REVISED SCHEME

For

UNDER GRADUATE PROGRAMME

(Bachelor of Technology)

IN

MECHANICAL ENGINEERING

(EFFECTIVE FROM: 2019 BATCH)

DEPARTMENT OF MECHANICAL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY SRINAGAR

HAZRATBAL, SRINAGAR, KASHMIR, J&K, INDIA - 190006

B.TECH.3rd SEMESTER (Mechanical)

S. No	Course Code	Course Title	Hours Per Week			Total Contact Hours	Credits
			L	T	P		
1.	MET201	Manufacturing Processes	3	1	0	4	4
2.	MET202	Mechanics of Solids	3	1	0	4	4
3.	MET203	Fundamentals of Dynamics	3	0	0	3	3
4.	MET204	Engineering Thermodynamics	3	1	0	4	4
5.	MET205	Fluid Mechanics - I	3	1	0	4	4
6.	MAT206	Applied Mathematics for Engineers	3	0	0	3	3
7.	MEL201	Machine Drawing & Solid Modelling	0	0	2	2	1
8.	MEL202	Mechanics of Solids Lab	0	0	2	2	1
9.	MEL203	Manufacturing Processes Lab	0	0	2	2	1
						Total Credits	25

B.TECH. 4th SEMESTER (Mechanical)

S. No	Course Code	Course Title	Hours Per Week			Total Contact Hours	Credits
			L	T	P		
1.	MET250	Applied Thermodynamics	3	1	0	4	4
2.	MET251	Mechanics of Materials	3	1	0	4	4
3.	MET252	Theory of Mechanisms and Machines	3	1	0	4	4
4.	MET253	Materials Science and Engineering	3	1	0	4	4
5.	MET254	Non-Traditional Machining and Automation	3	1	0	4	4
6.	ECT254	Basic Electronics	3	0	0	3	3
7.	MEL255	Thermo-Fluids Lab	0	0	2	2	1
8.	MEL256	Non-Traditional Machining and Automation Lab	0	0	2	2	1
						Total Credits	25

BTECH. 5th- SEMESTER (Mechanical)

S. No.	Course Code	Course Title	Hours Per Week			Total Contact Hours	Credits
			L	T	P		
1.	MET301	Heat Transfer	3	1	0	4	4
2.	MET302	Design of Machine Elements	3	1	0	4	4
3.	MET303	Mechanical Vibrations	3	1	0	4	4
4.	MET304	Industrial Engineering - I	3	1	0	4	4
5.	MET305	IC Engines	3	1	0	4	4
6.	ECT349	Microprocessors in Automation	3	0	0	3	3
7.	MEL310	Heat Transfer Lab	0	0	2	2	1
8.	MEL311	Mechanisms and Vibrations Lab	0	0	2	2	1
						Total Credits	**25**

B.TECH. 6th SEMESTER (Mechanical)

S. No.	Course Code	Course Title	Hours Per Week			Total Contact Hours	Credits
			L	T	P		
1.	MET351	Production Engineering	3	1	0	4	4
2.	MET352	Mathematical Methods	3	1	0	4	4
3.	MET353	Control Systems	3	1	0	4	4
4.	MET354	Fluid Mechanics – II	3	1	0	4	4
5.		**Elective I**	2	1	0	3	3
	MET3050	Finite Element Method					
	MET3051	Additive Manufacturing Processes					
	MET3052	Advanced Thermodynamics					
6.		**Elective II**	2	1	0	3	3
	MET3053	Introduction to MEMS					
	MET3054	Linear Optimization in Engineering					
	MET3055	Advanced Fluid Mechanics					
7.	MEL361	Applied Thermodynamics Lab	0	0	2	2	1
8.	MEL362	Industrial Engineering – I Lab	0	0	2	2	1
9.	MEI364	Industrial Training	-	-	-	-	1
						Total Credits	**25**

B.TECH. 7th SEMESTER (Mechanical)

S. No.	Course Code	Course Title	Hours Per Week			Total Contact Hours	Credits
			L	T	P		
1.	MET401	Mechatronics and Measurement Systems	**3**	**1**	**0**	**4**	**4**
2.	MET402	Industrial Engineering - II	**3**	**1**	**0**	**4**	**4**
3.	MET403	Machine Design	**3**	**1**	**0**	**4**	**4**
4.		**Elective-III**	**3**	**1**	**0**	**4**	**4**
	MET4001	Advanced Mechanics of Solids					
	MET4002	Material Testing Inspection & Characterization					
	MET4003	Refrigeration & Air conditioning					
5.		**Elective-IV**	**3**	**1**	**0**	**4**	**4**
	MET4004	Basic Fracture Mechanics					
	MET4005	Advanced Manufacturing Technology					
	MET4006	Conduction heat Transfer					
	MET4007	Online Course					
6.	MEL411	Mechatronics and Measurement Systems Lab	**0**	**0**	**2**	**2**	**1**
7.	MEL412	Industrial Engineering – II Lab	**0**	**0**	**2**	**2**	**1**
8.	MES414	Seminar	**0**	**0**	**4**	**4**	**1**
9.	MEP413	Major Project – Stage I	**0**	**0**	**6**	**6**	**2**
						Total Credits	**25**

B TECH. 8th SEMESTER (Mechanical):

S. No.	Course Code	Course Title	Hours Per Week			Total Contact Hours	Credits
			L	T	P		
1.	MET451	Operations Research	**3**	**1**	**0**	**4**	**4**
2.		**Elective-V**	**3**	**1**	**0**	**4**	**4**
	MET4056	Theory of thin plates & shells					
	MET4057	Entrepreneurship development & Risk Management					
	MET4058	Power Plant Engineering					
3.		**Elective-VI**	**3**	**1**	**0**	**4**	**4**
	MET4059	Theory of Elasticity					
	MET4060	Advanced welding & Allied Processes					
	MET4061	Renewable Energy Systems					
4.		**Elective-VII**	**3**	**1**	**0**	**4**	**4**
	MET4062	Mechanics of Composite Materials					
	MET4063	Value Engineering					
	MET4064	Design of fluid Thermal Systems					
	MET4065	Online Course					
5.	MEP463	Major Project – Stage II	**0**	**0**	**18**	**-**	**9**
						Total Credits	**25**

*The evaluation will be done as per statutes.

