas evolution and venting, heat flow during solidification – thermal gradient & cooling rate, conduction, Chvorinov's rule for solidification time, shrinkage, cooling stresses, distortion, effect on microstructure of metals.	
	TECHNOLOGY OF TOOLINGS	**(10 hours)**
	Design of Tools for metal casting – intermediate tools (pattern), final tools(moulds/die), part orientation and mould parting; testing of mould materials, positioning of undercuts, types of core and core print design, core strength, No-bake cores, core heat transfer and gas transfer, pattern allowances, multi-cavity mould layout. Pattern & mould material for investment casting and shell moulding processes.	
	DESIGN OF RISERS	**(10 hours)**
	Types of risers – top and side risers, Open and blind risers; requirements, location, capacity & efficiency, Design of risers – riser size, riser shape, modulus method, Caine's curve method, shape factor method, Neck size; Directional solidification, Feeding aids – external and internal	

	chills, insulating/exothermic sleeves and covers, paddings, fin, effective feeding distance of chills, concept of Modulus extension factor (MEF) for feeder sleeves.	
	DESIGN OF GATING SYSTEM	**(10 hours)**
	Elements of gating system, Calculation of ideal filling time, filling rate of ferrous and non-ferrous metals, size & position of choke, gating ratio, pressurized and non-pressurized gating system, design of down sprue, sprue well, runner, gate, selection of gates, gate-casting junction, filtration of molten metal, evaluation of gating design.	
	CASTING OF FERROUS AND NON-FERROUS ALLOYS	**(07 hours)**
	Moulding, melting, pouring, solidification, major issues in casting of Grey Iron, S. G. Iron, Steels and alloy steels, Aluminium alloys, Cu alloys.	
	(Total Contact Time: = 45 Hours)	

3.	**Books Recommended**
1	B. Ravi, Metal Casting: Computer Aided Design and Analysis, PHI Learning Pvt. Ltd., 2005
2	R.W. Heine, C. R. Loper and P.C. Rosenthal, Principles of Metal Casting, Tata McGraw-Hill, 2017
3	P. L. Jain, Principles of Foundry Technology, TMH Publications, 2014
4	P. Beeley, Foundry Technology, Elsevier (reprint by: Butterworth-Heinemann), 2001
5	A. K. Chakrabarti, Casting Technology and Cast Alloys, PHI Ltd., 2005.

B.Tech. IV (DoME) Semester – 7 MANUFACTURING OF COMPOSITES (ELECTIVE-V) ME483	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs): At the end of the course, students will be able to	
CO1	Classify composite materials and demonstrate fundamentals of composite materials.
CO2	Analyze, evaluate, and select a manufacturing process appropriate for a given part within various constraints.
CO3	Demonstrate basics and progressive techniques of composites manufacturing.
CO4	Compare thermoset and thermoplastic based composites manufacturing processes.
CO5	Explain the various issues associated with cost and producibility.
CO6	Describe including design for manufacturing and maintenance the characterizing, dispositioning, and rework/repair of defects.

2.	**Syllabus**	
	Introduction	**(10 hours)**
	Introduction to Composites; Function of the Matrix and Reinforcement in Composites; Polymer Matrix and Nano Composites; Matrices: Thermosets and Thermoplastic; Fiber Reinforcement. Properties and testing composites; Properties of Composites; Composites testing; Composites design: Laminate theory, Rule of mixtures, symmetry and balance.	
	Thermoset composites manufacturing	**(09 hours)**
	Thermoset composites manufacturing processes; Material selection process control; Design for manufacturing. Thermoset composite manufacturing: Lay-up processes, Spray up process; Fiber placement process; Resin transfer moulding. Fiber manufacturing processes.	
	Thermoplastic composite manufacturing	**(10 hours)**
	Thermoplastic composite manufacturing processes; Thermoplastic composite manufacturing: Vacuum assisted resin transfer moulding; Compression moulding process; Filament winding; Sheet moulding; Injection moulding; Sheet moulding; Calendaring; Extrusion; Blow moulding; Rotational moulding; Thermoforming.	
	Metal matrix composites manufacturing	**(08 hours)**

	Metal and ceramic matrix composites; Metal matrix and reinforcement; Manufacturing processes for metal matrix composites: dispersion hardened and particle composite; layer composites and infiltration method.	
	Ceramic matrix composites manufacturing	**(08 hours)**
	Prevention of Damage, repair of Composites and selection of processes; Ceramic matrix composites manufacturing: Hot isostatic processing; Non-destructive testing of composites; Manufacturing process selection: Cost, performance, size shape, rate of production. Steps for process selection. Dispositioning.	
	(Total Contact Time: = 45 Hours)	

3.	**Books Recommended**
1	K. K. Chawla, Composite Materials - Science and Engineering, Springer, 2001
2	P. K. Mallick, Fiber Reinforced Composites: Materials, Manufacturing and Design 3rd Edition, Maneel Dekker Inc, 2019.
3	B.T. Astrom, Manufacturing of Polymer Composites, Chapman and Hall, 2018
4	A.C. Loos, Manufacturing of Polymer Composites, Vol. 6, American Society for Composites, 2013.
5	F.C. Campbell, Manufacturing Processes for Advanced Composites, Elsevier, 2004.

B.Tech. IV (DoME) Semester – 7 COMPUTER INTEGRATED MANUFACTURING (ELECTIVE-V) ME485	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs):

At the end of the course, students will be able to

CO1	Describe different types of Automation and CIM.
CO2	Develop the CNC Program for the given geometry for Drilling, Milling and Turning machines.
CO3	Create the part program using APT.
CO4	Analyze the production flow based on part classification, identification and coding.
CO5	Evaluate the different types of flexibilities in manufacturing.
CO6	Explain and evaluate types and steps of computer aided process planning.

2.	Syllabus	
	INTRODUCTION TO CIM	**(04 hours)**
	Introduction to automation, Types of automation, Automation principles and strategies, Definition of CIM, CIM wheel, Evolution of CIM, Benefits of CIM, CIM hardware and software, Nature and role of the elements of CIM system, Development of CIM.	
	COMPUTER AIDED MANUFACTURING	**(18 hours)**
	Components of NC/CNC system, Specification of CNC system, Classification of CNC machines, Constructional details of CNC machines, Axis designation, CNC control loops. Basic programming terms, Programming formats, Preparatory command, Miscellaneous functions, Machine zero, work zero and tool zero, Work offsets, Tool length offset and setup methods, Cutter radius offset, Machine zero return, Part programming for milling - linear and circular interpolation, subprogram, fixed/canned cycles, mirrors commands, machining large hole pattern, polar coordinates, round and rectangular pocket machining and cycles, subroutines, mirror, Part programming for lathe - lathe cycles, with and without tool nose radius feature, repetitive fixed cycle.	
	PART PROGRAMMING WITH AUTOMATICALLY PROGRAMMED TOOLS (APT)	**(05 hours)**
	Computer aided part programming, APT: Geometry, motions and auxiliary commands, drill cycle commands, programming for geometry and drill cycle and hole pattern	

	GROUP TECHNOLOGY	**(08 hours)**
	Definition, implementation considerations, benefits and applications, G.T. methods - visual search method, production flow analysis, Parts classification and coding, Design and manufacturing attributes, Concept of composite component, Rank order clustering, machine cell formation, Cell group tooling, Design rationalization, possibilities of integration with CAD/CAM.	
	FLEXIBLE MANUFACTURING SYSTEM	**(07 hours)**
	Introduction, General Considerations for FMS, types of FMS, Flexibilities, their measurements, Computer control in FMS, Automated material handling systems, AGVs, Automatic storage and retrieval systems, Manufacturing cells, cellular v/s flexible manufacturing.	
	COMPUTER AIDED PROCESS PLANNING	**(03 hours)**
	Introduction to CAPP, Route card, Manual and computer aided process planning, steps, and types.	
		(Total Contact Time: = 45 Hours)

3.	**Books Recommended**
1	Krar, S.F. and Gill, A., CNC: Technology and Programming, McGraw-Hill, 1990
2	Groover, M.P., Automation, production systems, and computer-integrated manufacturing. Pearson Education India, 5th Edition, 2019
3	P. Radhakrishnan, S. Subramanyan, and V. Raju, CAD/CAM/CIM, New Age International Publishers, 3rd edition, 2011
4	P. N. Rao, CAD/CAM Principles and Applications, Tata McGraw Hill, 2nd Edition, 2006
5	S. Kant Vajpayee, Principles of Computer Integrated Manufacturing, PHI, New Delhi, 1st Edition, 1998

B.Tech. IV (DoME) Semester – 7 DESIGN OF PRESSURE VESSELS (ELECTIVE-VI) ME487	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs): At the end of the course, students will be able to	
CO1	Describe the factors influencing the design of pressure vessels.
CO2	Calculate the different stresses and strains in a pressure vessel.
CO3	Design the head and shell for the pressure vessel
CO4	Estimate the stresses in the nozzle and its reinforcement
CO5	Analyze the critical part of pressure vessels.
CO6	Evaluate the buckling pressure and type of failure

2.	Syllabus	
	INTRODUCTION	**(04 Hours)**
	Factors influencing the design of vessels, Classification of pressure vessels, Material selection, Loads, and types of failures	
	STRESSES IN PRESSURE VESSELS	**(13 Hours)**
	Stresses in circular ring, Cylinder and sphere, Membrane stresses in vessels under internal pressure, Thick cylinders, Shrink-fit stresses, Autofrettage of thick cylinders, Thermal stresses	
	DESIGN OF HEADS	**(05 Hours)**
	Introduction, Design for hemispherical head, Ellipsoidal head, torispherical head, Conical head, Flat heads and covers	
	DESIGN OF NOZZLES AND OPENINGS	**(05 Hours)**
	Introduction, Stress concentration about a circular hole, Cylindrical and spherical shell with circular hole under internal pressure, Reinforcement of openings, Nozzles in pressure vessels	
	DISCONTINUITY STRESSES IN PRESSURE VESSEL	**(11 Hours)**
	Introduction, Beam on elastic foundation, infinitely long beam, Semi-Infinite beam, Cylindrical vessel under axially symmetrical loading, Extent and significance of load deformations on pressure vessels, Stresses built in a bimetallic joint, Deformation and stresses in flanges	

	BUCKLING OF VESSELS	**(07 Hours)**
	Buckling phenomenon, Elastic Buckling of circular ring and cylinders under external pressure, Collapse of thick-walled cylinders or tubes under external pressure, Effect of supports on Elastic buckling of cylinders, Buckling under combined External pressure and axial loading	
		(Total Contact Time: = 45 Hours)

3.	**Books Recommended**
1	Subhash Reddy Gaddam, Design of Pressure Vessels, CRC Press; 1st edition (17 December 2020)
2	J.F. Harvey, Theory and Design of Pressure Vessels, 1st edition, CBS, India 2001
3	Henry M. Bednar, Pressure Vessel Design Handbook, Van Nostrand Reinhold Company, USA, 1 August 1981
4	Moss Demis R., Pressure Vessel Design Manual, Gulf Publishing Co., Houston, 1987
5	J Spence, A S Tooth, Pressure Vessel Design: Concepts and principles, CRC Press, 10 Sept 2012

B.Tech. IV (DoME) Semester – 7 THEORY OF PLATES AND SHELLS (ELECTIVE-VI) ME489	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs):

At the end of the course, students will be able to

CO1	Understand the simple bending of plates and different boundary conditions for plates.
CO2	Apply Navier's method and Leavy's method of solution for rectangular plates.
CO3	Analyze circular plates subjected to different kinds of loads.
CO4	Calculate Eigen value for vibration analysis of rectangular plates.
CO5	Utilize approximate methods to solve the rectangular plate problems.
CO6	Design various types of circular cylindrical shells.

2.	**Syllabus**	
	Classical Plate Theory: Classical Plate Theory – Assumptions – Differential Equation – Boundary Conditions	**(08 Hours)**
	Plates of Various Shades: Navier's Method of Solution for Simply Supported Rectangular Plates – Leavy's Method of Solution for Rectangular Plates under Different Boundary Conditions. Governing Equation – Solution for Axi-symmetric loading – Annular Plates – Plates of other shapes	**(10 Hours)**
	Eigen Value Analysis: Free Vibration Analysis of Rectangular Plates.	**(08 Hours)**
	Approximate Methods: Rayleigh – Ritz, Galerkin Methods– Finite Difference Method – Application to Rectangular Plates for Static, Free Vibration and Stability Analysis	**(12 Hours)**
	Shells: Basic Concepts of Shell Type of Structures – Membrane and Bending Theories for Circular Cylindrical Shells.	**(07 Hours)**
		(Total Contact Time: = 45 Hours)

3.	Books Recommended
1	A. C. Ugural, Plates and Shells Theory and Analysis, CRC Press, 4th Edition, 2017.
2	R Szilard, Theories and Applications of Plate Analysis Classical, Numerical and Engineering Methods, Wiley, 2004.
3	J. N. Reddy, Theory and Analysis of Elastic Plates and Shells, CRC Press, 2007.
4	K. Chandrashekhara, Theory of Plates, University Press, Hyderabad, 2001.
5	S. S. Bhavikatti, Theory of Plates and Shells, New Age International, 2015.

B.Tech. IV (DoME) Semester – 7 CONTINUUM MECHANICS (ELECTIVE-VI) ME491	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs): At the end of the course, students will be able to	
CO1	Utilize basic tensorial calculus required for understanding the continuum behaviour of matters.
CO2	Illustrate the kinematics of continuum body deformation.
CO3	Analyse the configuration dependent stress and strain measures.
CO4	Apply the knowledge about the fundamental balance principles of continuum objects.
CO5	Formulate a good foundation in constitutive modelling of solids.
CO6	Compare yield criteria and rheological models.