MECHANICAL ENGINEERING DEPARTMENT

B.TECH.3rd SEMESTER (Mechanical)

S. No	Course Code	Course Title	Hours Per Week			Total Contact Hours	Credits
			L	T	P		
1.	MET201	Manufacturing Processes	3	1	0	4	4
2.	MET202	Mechanics of Solids	3	1	0	4	4
3.	MET203	Fundamentals of Dynamics	3	0	0	3	3
4.	MET204	Engineering Thermodynamics	3	1	0	4	4
5.	MET205	Fluid Mechanics - I	3	1	0	4	4
6.	MAT206	Applied Mathematics for Engineers	3	0	0	3	3
7.	MEL201	Machine Drawing & Solid Modelling	0	0	2	2	1
8.	MEL202	Mechanics of Solids Lab	0	0	2	2	1
9.	MEL203	Manufacturing Processes Lab	0	0	2	2	1
						Total Credits	**25**

<table>
<tr><td rowspan="3">Subject: Manufacturing Processes
(Code: MET201)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Mechanical Engineering
2nd Year & 3rd Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

Course Outcomes: At the end of the course, the student should be able to:

CO1: Identify and analyse the functioning of machine tools and estimate the machining time
CO2: Explain and analyse the conventional machining processes
CO3: Analyse the welding process behaviour for fusion and solid state welding techniques
CO4: Explain the basics of casting processes and their applications in manufacturing domain

Detailed Syllabus:

UNIT I
Introduction to manufacturing processes, Introduction to machine tool. Basic elements of machine tool, machine tool drives. Lathe machine: Tool geometry, machining parameters. Lathe operations (Facing, Turning, Drilling, Reaming, Boring), Taper turning by different methods. Milling Machine: types, working principle, milling parameters, operations (slab, end, slot, face milling), up and down milling. Estimating machining time in lathe and milling operations, different types of indexing methods in milling

UNIT II
Drilling: Types of drilling machines, portable, bench, upright, Radial, Spot facing. Drilling process parameters, Estimating machine time. Reaming: Types of reamer, reaming operations. Broaching: Types of broaches, tool material, teeth terminology and other details. Methods of broaching. Working principle and operation of shaping, planning and slotting

UNIT III
Welding: Introduction to welding, Principle of Welding, Classification of welding, Arc Initiation, Characteristic and power of electric arc, Power source characteristics, Modes of metal transfer in Arc welding, Gas welding, SMAW, GTAW, GMAW, Resistance and Thermit welding, High energy beam welding, Solid state welding processes, Underwater Welding, Welding defects, Welding of Plastics

UNIT IV
Casting Processes: Introduction, Industrial applications, casting terminology, mould, types of mould (Grey and Dry sand Mould), Pattern types, allowances, preparation of mould, various stages in the casting process, testing of moulding sand, types of casting processes (Die, Centrifugal, Continuous, and investment casting), Solidification time, Gating and rising system design

Text Book:

1. Ghosh, A. and Malik, A.K., "Manufacturing Science", Affiliated East Press, New-Delhi.

Reference Books:

1. Campbell, J.S., "Principles of Manufacturing Materials and Processes", McGraw-Hill, New-York.
2. Rao, P.N., "Manufacturing Technology", Vol. 2, McGraw-Hill Education, New Delhi.
3. Lindberg, R.A., "Processes and Materials of Manufacturing", Allyn and Bacon, Boston.
4. Schey, J.A., "Introduction to Manufacturing Processes", McGraw-Hill, New-York.
5. Sindo Kou, "Welding Metallurgy", 2nd Edition, Wiley-Interscience.

Subject: Mechanics of Solids (Code: MET202)	Year & Semester: B. Tech Mechanical Engineering 2nd Year & 3rd Semester		Total Course Credit: 4		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term	Class Assessment	End-Term		
	30 Marks	10 Marks	60 Marks		

Pre-Requisites: *Engineering Mechanics*

Course Outcomes: At the end of the course, student will be able to:

CO1	Understand the concept of Stress, Strain and Elastic Constants.
CO2	Evaluate principal stresses, strains and analyze thin/thick pressure vessels.
CO3	Assess Shear force and bending moment diagram and determine the stresses for the beam subjected to different loading conditions.
CO4	Analyze columns for critical buckling loads and solve problems of shafts subjected to twisting moments.

Detailed Syllabus:

UNIT-I

Resistance and Deformation: Concept of Resistance and deformation - Determinate and Indeterminate problems in Tension and Compression - Concept of continuum, homogeneity and isotropy, types of force on a body, state of stress at a point, equality of cross shear -Thermal Stresses - pure shear - Young's modulus of elasticity, Poisson's ratio, Modulus of rigidity and Bulk modulus - Relation between elastic constants - Stress-strain diagrams for brittle and ductile materials - working stress - Strain energy in tension and compression - Impact loading.

UNIT-II

Analysis of Stress and Strain: Plane stress, Stresses on inclined planes, Principal stresses and maximum shear stress, Principal angles, Shear stresses on principal planes, Maximum shear tress, Mohr circle for plane stress conditions.

Thin and Thick Cylinders: Thin and Thick Cylinders - spherical shells subjected to internal fluid pressure - Wire wound thin cylinders - Compound cylinders - Shrink fit.

UNIT-III

Shear Force and Bending Moment: Types of supports - Types of beams - Types of loads - articulated beams - Shear Force and Bending Moment diagrams.

Theory of Simple Bending: Assumptions - Bending stresses in beams - Efficiency of various cross sections - Composite beams. Flexural shear stress distribution in different cross sections of beams.

UNIT-IV

Torsion of Circular cross sections: Theory of pure torsion - transmission of Power in Solid and Hollow circular shafts - Combined bending and torsion.

Buckling of columns: Concept of buckling and stability, differential equations of compression member with different boundary conditions, eccentrically loaded columns, secant formula, column with initial imperfections, Rankine formula.

Reading:

Text Books:

1. Hibbeler, R. C., "Mechanics of Materials" 8th Edition, Pearson Education India, 2011.
2. Timoshenko and Gere, "Mechanics of Materials", CBS Publishers, 2011.
3. Shames, I. H., Pitarresi, J. M., "Introduction to Solid Mechanics", Pearson, 2015.

Reference Books:

1. Popov, E. P., "Engineering Mechanics of Solids", PHI, 2009.
2. Beer, F. Jr., Johnston, E. R., DeWolf, J., Mazurek, D., "Mechanics of Materials", 7th Edition, McGraw-Hill Education, 2014.

Subject: Fundamentals of Dynamics (Code: MET203)	Year & Semester: B. Tech Mechanical Engineering 2nd Year & 3rd Semester		Total Course Credit: 3		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Class Assessment	End-Term		
	30 Marks	10 Marks	60 Marks		

Course Outcomes: At the end of the course, the student should be able to:

CO1: Apply the concepts and laws of dynamics to solve complex engineering problems
CO2: Use the concepts of impulse-momentum to develop relations governing particle impacts
CO3: Use Newton's second law to determine trajectory properties of particles under central-force attraction
CO4: Apply the knowledge of dynamics of rigid bodies to systems like ships and airplanes

Detailed Syllabus:

UNIT I
Kinematics of particles, basic concepts, rectilinear motion, plane curvilinear motion, rectangular coordinates (x-y), normal and tangential coordinates (n-t), polar coordinates (r-θ), space curvilinear motion, relative motion (translating axes), constrained motion of connected particles

UNIT II
Kinetics of particles, equations of motion and their solution, impulse, momentum, work and energy, linear impulse and linear momentum, angular impulse and angular momentum, impact, central-force motion, relative motion, kinetics of systems of particles, generalized Newton's second law, work-energy, impulse-momentum, conservation of energy and momentum

UNIT III
Dynamics of rigid bodies, rotation, absolute motion, relative velocity, instantaneous center of zero velocity, relative acceleration, motion relative to rotating axes, plane kinetics of rigid bodies, translation, fixed-axis rotation, general plane motion, mass moments of inertia

UNIT IV
Work energy relations, virtual work, impulse-momentum equation, and three-dimensional dynamics of rigid bodies, gyroscopic motion, and steady precession

Text Book:
1. Meriam, J. L., Kraige, L. G., Bolton, J. N., "Engineering Mechanics: Volume 2, Dynamics", 9th Edition, Wiley, 2018.