2.	Syllabus	
	Tensor Algebra: Scalar, Vector, second and higher order Tensors, Eigen values & vectors, Transformation of Tensors, Tensor valued functions, gradient operators and Integral theorems. **Kinematics:** References and deformations configurations, Mapping and deformation gradients, material and spatial representations, Nanson's formula, Strain measures, Rotation & stretch tensors, rate of deformation.	**(15 Hours)**
	Kinetics: Concept of stress, Cauchy's stress theorem, first and second Piola-Kirchoff's & Cauchy's stress tensors, Normal and shear stress, Extremal stress values, stress states. **Balance Principles:** Mass conservation, Reynold's transport theorem, Momentum and energy balances in references and current configuration, Weak and strong forms of balance equation, Continuum thermodynamics, Clausius-Duhem inequality, Frame dependent and independent quantities, Objective rates.	**(20 Hours)**
	Constitutive Modelling: Fluid and solid constitutive equations, generalized Hooke's law, material symmetry, visco elasticity, metal plasticity: Yield criteria, Flow rule, Hardening rule, loading & unloading conditions, multiplicative strain decomposition, rheological models.	**(10 Hours)**
		(Total Contact Time: = 45 Hours)

3.	Books Recommended
1	C. S. Jog, Continuum Mechanics: Volume 1: Foundations and Applications of Mechanics, Cambridge University Press, 2015.
2	J. W. Rudnicki, Fundamentals of Continuum Mechanics, Wiley, 2015.
3	W. M. Lai, D. Rubin and E. Krempl, Introduction to Continuum Mechanics, Butterworth-Heinemann, 4th Edition, 2015.
4	J. H. Heinbockel, Introduction to Tensor Calculus and Continuum Mechanics, Trafford Publishing, 2001.
5	A. F. Bower, Applied Mechanics of Solids, CRC Press, 2010.

B.Tech. IV (DoME) Semester – 7 TWO PHASE FLOW (ELECTIVE-VI) ME493	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs):

At the end of the course, students will be able to

CO1	Identify two-phase flow with and without phase change.
CO2	Demonstrate the flow regimes of gas-liquid and gas-solid two-phase flow.
CO3	Predict void fraction and pressure drop for gas-liquid two-phase flow.
CO4	Estimate void fraction and pressure drop for gas-solid two-phase flow.
CO5	Solve commonly encountered two-phase flow with phase change.
CO6	Assess modern two-phase flow measurement techniques and instruments.

2.	**Syllabus**	
	INTRODUCTION	**(06 hours)**
	Introduction, horizontal two-phase flow, lockhart and Martinelli procedure, flow factor method, vertical two-phase flow, two-phase flow through inclined pipes.	
	FLOW REGIMES	**(06 hours)**
	Flow regimes in vertical horizontal and inclined pipes, gas-liquid flow in pipes, flow regimes in vertical, horizontal and inclined pipes, flow regimes in gas-solid two-phase flow, pressure drop and void fraction modelling for specific flow regimes.	
	GAS-LIQUID FLUIDIZATION	**(08 hours)**
	Simultaneous flow of liquids and gases, Gas-liquid particle process, gas liquid particle operation, flow of gas-bubble formation, bubble growth gas holdup, gas mixing liquid holdup, liquid mixing, flow of liquid mixing, gas liquid mass transfer. Circulation in boiler-natural and forced, effective pressure head in boiler tubes, variation of major parameters of drum during transient conditions, hydrodynamics stability of vapor-liquid system.	
	GAS-SOLID FLUIDIZATION	**(06 hours)**
	Introduction, dynamics of particles submerged in fluids, flow through packed bed, fluidization, calculation of pressure drop in fixed bed, determination of minimum fluidization velocity,	

	expanded bed, dilute phase, moving solid fluidization, elutriation in fluidized bed, semi-fluidization, pulsating columns, oscillating fluidized bed, Pneumatic transport and hydro-transport of solids in pipes.	
	TWO PHASE FLOW WITH CHANGE OF PHASE	**(8 hours)**
	Film wise condensation of pure vapors, drop wise condensation in plated surfaces, condensation in presence of non-condensable gas-pool boiling, boiling in forced flow inside tubing.	
	MEASUREMENT TECHNIQUES IN TWO-PHASE FLOW	**(05 hours)**
	Pressure drop measurements during two phase flow through a pipe, void fraction measurement, detection of flow pattern.	
	SPECIAL TOPICS ON TWO-PHASE FLOW	**(06 hours)**
	Case study on applications, Numerical modeling on Euler-Euler, and Euler-Langrange approach using software.	
	(Total Contact Time: = 45 Hours)	

3.	**Books Recommended**
1	S. K. Das, D. Chatterjee, Vapor Liquid Two Phase Flow and Phase Change, Springer, 2023
2	P B Whalley, Boiling, Condensation and Gas-Liquid Flow. Oxford University Press, 1987
3	A. J. Ghajar, Single- and Two-Phase Flow Pressure Drop and Heat Transfer, Springer, 2022
4	M. Ishii and T. Hibiki, Thermo-Fluid Dynamics of Two-Phase Flow, Springer, 2006
5	C. Kleinstreuer, Two-Phase Flow: Theory and Applications, Taylor & Francis, 2003

B.Tech. IV (DoME) Semester – 7 CRYOGENICS ENGINEERING (ELECTIVE-VI) ME495	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs): At the end of the course, students will be able to	
CO1	Choose suitable cryogen and material for development of cryogenic system for different applications
CO2	Design and analyse gas liquefaction system and cryogenic refrigeration systems including cryocoolers
CO3	Decide proper cryogenic insulating material and designing of cryogenic insulation.
CO4	Analyse and design gas separation systems using cryogenics.
CO5	Apply the concepts of cryogenic material and design vacuum systems for cryogenic application.
CO6	Select and design storage, handling, and transfer systems for cryogens.

2.	Syllabus	
	CRYOGENS, PROPERTIES OF CRYOGENS AND CRYOGENIC MATERIALS	**(04 hours)**
	Introduction to cryogenics, chronology of cryogenics, cryogens and their properties, fountain effect, Rollin effect, second sound effect, ortho and Para hydrogen, properties of cryogenics materials.	
	LOW TEMPERATURE PRODUCTION	**(04 hours)**
	Low temperature production methods: Joule-Thomson effect, inversion temperature, J-T expansion for ideal and real gases, isentropic expansion	
	GAS LIQUEFACTION SYSTEMS	**(08 hours)**
	Gas liquefaction system: thermodynamically ideal gas liquefaction system, Linde-Hampson system, figure of merit, Precooled Linde Hampson system, dual pressure Linde Hampson system, Claude system, Collins system, liquid yield and work of liquefaction, Heylandt system, Kapitza system, Cascade system	
	CRYOCOOLERS AND ANALYSIS OF CRYOCOOLERS	**(08 hours)**

	Cryocoolers: types of cryocoolers, open cycle, closed cycle cryocoolers, regenerative type and recuperative type cryocoolers, Stirling cryocooler, Gifford Mc Mohan cryocooler, Pulse tube cryocooler, Schmidt's analysis, phasor analysis	
	GAS SEPARATION AND RECTIFICATION	**(08 hours)**
	Gas separation systems: types of gas separation systems, ideal gas separation system, ideal gas separation work, figure of merit, distribution coefficient, phase equilibrium curve, enthalpy composition diagram, rectification column	
	CRYOGENICS INSULATION	**(06 hours)**
	Insulation at cryogenic temperature: mode of heat transfer effecting heat in leak and boil off, mass insulation, reflective insulation, vacuum insulation, combination of mass, reflective and vacuum insulation, multi-layer insulation	
	INSTRUMENTATION, STORAGES AND VACUUM SYSTEM IN CRYOGENICS	**(07 hours)**
	Vacuum Technology for cryogenic applications, Cryogenics instrumentation: temperature sensors, pressure sensors, flow sensors, stain gauges, heat exchanges, Storage for cryogenics fluid: Dewar vessel, piping, storage and handling	
	(Total Contact Time: = 45 Hours)	

3.	**Books Recommended**
1	Randall F. Barron, Cryogenics Systems, Oxford University Press,1985
2	Haselden, C., Cryogenics Fundamentals, Academic Press, 2001
3	Timmerhaus F., Cryogenics Process Engineering, Plenum Press,1996
4	Pipko A., Fundamentals of Vacuum Engineering, Mir Publication, 1984
5	Mikulin, Y., Theory and Design of Cryogenics System, Oxford Press, 2002

B.Tech. IV (DoME) Semester – 7 DESIGN OF SOLAR THERMAL SYSTEMS (ELECTIVE-VI) ME497	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs): At the end of the course, students will be able to	
CO1	Calculate inclination angle of solar collectors
CO2	Design solar water and air heater
CO3	Develop solar concentrator for specific application
CO4	Build solar powered desiccant air conditioning system
CO5	Plan solar powered atmospheric water harvesting system
CO6	Design solar thermal desalination system

2.	Syllabus	
	FUNDAMENTALS OF SOLAR ENERGY	**(04 hours)**
	Energy demand and potential of solar energy, Reckoning of time, Solar angles, Solar radiation and resource	
	SOLAR COLLECTOR	**(16 hours)**
	Flat Plate Collector: Basic elements, Performance analysis, Absorptivity, Heat transfer coefficients and correlations, Collector efficiency and heat removal factors, Effect of various parameters, Case study: application of flat plate collector for air heating and water heating. Evacuated tube Collector: Principle of working, advantages of evacuated tube collector over flat plate collector, Types of evacuated tubes, Thermal analysis, Case study: application of evacuated tube collector for air heating and water heating. Parabolic trough collector: Principle of working, optical and thermal analysis of parabolic trough collector, End effect and blocking in a parabolic trough collector, Case study: application of parabolic trough collector for process heat. Parabolic dish collector and Scheffler reflector: Principle of working, construction, tracking mechanism, application of parabolic dish collector and Scheffler reflector.	
	SOLAR REFRIGERATION AND AIR CONDITIONING	**(10 hours)**

	Scope of solar cooling, Photovoltaic refrigeration, Adsorption/ absorption refrigeration using solar heat, solid and liquid desiccant, construction of desiccant bed, desiccant wheel and desiccant coated heat exchanger. Heat and mass balance of desiccant wheel, Construction and principle of working of solar powered desiccant air conditioning system, selection of solar collector, Energy, exergy and economic analysis. Concept of heat storage.	
	ATMOSPHERIC WATER HARVESTING USING SOLAR HEAT	**(08 hours)**
	Need of atmospheric water harvesting system, selection of desiccant material and solar collector, Construction and principle of working of solar powered atmospheric water harvesting system, effect of design and operating parameters on daily yield, Energy, exergy and economic analysis.	
	SOLAR THERMAL DESALINATION	**(07 hours)**
	Need of desalination system, types of desalination techniques, solar thermal desalination, solar still, improvements in solar still, limitations of solar still, Humidification-dehumidification desalination using solar heat, selection of solar collector, heat and mass balance of humidifier, packing materials of humidifier effect of design and operating parameters on daily yield, Energy, exergy and economic analysis.	
	(Total Contact Time: = 45 Hours)	

3.	**Books Recommended**
1	Kalogirou S. A., Solar Energy Engineering: Processes and Systems, Academic Press, 3rd Edition, 2023
2	Garg H.P., Prakash J., Solar Energy: Fundamentals and Applications, Tata McGraw-Hill, 1st Revised Edition, 2016
3	Goswami D. Y., Principles of Solar Engineering, CRC Press, 4th Edition, 2022
4	Duffie J. A., Beckman W.A., Solar Engineering of Thermal Processes, John Wiley and Sons, 4th edition, 2013
5	Sukhatme S., Nayak J: Solar Energy: Principles of Thermal Collection and Storage, Tata McGraw Hill, 3rd edition, 2008

B.Tech. IV (DoME) Semester – 7 SURFACE ENGINEERING & HEAT TREATMENT (ELECTIVE-VI) ME499	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs):

At the end of the course, students will be able to

CO1	Describe the importance of surface engineering and heat treatment.
CO2	Summarize concepts of various surface coating techniques.
CO3	Determine phase transformation mechanism during heat treatment.
CO4	Analyze various phases achieved through heat treatment and its significance
CO5	Distinguish heat treatment processes adopted for various ferrous and non-ferrous metals.
CO6	Express significance of various furnaces used for heat treatment.

2.	**Syllabus**	
	INTRODUCTION TO SURFACE ENGINEERING	**(05 hours)**
	Introduction to surface modification, need for surface modification, surface dependent engineering properties, importance of substrate and their pretreatment. Significance of surface engineered materials in modern engineering application. Industrial case studies describing surface failures.	
	SURFACE ENGINEERING PROCESSES	**(10 hours)**
	Classification of surface engineering processes. Various chemical/thermochemical treatment processes, electro-deposition and electro-less deposition techniques, various vapour deposition techniques, various surfacing techniques. Evaluation of coatings, importance of process parameters, criteria for selection of surface engineering techniques, case studies based on coatings and surface modification of important engineering component.	
	PHASE TRANSFORMATION DURING HEAT TREATMENT	**(07 hours)**
	Principle of heat treatment, variables of heat treatment, effect of heat treatment on various properties of materials. Recapitulation of phase diagram and TTT diagram. Phase transformation mechanism in steel during heat treatment, decomposition of austenite, transformation products of austenite: pearlite, bainite, martensite, etc., significance of retained austenite. Effect of heat treatment cycle on microstructure.	