Reference Book:
1. Shames I. H. and Rao, G. K., "Engineering Mechanics Statics and Dynamics", Pearson Education India; 4th Edition, 2005.

<table>
<tr><td rowspan="3">Subject: Engineering Thermodynamics (Code: MET204)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Mechanical Engineering 2nd Year & 3rd Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

Course Outcomes: At the end of the course, the student should be able to:

- **CO1:** Apply the basic concepts of thermodynamics to engineering systems
- **CO2:** Apply various laws of thermodynamics to solve problems involving heat and work transfer
- **CO3:** Design heat engines and heat pumps using the knowledge of basic thermodynamic cycles
- **CO4:** Develop fundamental relations between various thermodynamic properties to evaluate the un-measurable properties

Detailed Syllabus:

UNIT I

Introduction and basic concepts, microscopic and macroscopic views of matter, thermodynamic systems, properties, processes, cycles, thermal equilibrium, the state postulate, Zeroth law of thermodynamics, temperature, temperature scales, thermodynamic equilibrium, energy and the First law of thermodynamics, mechanical forms of work, internal energy, conservation of energy, energy transfer as work and heat, First law for a closed system, specific heats, isothermal, isobaric, and isentropic processes, compressibility.

UNIT II

First law for open systems, enthalpy, First law for cyclic processes, applications, Second law of Thermodynamics, Entropy and the Second law, Various statements of the Second law and their equivalence, Clausius statement, Kelvin-Planck statement, reversible cycles, Carnot cycle, inequality of Clausius, the principle of increase of entropy and its applications, Second law for closed systems, Second law for open systems.

UNIT III

The Maxwell relations, Gibb's function, Helmholtz function, relationship between specific heats, the Clapeyron equation, thermodynamic relations for ideal gases, computation of entropy and internal energy from measurable quantities, process with ideal gases and vapours, Ideal gas mixtures, Dalton's law of partial pressures, Gibbs–Dalton law, Amagat's law of additive volumes

UNIT IV

Internal energy, enthalpy, specific heat and entropy of an ideal gas mixture, air-water vapour mixture**,** complete and incomplete combustion analysis, heating value of fuels, analysis of products of combustion, Orsat apparatus.

Text Books:

1. Moran, M.J., Shapiro, H.J., Boettner, D.D., Bailey, M.B., "Fundamentals of Engineering Thermodynamics", John Wiley, 2018.
2. Cengal, Y., Boles, M., and Kanoglu, M., "Thermodynamics: An Engineering Approach", McGraw Hill, 2019.

Reference Books:

1. Wark, K., "Thermodynamics", McGraw Hill, 2001.
2. Van-Wylen, G.J., "Fundamentals of Classical Thermodynamics", John Wiley, 2001.

<table>
<tr><td rowspan="3">Subject: Fluid Mechanics-I (Code: MET205)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Mechanical Engineering 2nd Year & 3rd Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

Course Outcomes: At the end of the course, the student should be able to:

CO1: Apply the basic laws of hydrostatics to engineering problems involving static fluids and submerged surfaces

CO2: Evaluate and apply the principles of continuity, momentum, and energy conservation to systems involving fluid motion

CO3: Apply the Bernoulli equation to compute pressure and velocity changes in flow systems of different configuration and appreciate the application of elementary potential theory

CO4: Apply the knowledge of fluid dynamics to determine head losses in circular pipes and use elementary boundary-layer theory to determine lift and drag forces in engineering systems

Detailed Syllabus:

UNIT I

Definition of a fluid, methods of analysis, system and control volume, differential versus integral approach, methods of description, fluid as a continuum, velocity field, timelines, path lines, streak lines, and streamlines, stress field, viscosity, Newtonian and non-Newtonian fluids, surface tension, viscous and inviscid flows, laminar and turbulent flows, the basic equation of fluid statics, pressure variations in a static fluid, manometers, hydraulic systems, hydrostatic force on submerged surfaces, buoyancy and stability, fluids in rigid-body motion

UNIT II

Conservation of mass, control volume formulation, differential control volume, control volume moving with constant velocity, momentum equation for control volume with rectilinear acceleration, the angular-momentum principle, equation for fixed control volume, equation for rotating control volume, the rate of work done by a control volume, differential analysis of fluid motion, stream function and velocity potential, fluid translation, acceleration of a fluid particle in a velocity field, fluid rotation, fluid deformation, momentum equation, Navier-Stokes equations

UNIT III

Incompressible inviscid flow, momentum equation for frictionless flow, Euler's equation, Bernoulli equation, integration of Euler's equation along a streamline, static, stagnation, and dynamic pressures, applications of the Bernoulli equation, the Bernoulli equation interpreted as an energy equation, energy grade line and hydraulic grade line, unsteady Bernoulli equation, irrotational flow, stream function and velocity potential, Laplace's equation, superposition of elementary plane flows

UNIT IV

Dimensional analysis and similitude, non-dimensionalization of the basic differential equations, Buckingham Pi theorem, determining the π groups, significant dimensionless groups, flow similarity and model studies, internal incompressible viscous flow, fully developed laminar flow between infinite parallel plates, fully developed laminar flow in a pipe, flow in pipes and ducts, shear stress distribution, turbulent velocity profiles in fully developed pipe flow, energy considerations in pipe flow, kinetic energy coefficient, head loss calculation, major and minor losses, friction factor, restriction flow meters for internal flows, boundary-layer theory, boundary-layer thicknesses, laminar flat-plate boundary layer, momentum integral equation for flow with zero pressure gradient, friction and pressure drag, streamlining, aerodynamic lift

Text Book:

1. Pritchard, P. J., Leylegian, J. C., "Fox and McDonald's Introduction to Fluid Mechanics", Eighth edition, John Wiley and Sons, Inc., 2011.

Reference Books:

1. Shames, I. H., "Mechanics of Fluids", Fourth Edition, McGraw Hill, 2003
2. White , F.M., "Fluid Mechanics", McGraw Hill, 2001

Subject: Applied Mathematics for Engineers (Code: MAT206)	**Year & Semester: B. Tech Mechanical Engineering 2nd Year & 3rd Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Class Assessment	End-Term		
	30 Marks	10 Marks	60 Marks		

Course Outcomes: At the end of the course, the student should be able to:

- **CO1:** Solve problems related to differentiation and integration of complex functions
- **CO2:** Express complex functions in terms of series expansion, classify singularities and the apply the concepts of complex analysis in boundary value problems and potential theory
- **CO3:** Evaluate Laplace, Inverse Laplace transforms, Fourier and Inverse Fourier transforms of various functions and related problems
- **CO4:** Apply the methods of Laplace and Fourier transforms in solving ODE, PDE and Integral equations

Detailed Syllabus:

UNIT I

Complex Variables: Function of a Complex variable, Limit, Continuity and Differentiability of complex function. Cauchy-Riemann Equations, Analytic function, Harmonic functions, Complex Integration Cauchy Integral Theorem and its consequences, Taylor Series, Laurant Series, Classification of Singularities, Residues, Cauchy's Residue Theorem and its Applications, Zeros of Analytic functions.