	HEAT TREATMENT OF FERROUS ALLOYS	**(10 hours)**
	Study of microstructural changes at various temperatures during slow cooling of steel. Influence of alloying elements on phase stability. Heat treatments for carbon steels, alloy steels, structural and tool steels, cast irons, etc. Hardenability of steels, effect of quenching media, PWHT. Surface treatment processes.	
	HEAT TREATMENT OF NON-FERROUS ALLOYS	**(7 hours)**
	Principle of heat treatment for non-ferrous alloys. Heat treatment of aluminium alloys, magnesium alloys, copper and its alloys, nickel alloys and titanium alloys.	
	FURNACES AND OTHER ISSUES DURING HEAT TREATMENT	**(06 hours)**
	Classification of heat treatment furnaces, controlled atmospheres for furnace. Industrial heat treatment practices. Distortion in heat treated components, possible defects, causes and remedies. Air pollution during heat treatment, environmental and safety regulations. Energy economy of heat treatment.	
	(Total Contact Time: = 45 Hours)	

3.	**Books Recommended**
1	T. Burakowski and T. Wierzchon, Surface Engineering of Metals: Principles, Equipment, Technologies, 1st Edition, CRC press, 1999.
2	M. Ohring, Material Science of Thin Films, 2nd Edition, Academic press, 2002
3	J. Takadoum, Materials and Surface Engineering in Tribology, 1st Edition, John Wiley & Sons, 2008
4	T. V. Rajan, C. P. Sharma and A. Sharma, Heat Treatment: Principles and Techniques, 2nd Edition, PHI Learning Pvt. Ltd., 2011
5	R. C. Sharma, Principles of Heat Treatment of Steels, 1st Edition (Reprint), New Age International, 2018

B.Tech. IV (DoME) Semester – 7 HYBRID MACHINING PROCESSES (ELECTIVE-VI) ME501	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs):

At the end of the course, students will be able to

CO1	Select machining process (es), tool (s) and machine tool (s) to produce a given part.
CO2	Illustrate effect of machining parameters on process performances.
CO3	Explain working principle and machine setup of hybrid machining processes.
CO4	Analyze mechanism of material removal for hybrid machining processes.
CO5	Identify the need and capabilities of hybrid machining processes.
CO6	Demonstrate the hybrid micromachining and technologies

2.	Syllabus	
	INTRODUCTION TO HYBRID MACHINING PROCESSES	**(04 hours)**
	Introduction to hybrid machining processes, needs, evolution, importance, challenges, classification, current scenario and scope in modern industries.	
	COMBINED HYBRID MACHINING PROCESSES- I	**(12 hours)**
	Elements of process, needs, principles, material removal mechanism, effect of process parameters, equipment, variants, processes capabilities, limitations and applications of Electro-chemical energy-based hybrid machining processes: Electrolytic magnetic abrasive machining, Electrochemical grinding, Electrochemical honing, Electrochemical buffing, Electrochemical superfinishing.	
	COMBINED HYBRID MACHINING PROCESSES- II	**(10 hours)**
	Elements of process, needs, principles, material removal mechanism, effect of process parameters, equipment, variants, processes capabilities, limitations and applications of Thermal energy-based hybrid machining processes: Electrical discharge diamond grinding, Electrochemical discharge machining, Electrochemical discharge grinding.	
	ASSISTED HYBRID MACHINING PROCESSES- I	**(12 hours)**

	Elements of process, needs, principles, material removal mechanism, effect of process parameters, equipment, variants, processes capabilities, limitations and applications of Vibration assisted HMPs: Ultrasonic assisted- electrical discharge machining; Ultrasonic assisted- electrochemical machining, Heat assisted HMPs: Laser assisted- electrical discharge machining, Laser assisted- electrochemical machining; Laser assisted- conventional and non-conventional machining; Spark assisted chemical engraving; Abrasive assisted HMPs: Abrasive assisted- electrical discharge machining, Abrasive assisted- electrochemical machining.	
	ASSISTED HYBRID MACHINING PROCESSES- II	**(07 hours)**
	Elements of process, needs, principles, material removal mechanism, effect of process parameters, equipment, variants, processes capabilities, limitations and applications of Magnetic field assisted HMPs: Magnetic field assisted- electrical discharge machining, Magnetic field assisted-flow finishing; Electrorheological fluid assisted- ultrasonic machining, Introduction to hybrid micromachining and technologies.	
	(Total Contact Time: = 45 Hours)	

3.	**Books Recommended**
1	V. K. Jain, Advanced machining processes; Allied publishers, 2009
2	V. K. Jain (ed.), Nanofinishing Science and Technology: Basic and Advanced Finishing and Polishing Processes; CRC Press, Taylor & Francis Group, Boca Raton, USA, 381-406, 2017
3	M.M. Sundaram, Hybrid Machining Process. In: Nee, A. (eds) Handbook of Manufacturing Engineering and Technology. Springer, London, 2014
4	Xichun Luo and Yi Qin, Hybrid Machining: Theory, Methods, and Case Studies, Elsevier Ltd., 2018
5	Rupinder Singh and J. Paulo Davim, Non-Conventional Hybrid Machining Processes: Theory and Practice, CRC Press, 2024

B.Tech. IV (DoME) Semester – 7 PROJECT MANAGEMENT (ELECTIVE-VI) ME503	Scheme	L	T	P	Credit
		3	0	0	03

1. Course Outcomes (COs): At the end of the course, students will be able to	
CO1	Explain the introductory concepts related feasibility assessments and define the role, skills and functions of a project manager.
CO2	Design various mathematical/analytical models for project monitoring & control and the network for project execution.
CO3	Solve and analyses various problems related to financial models towards budgeting and project feasibility & risk assessment.
CO4	Define and cite the key concepts related to financial management of real projects.
CO5	Analyze or models incorporating financial ratio analysis towards the assessment of firms' overall financial Status.
CO6	Develop the ability to solve for financial modelling problems adapting to real project execution practices using mathematical/analytical approaches.

2.	Syllabus	
	PROJECT MANAGEMENT AND FEASIBILITY	**(09 hours)**
	Introduction to projects. Characteristics and types of projects, Gaining importance, Project selection, technical feasibility and technology selection, project life cycle, market feasibility, Social Cost Benefit Analysis, project manager's skills and functions, learning curves.	
	PROJECT MONITORING AND CONTROL	**(09 hours)**
	Network analysis, construction of networks, CPM, various types of floats and their application, PERT and its applications. Time cost relationship, crashing for optimum cost and optimum time. Resource leveling. Earned Value Analysis.	
	FEASIBILITY AND RISK ANALYSIS	**(09 hours)**
	Time value of money, DCF and Non DCF Methods for Evaluating Projects. Types of risk, techniques of risk evaluation and its mitigation. Sensitivity analysis, Hiller's model, scenario analysis, simulation with numerical aspects.	
	FINANCIAL MANAGEMENT AND ANALYSIS	**(09 hours)**

	Concept, Nature, Scope, and Objective of Financial Management, Finance Functions, Sources of Finance. Liquidity, Activity, Profitability and Leverage Ratios. Interpretation of ratios.	
	CAPITAL STRUCTURING AND WORKING CAPITAL MANAGEMENT	**(09 hours)**
	Cost of Capital, Cost of Debt, Preference shares, Equity Shares, Weighted Average Cost of Capital. Working Capital: Concept, Need and Determinants. Computing working capital.	
	(Total Contact Time: = 45 Hours)	

3.	**Books Recommended**
1	Prasanna Chandra, Projects, planning, analysis, selection, financing, implementation and review, Tata McGraw Hill, New Delhi, 2002
2	I.M. Pandey, Financial Management, Vikas Publication House, New Delhi, 2015
3	M.Y. Khan, P.K. Jain, Financial Management, Tata McGraw Hill, New Delhi, 2018
4	C.F. Gray, E.W. Larson and G.V. Desai, Project Management: The Managerial Process, 7th Edition, New York: McGraw-Hill/Irwin, 2017
5	K. Schwalbe, Introduction to Project Management, Boston: Course Technology, 2nd Edition, Cengage Learning, 2009

B.Tech. IV (DoME) Semester – 7 ADVANCED VIBRATION (HONORS) MEHD4	Scheme	L	T	P	Credit
		3	1	0	04

1. Course Outcomes (COs): At the end of the course, students will be able to	
CO1	Explain different vibration systems.
CO2	Analyse single and multi-degree freedom systems.
CO3	Solve the problems related to isolation and stability criteria.
CO4	Analyze the vibration and fault detection in rotating components.
CO5	Illustrate different vibration systems.
CO6	Analyse single and multi-degree freedom systems.

2.	Syllabus	
	INTRODUCTION	**(07 Hours)**
	Free and forced vibrations with and without damping, transient vibrations, Laplace transform formulation	
	ISOLATION AND STABILITY CRITERION	**(08Hours)**
	Vibration isolation and transmissibility, undamped vibration absorbers, self-exited vibrations, criterion of stability, effect of friction on stability	
	NONLINEAR VIBRATION	**(10 Hours)**
	Free vibration with nonlinear spring force or nonlinear damping, phase plane, energy curves, Lienard's graphical construction, methods of isoclines, random vibration, power spectral density, bandwidth in vibration, numerical methods for vibration analysis, vibration of continuous systems, Euler equation for beams, effect of rotary inertia and shear deformation	
	VIBRATION ANALYSIS OF ROTORS	**(10 Hours)**
	Transverse vibrations single, two and three rotor systems, critical speeds of shafts, torsional vibrations of rotors: one, two and three disc rotor system, frequency of torsional vibration systems, coupling of torsional and bending vibrations due to pre-twist and eccentricity, rotor faults, forward and backward rotor whirl model, variable elasticity effects in rotating systems,	

	flow induced vibration in rotating systems, Newkirk effect, stresses in rotating disc and blade, disc of uniform strength, thermal stresses	
	DIAGNOSTIC TECHNIQUES	**(10 Hours)**
	Introduction to diagnostic maintenance and instrumentation in machinery vibration, amplitude, frequency and phase characteristics, signature analysis-trend plot, time-domain plot, frequency-domain plot, FFT, spectrum plot, fault detection transducers, artificial intelligence techniques applied to vibration analysis	
	(Total Contact Time: = 45 Hours)	

3.	**Books Recommended**
1	S. S. Rao. Mechanical Vibrations, 4thEdition, Pearson Education, 2007
2	L. Meirovitch. Fundamentals of Vibrations, McGraw Hill, 2001
3	E. Krämer. Dynamics of Rotors and Foundations, Springer-Verlag, New York, 1993
4	R. Subbiah and J. E. Littleton. Rotor and Structural Dynamics of Turbomachinery-A Practical Guide for Engineers and Scientists, Springer International Publishing, 2018
5	G. Genta. Dynamics of Rotating Systems, Springer, New York, 2005

B.Tech. IV (DoME) Semester – 7 DESIGN AND ANALYSIS OF ROTODYNAMIC MACHINES (HONORS) MEHT4	Scheme	L	T	P	Credit
		3	1	0	04

1. Course Outcomes (COs):

At the end of the course, students will be able to

CO1	Explain the working principles of Rotodynamic machines and apply it to various types of turbomachines
CO2	Design compressors and gas turbines.
CO3	Determine the off-design behavior of axial and Radial turbines and compressors
CO4	Design pumps and hydro turbines
CO5	Establish performance characteristics curves of thermal and hydro Rotodynamic machines
CO6	Assess & analyze the performance outcomes of thermal and hydro Rotodynamic machines.

2.	**Syllabus**	
	DESIGN OF CENTRIFUGAL COMPRESSORS	**(06 Hours)**
	Components of centrifugal compressor, velocity diagrams, slip factor, energy transfer, power input factor, Mollier chart, stage pressure rise and loading coefficient, degree or reaction, pre-whirl and inlet guide vanes, kinematic parameters, Centrifugal compressor — Inlet section, Impeller passages, operational range, velocity variation, Losses.	
	DESIGN OF AXIAL FLOW COMPRESSORS	**(15 Hours)**
	Description of axial flow compressor, Mollier chart, velocity diagrams, Stage characteristics, Blading efficiency, Design parameters, Blade loading, reaction ratio, Lift coefficient and solidity, Three dimensional flow considerations, Radial equilibrium design approach, Actuator disc theory approach, Design procedure and calculations, free vortex blade, forced vortex or solid rotation blades, constant reaction blade, multistage compression, secondary flow (passage vortex, trailing vortex, corner vortex, horseshoe vortex, leakage vortex, scraping vortex) and loss assessment, rotating stall, surge, chocking, operating range.	
	DESIGN OF TURBINE FLOW PASSAGES	**(06 Hours)**

	Introduction, Isentropic Velocity ratio, Energy distribution in turbines, different efficiencies (nozzle efficiency, carryover efficiency, blade passage efficiency, vane efficiency, stage efficiency), reheat factor, losses in turbine, h – s diagrams of turbines.	
	DESIGN OF IMPULSE TURBINE FLOW PASSAGES	**(08 Hours)**
	Velocity triangles, work and energy relationship, stage efficiency, Blade pitch and width, Blade height, Blade entrance and exit angles, Geometry of impulse blade profiles, Losses in impulse blade passages, Design procedure for single stage and multistage impulse turbines, diagram efficiency of a two-stage turbine, Pressure compounding (Rateau Turbine), Velocity compounding (Curtis Turbine), Pressure and Velocity compounding. Work done and efficiency of a Pelton wheel turbine, heads and efficiencies of Pelton wheel turbine.	
	DESIGN OF REACTION TURBINE FLOW PASSAGES	**(06 Hours)**
	Reaction blade profiles, Blade angles, Blade width and height, Losses in reaction blade passages, Degree of reaction, design procedure for impulse reaction turbines, Calculations for axial thrust, Turbines for optimum capacity.	
	HYDRAULIC DESIGN OF CENTRIFUGAL PUMPS	**(04 Hours)**
	Fundamental Equation of centrifugal pump, work done and manometric efficiency, pressure rise in pump impeller, overall, mechanical, volumetric and manometric efficiency, ideal, virtual and Manometric heads, Net Positive Suction Head, one dimensional theory, Selection of speed - determination of impeller inlet and outlet dimensions	
		(Total Contact Time: = 45 Hours)