UNIT II

Boundary Value Problems and Potential Theory, Laplace's Equation and Conformal Mappings, Standard Solution of Laplace equation, Steady–State Temperature Distribution, Steady Two Dimensional Fluid Flow.

UNIT III

Laplace transform, Laplace transform of some elementary functions, Properties of Laplace transform, Differentiation and Integration of Laplace transform, Dirac-delta function and its Laplace transform, Heaviside's expansion theorem, Inverse Laplace transform, Initial and Final value theorems, Convolution theorem, Use of Laplace transforms in the solution of linear differential equation.

UNIT IV

Fourier Transforms, Definition of Fourier transform, Fourier Integral Theorem, Properties of Fourier transform, Fourier sine and cosine, Convolution Theorem, Applications of Fourier transforms to Ordinary and Partial differential equations.

Text Books:

1. Brown, W., and Churchill, R. V., "Complex Variables and Applications," 8th Edition, Mc-Graw Hill International Edition, 2009
2. Debnath, L., and Bhatta, D., "Integral Transforms and their Applications," 2nd Edition, CRC press, 2007

Reference Books:

1. Jeffrey, A., "Complex Analysis and Applications," 2nd Edition, CRC Press, 2005
2. Needham, T., "Visual Complex Analysis," Oxford University Press
3. Jain, R. K., and Iyengar, S. R. K., "Advanced Engineering Mathematics," 3rd Edition, Narosa Pub. House, 2008
4. Spiegel, M. R., "Schaum's Outlines Laplace Transforms," Tata Mc-Graw Hill, 2005

<table>
<tr><td rowspan="3">Subject: Machine Drawing & Solid Modelling
(Code: MEL201)</td><td rowspan="3">Year & Semester: B. Tech Mechanical Engineering
2nd Year & 3rd Semester</td><td colspan="3">Total Course Credit: 1</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>0</td><td>0</td><td>2</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Continuous Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>60 Marks</td><td colspan="3">40 Marks</td></tr>
</table>

Course Outcomes: At the end of the course, the student should be able to:

- **CO1:** Draw machine elements including keys, couplings, cotters, rivets, bolted and welded joints, using the conventions for engineering components and materials
- **CO2:** Construct an assembly drawing using part drawings of machine components
- **CO3:** Create part drawing of machine components using machine assembly
- **CO4:** Apply geometric modelling techniques in design and analysis

Detailed Syllabus:

UNIT I

Introduction to machine element drawing, review of dimensioning, types of sectioning and use, need and significance of version control in drawings, methods of recording modifications in typical drawings, Introduction to generation of drawings as a design process for machine assembly. Use of datum planes to locate features and machine elements uniquely in assemblies. Standardized representation and types of threads, fasteners, welds.

UNIT II

Introduction to important machine elements such as bearings (rolling contact/sliding contact), Use of appropriate fits for correct functioning, representation of springs and related components, detailing of components involving shafts, bearing, pulleys, gears, belts, brackets for assembly, generation of assembly drawings using standard modeling software including sectioning and bill of materials, evolving details of components from assembly considerations.

UNIT III

Solids Modelling for Design: Solid entities, Boolean operations, Topological aspects, Invariants. Write-frame modelling, B-rep of Solid Modelling, CSG approach of solid modelling. Popular modelling methods in CAD software. Data Exchange Formats and CAD Applications.

UNIT IV

Development of three-dimensional models and fabrication/assembly drawings from engineering sketches and orthographic drawings and utilization of three-dimensional models in design work. Introduction to engineering topics such as finite-element analysis (FEA) and computational fluid dynamics (CFD). Additional advanced topics include stress/deflection calculations using beam theory mathematical models.

Text Books:

1. Bhatt, N.D., "Machine Drawing", Charotar Publishing House, 2003.
2. Saxena A. and Sahay B., "Computer-Aided Engineering Design", Anamaya Publishers, New Delhi, 2005.

Reference Books:

1. Sidheswar, N., Kannaiah, P. and Sastry, V.V.S., "Machine Drawing", Tata McGraw Hill Book Company, New Delhi, 2000.
2. Mortenson M. E., "Geometric Modeling", Tata McGraw Hill, 2013.

Subject: Mechanics of Solids Lab (Code: MEL202)	Year & Semester: B. Tech Mechanical Engineering 2nd Year & 3rd Semester	Total Course Credit: 1		
		L	T	P
		0	0	2
Evaluation Policy	Continuous Assessment (60 Marks)	End-Term (40 Marks)		

Pre-Requisites: *Engineering Mechanics*

Course Outcomes: At the end of the course, student will be able to:

CO1	Predict the behavior by conducting tests and evaluate the modulus of elasticity, yield strength ,UTS and shear strength of different engineering materials
CO2	Compute modulus of rupture of beams and critical load of columns by performing experiments
CO3	Determine the notch toughness and hardness of engineering materials
CO4	Find out the compressive strength, angle of twist and shear modulus of test specimen.

List of Experiments:

1. Tensile test of mild steel and aluminium bars.
2. Shear test on specimen of two different metals.
3. Bending tests on a steel bar/wood.
4. Impact tests on metals: a) Izod Test; b) Charpy Test
5. Torsion test on specimen of different metals for determining the angle of twist for a given torque.
6. Hardness tests on metal to determine Brinell and Rockwell hardness.
7. Buckling load for a column.
8. Compressive test of a specimen.

Subject: Manufacturing Processes Lab (Code: MEL203)	Year & Semester: B. Tech Mechanical Engineering 2nd Year & 3rd Semester	Total Course Credit: 1		
		L	T	P
		0	0	2
Evaluation Policy	Continuous Assessment (60 Marks)	End-Term (40 Marks)		

Course Outcomes: At the end of the course, the student should be able to:

CO1: Describe the geometry of single point cutting tool
CO2: Apply knowledge of metal cutting to perform various machining operations
CO3: Explain the working and use of various components of conventional machine tools
CO4: Investigate the effect of machining process parameters on surface roughness

List of Experiments:

1. To study the construction details and working principle of Lathe Machine.
2. To perform taper turning operation on Lathe Machine
3. To perform step turning operation on Lathe Machine
4. To study the tool geometry of a single point cutting tool.
5. To perform drilling operation on a given work piece using Drilling Machine
6. To perform shaping operation on a given work piece using Shaper Machine
7. To perform external thread cutting operation on Lathe Machine
8. To investigate the effect of turning process parameters on the surface roughness of machined component

MECHANICAL ENGINEERING DEPARTMENT

B.TECH. 4th SEMESTER (Mechanical)

S. No	Course Code	Course Title	Hours Per Week			Total Contact Hours	Credits
			L	T	P		
1.	MET250	Applied Thermodynamics	3	1	0	4	4
2.	MET251	Mechanics of Materials	3	1	0	4	4
3.	MET252	Theory of Mechanisms and Machines	3	1	0	4	4
4.	MET253	Materials Science and Engineering	3	1	0	4	4
5.	MET254	Non-Traditional Machining and Automation	3	1	0	4	4
6.	ECT254	Basic Electronics	3	0	0	3	3
7.	MEL255	Thermo-Fluids Lab	0	0	2	2	1
8.	MEL256	Non-Traditional Machining and Automation Lab	0	0	2	2	1
						Total Credits	**25**

<table>
<tr><td rowspan="3">Subject: Applied Thermodynamics (Code: MET250)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Mechanical Engineering 2nd Year & 4th Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

Course Outcomes: At the end of the course, the student should be able to:

- **CO1:** To identify the properties of substances on property diagrams and obtain the data from property tables.
- **CO2:** To explain the working of boiler along with its various components of boilers and combustion of fuel.
- **CO3:** To apply the concepts of thermodynamics to various thermal applications such as IC engines, steam nozzles and turbines.
- **CO4:** To execute the concepts of thermodynamics to refrigeration and air-conditioning systems.

Detailed Syllabus:

UNIT I

Pure Substance, Ideal and real Gases, perfect gases, Generation of Steam, use of Steam Tables and Mollier diagram, various phases of a substance, triple point and critical point, sub-cooled liquid, saturated liquid, vapor pressure, two-phase mixture of liquid and vapor, saturated vapor and superheated vapor states of a pure substance (with water as an example), dryness fraction and its measurement, representation of the properties of a pure substance on p-T, h-s and p-V diagrams, detailed treatment of properties of steam for industrial and scientific use.

Vapor Power cycles: Carnot vapor power cycle, Effect of pressure & temperature on Rankine cycle, Reheat cycle, Regenerative cycle, Feed water heaters, Binary vapor cycle, combined cycles, Cogeneration, Air standard Cycles, Carnot, Otto, Diesel and dual cycles, work output and efficiency, mean effective pressure, deviation of actual cycles from ideal cycles

UNIT II

Fuels and Combustion: Combustion analysis, Heating Values, Air requirement, Air/Fuel ratio, Standard heat of reaction and effect of temperature on standard heat of reaction, heat of formation, adiabatic flame temperature.

Boilers: Steam generators-classifications, working of fire-tube and water-tube boilers, boiler mountings and accessories, draught and its calculations, air preheater, feed water heater, super heater. Boiler efficiency, Equivalent evaporation. Boiler trial and heat balance, Condensers: classification, Air leakage, Condenser performance parameters

UNIT III

Nozzles: Flow through nozzle, Variation of velocity, Area and specific volume, Choked flow, Throat area, Nozzle efficiency, off design operation of nozzle, Effect of friction on nozzle, super saturated flow. Steam Engines: Rankine and modified Rankine cycles, working of stream engine,

Steam Turbines :Classification of steam turbine, Impulse and reaction turbines, Staging, Stage and overall efficiency, Reheat factor, Bleeding, Velocity diagram of simple & compound multistage impulse & reaction turbines & related calculations work done efficiencies of reaction, Impulse reaction Turbines, state point locus, Comparison with steam engines, Losses in steam turbines, Governing of turbines.

UNIT IV

Applications of Refrigeration and Air-conditioning, Thermal Principles for Refrigeration, Vapor Compression System, Reversed Carnot Cycle, Survey of Refrigerants, Designation of Refrigerants, Selection of Refrigerants, Thermodynamic Requirements, Centrifugal compressors, Multistage compression, multi-evaporator system, cascade systems, Condensers, Heat Transfer in Condensers, Evaporators, Heat Transfer in Evaporators, Extended surface Evaporator, Cooling and Dehumidifying coils, Automatic or constant-pressure expansion valve, Psychometric properties, Wet bulb temperature, Psychometric chart, mixing process.

Text Books:

1. Eastop, T. D., "Applied Thermodynamics for Engineering Technologist", Pearson Education, 1990.
2. Arora, C. P., "Refrigeration and Air-conditioning", McGraw Hill, New Delhi,

Reference Books:

1. Helsdon, R. M., Hiller, N., Walker, G. E., "Introduction to Applied Thermodynamics", Elsevier, 1965.
2. Pai, B. U., "Turbomachines", 1st Edition, Wiley.
3. Hundy, G. H., Trott, Albert Runcorn, Welch, T., "Refrigeration, Air Conditioning and Heat Pumps," 5th Edition, Butterworth-Heinemann, Elsevier.

Subject: Mechanics of Materials (Code: MET251)	Year & Semester: B. Tech Mechanical Engineering 2nd Year & 4th Semester		Total Course Credit: 4		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term	Class Assessment	End-Term		
	30 Marks	10 Marks	60 Marks		

Pre-Requisites: *Engineering Mechanics, Mechanics of Solids*

Course Outcomes: At the end of the course, the student should be able to:

CO1	Analyze the elements and determine the slope and deflection of the beams.
CO2	Describe various energy theorems & compute deflection of beams/trusses using energy principles.
CO3	Identify & calculate the stresses in unsymmetrical bending/ curved beams and Analyze the effect of forces on springs.
CO4	Understand the concept of principal stresses and failure theories and evaluate the rotational stresses.

Detailed Syllabus:

UNIT-I

Deflection of Beams: Slope and deflection of beams - Double Integration method - Macaulay's method - Strain energy due to normal and shear stresses, The total elastic strain of dilation and distortion, The energy elastic theorems, Theorems on virtual work, Castigliano's theorem, Complementary energy theorems, Strain energy due to axial bending and Torsional loads, Stresses due to suddenly applied loads, Use of energy theorems to determine deflection of beams and twists of shafts, Maxwell's theorem of reciprocal deflections and its corollaries, Unit couple and unit load methods of determining slopes, deflections.

UNIT-II

Unsymmetrical Bending: Stresses due to unsymmetrical bending, combined bending & axial loads, Shear centre for symmetrical and unsymmetrical sections.
Bending of curved bars: Introduction, stresses in curved bars having rectangular, circular, triangular and trapezoidal section, stresses in crane hooks.
Springs: Axial load and torque on helical springs - stresses and deformations - compound springs - leaf springs.

UNIT-III

Theories of Elastic Failure: Concept of factor of safety, Maximum Principal Stress Theory, Maximum Principal Strain Theory, Maximum Shear Stress Theory, Strain Energy Theory, Distortion energy theory.
Stresses due to rotation: Rotating ring, rotating thin disc, rotating thin solid and hollow disc, disc of uniform strength, rotating long solids and hollow cylinders.