3.	**Books Recommended**
1	Dynamics of Rotating Machines, Michael I. Friswell et al., Cambridge University Press, 2024.
2	Rotodynamic Pumps (Centrifugal and Axial), K. Srinivasan, Springer, 2024.
3	Design, Modeling and Reliability in Rotating Machinery, Robert X. Perez, Wiley, 2022.
4	Turbines, Compressors, and Fans, S. M. Yahya, Tata McGraw Hill, 4th edition, 2011.
5	Sawhney G. S., "Thermal and Hydraulic Machines", Prentice Hall India Learning Pvt. Ltd., India, 2011

B.Tech. IV (DoME) Semester – 7 METAL ADDITIVE MANUFACTURING (HONORS) MEHM4	Scheme	L	T	P	Credit
		3	1	0	04

1. Course Outcomes (COs):

At the end of the course, students will be able to

CO1	Classify the metal AM processes, and explain tool path generation & slicing methods.
CO2	Explain principles of metal additive manufacturing methods.
CO3	Describe the metallurgical and manufacturing quality assessment for metal AM.
CO4	Show various heat sources and their interaction with different feedstocks.
CO5	Compare the different metal AM processes and describe machine architectures.
CO6	Outline the pre & post processing for metal additive manufacturing.

2.	Syllabus	
	INTRODUCTION TO ADDITIVE MANUFACTURING (AM)	**(04 Hours)**
	Need for additive manufacturing (AM), Manufacturing systems, Introduction to additive manufacturing (AM), Classification of additive manufacturing. Current and future estimation for metal AM market size, Applications of metal AM, Challenges and opportunities. Classification of metal additive manufacturing processes.	
	CAD DATA AND PRE-PROCESSING FOR AM	**(4 Hours)**
	CAD for additive manufacturing, CAD model development; Additive manufacturing file formats, Defects and Issues in Data Formats; Pre-processing - Part orientation and support structure generation, Design of support structure, Model slicing, Contour generation, Tool path generation, Build file preparation, Machine set-up.	
	METAL AM PROCESSES AND PHYSICS, LASER/ELECTRON BEAM AND BINDER JETTING	**(09 Hours)**
	Basic Processes: Direct Energy Deposition (DED) and Power Bed Fusion (PBF). AM Machine system and setup. Laser Beam: LASER theory, LASER generation unit, continuous and pulsed LASER, Type of LASER. Electron Beam: basics of electron beam, electron beam mechanism, electron beam for powder bed fusion. Process Parameters: AM process parameters, beam scanning strategies, parameters for PBF and DED, powder properties for PBF and DED	

	techniques for powder production, wire properties for DED, ambient parameters for PBF, and DED, geometry specific parameters for PBF, support structure for PBF.	
	METAL AM PROCESSES AND PHYSICS: BINDER AND MATERIAL JETTING	**(03 Hours)**
	Basic Process: Binder Jetting (BJ). AM Machine system and setup. Process Parameters: AM process parameters, powder properties for BJ, Techniques for powder production, ambient parameters for BJ, and geometry specific parameters for BJ, support structure for BJ.	
	FEEDSTOCKS, EMERGING METAL AM PROCESSES: FILAMENT, POWDER AND SHEET SYSTEMS	**(06 Hours)**
	Wire Fed Systems: Wire feed systems, positioning devices, printing heads. Powder Fed Systems: powder feeders and types, powder delivery nozzles, powder bed delivery and spreading system. **Emerging Metal AM Processes:** Material Extrusion, Material Jetting, Sheet Lamination. AM Machine system and setup. AM process parameters.	
	MECHANICAL AND METALLURGICAL PROPERTIES OF AM PARTS	**(09 Hours)**
	Metal AM Printed Parts: mechanical properties- tensile and static strength, fatigue behaviour, hardness, common defects in metal AM printed parts. Solidification: manufacturing of metallic materials, traditional and AM, solidification of metals, equilibrium and non-equilibrium phases for solidification: theory and mechanism for AM, description of metal AM parts. Phase diagrams: Iron-carbon, Al-alloy, Ti-alloy, and Ni-alloy. Intermetallic compounds, residual stress, dissimilar AM, corrosion.	
	POST PROCESSING AND TESTING	**(03 Hours)**
	Need of post processing, product quality evaluation, support structure removal, need of surface finishing, geometry and aesthetics, post processing techniques for metal AM parts. Non-destructive testing metal AM parts.	
	DESIGN FOR ADDITIVE MANUFACTURING	**(04 Hours)**
	Core concepts and objectives, Principles of design for manufacturing and assembly, Constraint approach to design for additive manufacturing: Guidelines and rules for part building, Topology optimization and generative design, exploring design freedom, design tools	
	RECENT TRENDS IN METAL ADDITIVE MANUFACTURING	**(03 Hours)**
	Composite 3D printing, 3D printing of bioimplants, 3D printing in space, 4D printing.	
		(Total Contact Time: = 45 Hours)

3.	Books Recommended
1	Ian Gibson, David Rosen, and Brent Stucker, Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, Springer, 2015. ISBN 978-1-4939-2112-6
2	R. Leach, and S. Carmignato, eds., Precision Metal Additive Manufacturing, CRC Press, 2020.
3	K.R. Balasubramanian, and V. Senthilkumar, eds., Additive Manufacturing Applications for Metals and Composites, IGI Global, 2020.
4	R.M. Mahamood, Laser Metal Deposition Process of Metals, Alloys, and Composite Materials, Engineering Materials and Processes, Springer International Publishing AG, 2018.
5	Hod Lipson and Melba Kurman, The New World of 3D Printing, Wiley, 2013. ISBN 978-1-118-35063-8

B.Tech. IV (DoME) Semester – 7 ENERGY CONSERVATION, MANAGEMENT AND AUDIT (HONORS) MEHE4	Scheme	L	T	P	Credit
		3	1	0	04

1. **Course Outcomes (COs):**

At the end of the course, students will be able to

CO1	Apply various energy conservation techniques to estimate energy saving potential in various thermal and electrical utilities.
CO2	Compare various appliances/utilities based on their stars and labelling, benchmarking values, PAT Scheme in industries.
CO3	Calculate the usage of energy for a given industrial thermal/electrical utility and suggest suitable way to minimize energy bill.
CO4	Analyse the saving potential of Cogeneration option for process industry.
CO5	Determine Energy conservation potential in various industrial utilities like fans, blowers, compressors, pumps etc.
CO6	Compute various performance parameters of HVAC systems and suggest suitable ways for improving energy efficiency.