Text Books:

1. Hibbeler, R. C., “Mechanics of Materials”, 6th Edition, East Rutherford, NJ: Pearson Prentice Hall, 2004
2. Srinath L. S., “Advanced Mechanics of Solids”, TMH Publishing Company Limited, 1992

Reference Books:

1. Boresi A. P., Schmidt R. J., Sidebottom O. M., “Advanced Mechanics of Materials”, 5th Edition, John Wiley & Sons, 1993
2. Cook, R. D., Young, W. C., “Advanced Mechanics of Materials”, Collier Macmillan Publishers, 1985
3. Ugural A. C., S. K. Fenster, “Advanced Mechanics of Materials and Applied Elasticity”, Prentice Hall; 5th Edition, 2011

<table>
<tr><td rowspan="3">Subject: Theory of Mechanisms and Machines (Code: MET252)</td><td rowspan="3" colspan="2">Year & Semester: B. Tech Mechanical Engineering 2nd Year & 4th Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

Course Outcomes: At the end of the course, the student should be able to:

CO1: Select and analyse the kinematic parameters for designing a suitable linkage mechanism
CO2: Explain the working principle of governors and gyroscopes in motion control
CO3: Select and design gear and cam mechanisms for a given input and output motion relationship
CO4: Apply the laws of friction in applications of mechanisms and machines

Detailed Syllabus:

UNIT I
Mechanism and machine, links and kinematic pairs, degrees of freedom, kinematic chain, mechanical advantage, transmission angle, inversions of four bar and slider crank mechanisms, Quick-return mechanism, straight line generators, velocity and acceleration analysis using instantaneous centre method and loop-closure equations, computer-aided analysis of four bar mechanism, graphical and computer-aided synthesis for motion and path generation

UNIT II
Governors, Watt governor, Porter governor, Proell governor, Hartnell governor, controlling force, sensitivity, stability, hunting, isochronism, effort and power of a governor, gyroscope, gyroscopic torque, gyroscopic effects on an airplane and ships, gyroscopic stabilization, stability analysis of a two-wheel vehicle, four-wheel drive on a curved path

UNIT III
Gears, classification, law of gearing, involute and cycloidal profiles, path and arc of contact, contact ratio, interference and undercutting, interchangeable gears, helical, bevel and spiral gears, gear trains, classification, simple, compound, reverted, and epicyclic gear trains, analysis of epicyclic gear trains, sun and planet gears, automobile differential

UNIT IV
Friction, types and laws of friction, screw jack, pivots and collars, bearings, friction clutches, brakes, Cams, classification and terminology, displacement diagrams, derivatives of follower motion, pressure angle and undercutting, motions of the follower, layout of cam profiles, graphical and analytical disc cam profile synthesis

Text Book:

1. Pennock, G. R., Shigley J. E., Uicker, J. J., "Theory of Machines and Mechanisms", Oxford University Press, 4th Edition, 2014.

Reference Books:

1. Bevan, T., "Theory of Machines", 3rd Edition, CBS publishers and distributors, 2005.
2. Norton, R. L., "Kinematics and Dynamics of Machinery", Tata McGrawHill, 2009.
3. Ghosh A. and Mallick A. K. "Theory of Mechanisms and Machines" East West Private Limited, New Delhi, 1988.
4. Rattan S. S. "Theory of Machines", 5th Edition, Tata McGrawHill, 2019.

<table>
<tr><td rowspan="3">Subject: Materials Science and Engineering
(Code: MET253)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Mechanical Engineering
2nd Year & 4th Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

Course Outcomes: At the end of the course, the student should be able to:

CO1: Explain the underlying concepts of engineering material chemistry and crystallography
CO2: Determine crystallographic directions and explain imperfections in solids, and processing of engineering materials
CO3: Explain the mechanisms of strengthening and the phase diagrams
CO4: Recognize the need of heat treatment processes and analyse the effect of cooling media on microstructure

Detailed Syllabus:

UNIT I

Introduction to material science and engineering, Importance of materials, Classification of engineering materials, Modern and advanced materials, Atomic structure and bonding, Fundamentals of electron arrangements and modern periodic table, Primary bonds and secondary bonds. Crystallography, Concept of unit cells and lattice arrangements, Crystal structure, Crystal systems, Bravais lattices, Co-ordination number, Atomic packing factor

UNIT II

Miller indices of direction and planes, single crystals, polycrystalline materials, Amorphous material, x-ray diffraction and determination of crystal structures, Imperfections in solids, point defects, line defects and volume defects, dislocations.
Ceramics: structure, types, properties and applications of ceramics, processing of ceramics. Composite materials. Nanomaterials and their potential applications. Plastics: Types of plastics/polymers, polymer structure, thermoplastic and thermosetting polymers, processing of polymers

UNIT III

Deformation and strengthening mechanisms, strain hardening, grain refinement, mechanical alloying, solid solution strengthening, precipitation hardening. Diffusion in solids, Phase diagrams, Solubility limit, Phases, Lever rule, Gibbs phase rule, Iron-Carbon equilibrium diagram. Mechanical properties and testing, Non-Destructive testing

UNIT IV

Heat Treatment: Introduction to heat treatment, different types of heat treatment processes, annealing, normalizing, quenching, tempering, case hardening, Time temperature transformation diagram, Recovery, Recrystallization, Ductile to brittle transition. Micro-structure of various metals and alloys, Micro structure of steel treated with different cooling media.

Text Book:

1. Callister Jr, W. D., Rethwisch, D. G., "Materials Science and Engineering: An Introduction", 8th Edition, John Wiley and Sons.

Reference Books:

1. Raghvan, V., "Materials Science and Engineering", 5th Edition, Prentice Hall India Learning Private Limited, 2005.
2. Ghosh, A., and Malik, A. K., "Manufacturing Science", 2nd Edition, Pearson India, 2010.

<table>
<tr><td rowspan="3">Subject: Non-Traditional Machining and Automation (Code: MET254)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Mechanical Engineering 2nd Year & 4th Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

Course Outcomes: At the end of the course, the student should be able to:

- **CO1:** Analyse and assess the importance of automation and industrial automated systems
- **CO2:** Identify and analyse functions and functioning of CNC machines
- **CO3:** Recognize the need of non-traditional machining processes and understand the working of high energy beam machining
- **CO4:** Illustrate underlying mechanisms in non-traditional machining processes along with their applications

Detailed Syllabus:

UNIT I

Introduction to automation and manufacturing automation, types of automation, Introduction to Flexible manufacturing systems (FMS), Elements, types and advantages of FMS, Cellular manufacturing, Types of flexibilities in FMS, test of flexibility, Product processing strategies. Introduction to robotics, Elements of Robotic Systems

UNIT II

Computer numeric control (CNC) machines, Open loop & closed loop CNC machines. Classification, advantages and applications of CNC machines, Introduction to CNC programming, G-codes and M-codes. Absolute and Incremental coordinate system, Adaptive control, Material Handling Equipment, Automated Guided vehicles (AGVs), Analysis of AGVs

UNIT III

Introduction to machining processes. Limitations of traditional machining processes. Introduction, need and applications of non- traditional machining processes. Classification of non- traditional machining processes. Mechanical machining, thermal machining, electrochemical machining. Introduction, working and applications of high energy beam machining processes. Virtual machining

UNIT IV

Introduction, working, process parameters and applications of Abrasive Jet Machining (AJM), Abrasive water jet machining (AWJM), Ultrasonic machining (USM), Electric Discharge Machining (EDM), Electrochemical machining (ECM). Introduction to Wire Electric Discharge Machining (WEDM). Effect of input parameters on material removal in AJM, USM and EDM.

Text Books:

1. Groover, M. P., "Automation, Production Systems and Computer Integrated Manufacturing", Prentice Hall Press, United States, 2007.
2. Ghosh, A., and Mallik, A.K., "Manufacturing Science", 2nd Edition, East-West Press, New-Delhi.

Reference Books:

1. Kumar, K., Zindani, D., Davim, J. P., "Advanced Machining and Manufacturing Processes", Springer, Switzerland.
2. Groover, M. P., "Fundamentals of Modern Manufacturing: Materials, Processes, and Systems", 5th Edition, Wiley Publication.

<table>
<tr><td rowspan="3">Subject: Basic Electronics (Code: ECT254)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Mechanical Engineering
2nd Year & 4th Semester</td><td colspan="3">Total Course Credit: 3</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>0</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

Course Outcomes: At the end of the course, the student should be able to:

- **CO1:** Explain the basic principles associated with semiconductor electronics
- **CO2:** Explain the behavior of different types of diodes and transistors at the circuit level
- **CO3:** Analyze and explain the behavior of operational amplifiers and their applications
- **CO4:** Apply the knowledge of digital logic gates and blocks in designing digital electronic circuits

Detailed Syllabus:

UNIT I

Introduction to semiconductors: Intrinsic and extrinsic semiconductors transport mechanism of charge carriers, electric properties, temperature dependence, and p-n junction diode: current components in p-n junction, characteristics-piece wise linear approximation, and diode circuit's half wave, full wave rectifiers, photo diodes

UNIT II

BJT: Operation and characteristics: CE, CB and CC configuration input, output characteristics biasing and bias stability, low frequency, h-parameter model, analysis and design of transistor amplifier circuits using h-parameters. Multistage amplifiers, transistor as a switch. Introduction to feedback and sinusoidal oscillators, FET's operation and characteristics, JFET model, application at low and high frequency, amplifiers, switching circuits, MOSFET types, operation and characteristics

UNIT III

Operational Amplifier: Operational amplifiers stages, differential amplifier, CMRR, cascade amplifier, ideal and practical operational amplifier characteristics and properties OP-amp applications, inverting and non-inverting amplifiers, difference amplifier, summer differentiator and integrator, rectifiers etc. Instrumentation amplifier

UNIT IV

Digital Logic: Introduction to Boolean theorems and codes, code conversion; Logic gates, combinatorial and sequential blocks

Text Books:

1. Millman, J., Halkias, C., Jit, Satyabrata, "Milman's Electronics Devices and Circuits", Tata McGraw Hill Education, 2010
2. Mano, M Morris, "Digital logic and computer design", Pearson Education India, 2017

Reference Books:

1. Behzad Razavi, "Fundamentals of Microelectronics", Wiley, 2008
2. Mottershed, A., "Electronic Devices and Circuits: An Introduction", Prentice Hall India, 1979.
3. Uyemura, J., "Digital System Design An Integrated Approach", Nelson Engineering, 1999.

<table>
<tr><td rowspan="3">Subject: Thermo-Fluids Lab (Code: MEL255)</td><td rowspan="3">Year & Semester: B. Tech Mechanical Engineering 2nd Year & 4th Semester</td><td colspan="3">Total Course Credit: 1</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>0</td><td>0</td><td>2</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Continuous Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>60 Marks</td><td colspan="3">40 Marks</td></tr>
</table>

Course Outcomes: At the end of the course, the student should be able to:

CO1: Calibrate flow and discharge measuring devices like the venturimeter and orifice meters
CO2: Determine fluid flow properties and characterize laminar and turbulent flows
CO3: Prepare heat balance sheet for steam boilers
CO4: Determine COP of a refrigerator and identify various parts of a cooling tower

List of Experiments:

Thermal:

1. Determination of calorific value using a Bomb Calorimeter.
2. Study of Various Types of Boilers, Boiler Mountings and Accessories
3. Performance and Energy Balance Test on a Fire Tube/ Water Tube Boiler.
4. Study of Refrigeration System and determination of its COP.
5. Study of a cooling tower.

Fluid Mechanics:

1. To determine the viscosity of a fluid by falling sphere (ball) viscometer.
2. To study the flow through a variable area duct and verify Bernoulli's energy equation.
3. To determine the coefficient of discharge for an obstruction flow meter (Venturimeter/orifice meter).
4. To study the transition from laminar to turbulent flow and to ascertain lower critical Reynolds number.
5. To determine the friction coefficient for pipes of different diameters.
6. To determine the velocity distribution for pipeline flow with a Pitot static probe and to measure pressure with pressure sensors.
7. To study the flow visualization through wind tunnel.

<table>
<tr><td rowspan="3">Subject: Non-Traditional Machining and Automation Lab
(Code: MEL256)</td><td rowspan="3">Year & Semester: B. Tech Mechanical Engineering
2nd Year & 4th Semester</td><td colspan="3">Total Course Credit: 1</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>0</td><td>0</td><td>2</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Continuous Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>60 Marks</td><td colspan="3">40 Marks</td></tr>
</table>

Course Outcomes: At the end of the course, the student should be able to:

CO1: Explain the working and use of various components of CNC machines.
CO2: Identify the sequence of codes to process a job
CO3: Create CNC programs for turning and milling operations
CO4: Perform machining operation on Wire Electric Discharge Machine

List of Experiments:

1. To Study the fundamentals of CNC Machine
2. To Study the different codes used in CNC Machine
3. To perform drilling operation on CNC Milling Machine
4. To perform slotting operation on CNC Milling machine
5. To perform turning operation on CNC Lathe Machine
6. To produce given profile using CNC Milling Machine
7. To perform machining operation on Wire Electric Discharge Machine (WEDM)
8. To investigate the effect of WEDM process parameters on the surface roughness of the machined component.

Reference Book:

1. Overby, A., "CNC Machining Handbook: Building, Programming and Implementation", McGraw-Hill, 2010.

Semester-V

S. No.	Course Code	Course Title	Hours Per Week			Total Contact Hours	Credits
			L	**T**	**P**		
1.	MET301	Heat Transfer	**3**	**1**	**0**	**4**	**4**
2.	MET302	Design of Machine Elements	**3**	**1**	**0**	**4**	**4**
3.	MET303	Mechanical Vibrations	**3**	**1**	**0**	**4**	**4**
4.	MET304	Industrial Engineering - I	**3**	**1**	**0**	**4**	**4**
5.	MET305	IC Engines	**3**	**1**	**0**	**4**	**4**
6.	ECT349	Microprocessors in Automation	**3**	**0**	**0**	**3**	**3**
7.	MEL310	Heat Transfer Lab	**0**	**0**	**2**	**2**	**1**
8.	MEL311	Mechanisms and Vibrations Lab	**0**	**0**	**2**	**2**	**1**
						Total Credits	**25**

Subject: Heat Transfer (Code: MET301)	Year & Semester: B. Tech Mechanical Engineering 3rd Year & 5th Semester		Total Course Credit: 4		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term	Class Assessment	End-Term		
	30 Marks	10 Marks	60 Marks		

After the completion of course, students will be able,

CO1	Identify, formulate and solve steady, transient and multidimensional heat conduction problems.
CO2	Understand the phenomenon of convection and be able to evaluate heat transfer coefficients for natural and forced convection.
CO3	Calculate radiation heat exchange between black as well as non-black surfaces
CO4	Be able to solve a wide range of real world problems involving conduction, convection and radiation

Unit I

Introduction, Physical origins and rate equations, conduction, convection, radiation, relationship to thermodynamics, Combined conduction-convection-radiation problems, Importance of heat transfer, conduction rate equation, thermal conductivity, general heat conduction equation, boundary and initial conditions, one dimensional steady heat conduction, plane wall, thermal resistance, composite wall, contact resistance, alternate conduction analysis, one dimensional steady heat conduction in cylinders and spheres, critical radius of insulation, one dimensional steady state heat conduction with heat generation in plane walls, cylinders and spheres, heat transfer from extended surfaces, fins with constant area, fin performance.