2.	**Syllabus**	
	GLOBAL AND NATIONAL ENERGY SCENARIO	**(08 Hours)**
	Energy consumption in various sectors, Energy resources like Coal, Oil, and Natural Gas –their demand and supply management, Indian energy scenario, Indian Coal & LPG scenario, Primary and Secondary Sources of Energy, Commercial and Non-Commercial Sources, India's installed energy capacity, per capita energy consumption. General aspects of Energy conservation and management, Roles of energy auditors, Roles of an energy manager, Energy policy of industry, Energy Conservation Act and its amendments, PAT Scheme.	
	ENERGY EFFICIENCY IN BOILER, STEAM, AND FURNACE SYSTEM UTILITIES	**(10 Hours)**
	Energy conservation opportunities in boiler systems, retrofitting of FBC in conventional boilers, Steam line distribution standard practices including sizing and layouts, selection, operation, maintenance of steam traps, and energy-saving opportunities in steam systems. Energy Efficiency in Furnaces: Sankey diagram, Fuel economy measures in furnaces Insulation and Refractories: Types of insulations, Economic thickness of insulation, Typical refractories for industrial applications. Benchmarking in Glass and Steel Industries.	

	ENERGY EFFICIENCY IN FURNACES AND REFRACTORIES:	**(07 Hours)**
	Sankey diagram, Fuel economy measures in furnaces Insulation and Refractories: Types of insulations, Economic thickness of insulation, Typical refractories for industrial applications. Benchmarking in Glass and Steel Industries.	
	COGENERATION	**(07 Hours)**
	Principle of cogeneration, Technical options for cogeneration, Factors influencing cogeneration choice, Important technical parameters for cogeneration, case study on savings with and without cogeneration.	
	ENERGY CONSERVATION IN FANS, BLOWERS COMPRESSORS, AND PUMP SYSTEMS	**(08 Hours)**
	Energy-saving opportunities, performance evaluation and efficient system operation. Air Systems: Efficient operation of the compressed air system, Leakage tests. Pumps and Pumping Systems: Pump curves, factors affecting pump performance, Energy loss in throttling, Effects of impeller diameter change, Flow control strategy, Variable speed drives, and Energy conservation opportunities.	
	ENERGY CONSERVATION IN HVAC AND COOLING TOWERS	**(05 Hours)**
	HVAC: factors affecting the performance and energy savings opportunities in HVAC. Cooling towers: Cooling towers: types and performance assessment & limitations, water loss in cooling tower. Energy Saving in Cooling Towers.	
	(Total Contact Time: = 45 Hours)	

3.	**Books Recommended**
1	General Aspects of Energy Conservation, Management and Audit: Guide Book for Energy Managers and Energy Auditors; Bureau of Energy Efficiency, Ministry of Power
2	Energy Efficiency in Electrical Utilities: Guide Book for Energy Managers and Energy Auditors; Bureau of Energy Efficiency, Ministry of Power
3	Energy Efficiency in Thermal Utilities: Guide Book for Energy Managers and Energy Auditors; Bureau of Energy Efficiency, Ministry of Power
4	S. A. Roosa, Energy Management Handbook, Fairmont Press, 2018
5	Wayne C Turner, Energy Management Handbook. Prentice Hall 3rd Edition, 2000

B.Tech. IV (DoME) Semester – 7 INDUSTRIAL ENGINEERING AND MANAGEMENT (MINORS) MEM44	Scheme	L	T	P	Credit
		3	1	0	04

1. Course Outcomes (COs): At the end of the course, students will be able to	
CO1	Demonstrate and apply selected industrial engineering techniques for enhancing productivity in an organization.
CO2	Apply the various forecasting and project management techniques.
CO3	Select the concept of break-even analysis, inventory control and resource utilization using queuing theory.
CO4	Utilize principles of work study and ergonomics for design of work systems.
CO5	Formulate mathematical models for optimal solution of industrial problems using linear programming approach.
CO6	Understand functions of a product/service and apply Value engineering and Reliability in real industrial problems.

2.	Syllabus	
	OVERVIEW OF INDUSTRIAL ENGINEERING	**(10 hours)**
	Types of production systems, concept of productivity, productivity measurement in manufacturing and service organizations, operations strategies, liability and process design. Facility location and layout: Factors affecting facility location; principle of plant layout design, types of plant layout; computer aided layout design techniques; assembly line balancing; materials handling principles, types of material handling systems, methods of process planning, steps in process selection, production equipment and tooling selection, group technology, and flexible manufacturing.	
	PRODUCTION PLANNING & CONTROL AND PROJECT MANAGEMENT	**(08 hours)**
	Forecasting techniques–causal and time series models, moving average, exponential smoothing, trend and seasonality; aggregate production planning; master production scheduling; materials requirement planning (MRP) and MRP-II; routing, scheduling and priority dispatching, concept of JIT manufacturing system. Project Management: Project network analysis, CPM, PERT and Project crashing.	
	ENGINEERING ECONOMY AND INVENTORY MANAGEMENT	**(08 hours)**

	Definition and meaning of management, Methods of depreciation; break-even analysis, techniques for evaluation of capital investments, financial statements, time-cost trade-off, resource levelling; Inventory functions, costs, classifications, deterministic inventory models, perpetual and periodic inventory control systems, ABC analysis, and VED analysis. Queuing Theory: Basis of Queuing theory, elements of queuing theory, Operating characteristics of a queuing system, Classification of Queuing models.	
	WORK SYSTEM DESIGN AND PRODUCT DESIGN & DEVELOPMENT	**(07 hours)**
	Work System Design: Taylor's scientific management, Gilbreths's contributions; work study: method study, micro-motion study, principles of motion economy; work measurement–time study, work sampling, standard data, Predetermined motion time system (PMTS); ergonomics; job evaluation, merit rating, incentive schemes, and wage administration. Product Design and Development: Principles of product design, tolerance design; quality and cost considerations; product life cycle; standardization, simplification, diversification, value engineering and analysis, and concurrent engineering.	
	OPERATIONAL ANALYSIS	**(12 hours)**
	Operational Analysis: Formulation of LPP, Graphical solution of LPP, Simplex Method, Sensitivity Analysis, degeneracy and unbound solutions. Transportation and assignment models; Optimality test: the stepping stone method and MODI method, simulation.	
	(Total Contact Time: = 45 Hours)	

3.	**Books Recommended**
1	Martand T Telsang, Industrial Engineering and Production Management, 3rd Edition, S. Chand Publishing, 2018.
2	M. Mahajan, Industrial Engineering and Production Management, Dhanpat Rai & Co. (P) Limited, 2015.
3	Ravi Shankar, Industrial Engineering and Management, 2nd Edition, Galgotia Publications Pvt Ltd., 2000.
4	P. K. Gupta and D. S. Hira, Operations Research, 11th Edition, S. Chand & Co., 2015.
5	Adam and Ebert, Production and Operation Management, 5th Edition, Pearson Education Asia, 2003.