Unit 2

Two-dimensional steady state heat conduction, method of separation of variables, conduction shape factor and dimensionless conduction heat rate, unsteady heat conduction, Lumped capacity analysis, criteria for lumped capacity analysis, transient heat conduction in a semi-infinite solid, Biotand Fourier numbers, transient heat conduction in large plane walls, long cylinders and spheres with spatial effects, transient heat conduction in multi-dimensional systems.

Unit 3

Convection boundary layers, Velocity and thermal boundary layer, local and average heat transfer convection coefficients, derivation of differential convection equations, solutions of convection equations for a flat plate, Nusselt and Prandtl numbers, relation between fluid friction and heat transfer, Turbulent-boundary-layer heat transfer, flow across cylinders and spheres, flow across tube banks, Internal forced convection, mean velocity, mean temperature, empirical relations for pipe and tube flows, Free convection heat transfer on a vertical flat plate, Grashof and Raleigh numbers, Empirical relations for free convection, Combined free and forced convection.

Unit 4

Thermal radiation, black and gray surfaces, Radiation laws, Radiation shape factor, relation between shape factors, Radiation heat exchange between black bodies, Radiation heat exchange between non-black bodies, Radiation shields, Condensation heat transfer phenomenon, condensation number, film condensation inside horizontal tube, boiling heat transfer, simplified relations for boiling heat transfer with water, heat exchangers, overall heat transfer coefficient, fouling, types of heat exchangers, log mean temperature difference, Effectiveness-NTU method, Compact heat exchangers.

Textbooks:

1. Incropera, F.P., Dewitt, D.P., Bergman, T.L., Lavine, A.S., "Principles of Heat and Mass Transfer", Wiley, 2017.
2. Holman, J.P., "Heat Transfer, McGraw Hill, 2011.

Reference Books:

1. Bejan, A., "Heat Transfer", John Wiley, 1993.
2. Cengal, Y.A., Ghajar, A.J., "Heat Transfer", McGraw Hill, 2020.

<table>
<tr><td rowspan="3">Subject: Design of Machine Elements
(Code: MET302)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Mechanical Engineering
3rd Year & 5th Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

Core Course Pre-requisites: Engineering mechanics, Mechanics of solids and Engineering materials science.

Course objective: To teach Mechanical Engineering Students how to apply the concepts of stress analysis, theories of failure and material science to analyze, design and/or select commonly used machine components.

Course Outcomes:
On successful completion of the course, Students should be able to:
1. Demonstrate knowledge on basic machine elements used in machine design.
2. Understand the stress and strain on machine components and identify and quantify failure modes for machine parts.
3. Design machine elements to withstand the loads and deformations for a given application, while considering additional specifications.
4. Approach a design problem successfully, taking decisions when there is not a unique answer.

Course Assessment:
Students will be assessed on:
1. Continuous assessment in the form of homework, assignments, attendance, and presentations (10% weightage).
2. One and half hour written exams designated as Mid-term (30% weightage).
3. Two hour written exams designated as End-term (60% weightage).

Course Content:

UNIT I

Design requirements, Selection of materials and manufacturing considerations in design.
Riveted joints: Introduction, Types of riveted joints, Failures of riveted joints, Strength of riveted joint, Efficiency of riveted joint. Design of longitudinal butt joint and circumferential lap joint for a Boiler.
Bolts, Nuts & Screws: Introduction, Advantages & disadvantages, Definitions, Forms of screw threads, Common types of screw fastenings, locking devices. Designation of screw threads, Stresses in screwed fastening due to static loading.
Welded connections: Introduction, Advantages & disadvantages of welded joints, welding processes, fusion welding, thermit welding, gas welding, Electric arc welding, forge welding. Types of welding joints, Lap joint, Butt joint, Strength of transverse fillet welded joints, strength of parallel fillet welded joints, special cases of fillet welded joints, axially loaded unsymmetrical welded sections.

UNIT II

Stress concentration: Theoretical or form stress concentration factor, Stress concentration factor due to holes and notches, Methods of reducing stress concentration. Cyclic loading and endurance limit: Completely Reversed or cyclic stresses, Fatigue and endurance limit, effect of loading on endurance limit, Effect of surface finish, size and miscellaneous factors on endurance limit. Combined steady and variable stress: Gerber method for combination of stresses, Goodman method for combination of stresses, Soderberg method for combination of stresses.

UNIT III

Cotter and Couplings: Types of cotter joints, Socket and spigot cotter joint, Design of socket and spigot cotter joint, Design of sleeve and cotter joint. Types of shaft couplings, Design of sleeve and muff coupling, Design of flange coupling.

Power Screws: Types of screw threads used for power screws, Torque required to raise load on square threaded screws, torque required to lower load by square threaded screws, Efficiency of square threaded screws, Maximum efficiency of a square threaded screw. Over Hauling and Self locking screws. Design of screw jack.

Shafts: types of shafts, design of shafts, shafts subjected to twisting Moment only, Shafts subjected to bending moment only, shafts subjected to combined twisting moment and bending moment.

Text Books:

1. Ullman D.G., "The Mechanical Design process", 3rd edition, McGraw Hill, 2009.
2. Mott, R.L, "Machine Elements in Mechanical Design", 4th edition, Prentice Hall, Singapore, 2005.
3. Richard G. Budynas and J. Keith Nisbett "Shigley's Mechaniucal Engineering Design", 9th Edition, McGraw Hill, 2018

Reference Books:

Shigley, J.E., "Hand Book of Machine Design", McGraw Hill, 2004

<table>
<tr><td rowspan="3">Subject: Mechanical Vibrations (Code: MET303)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Mechanical Engineering 3rd Year & 5th Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

Course Outcomes: At the end of the course, a student should be able to:

CO1: Develop the mathematical models of vibrating systems, determine their DOF, and determine the free and forced vibration response of such systems.
CO2: Determine the response of linear time-invariant systems to arbitrary forcing conditions using the convolution integral and the Laplace Transform method.
CO3: Formulate the equations of motion of multiple degree of freedom systems, express it as an eigen value problem and determine the free and force vibration response.
CO4: Derive the equations of motion of a continuous system, determine its natural frequencies and mode shapes, and obtain the free vibration response to given initial conditions.

Detailed Syllabus:

UNIT I

Harmonic Motion, Vibration Terminology, Complex Methods of Representing Harmonic Motion, Fourier Series and Harmonic Analysis, Free and Forced Vibrations, Degrees of Freedom, Mathematical Modeling of Vibrating Systems, Differential Equations of Motion, Solution of the Differential Equation of Motion, Torsional Vibrations, Various Types of Damping, Dry Friction or Coulomb Damping, Structural Damping, Viscous Damping. Logarithmic Decrement, Energy Dissipated By Damping, Equivalent Viscous Damping, Introduction to Energy Methods.

UNIT II

Forced Harmonic Vibrations, Rotating Unbalance, Support Motion, Vibration Isolation and Control, Vibration Measuring Instruments, Vibration Pickups, Vibrometers and Accelerometers, Vibrations under General Forcing Conditions, Impulse Excitation, Arbitrary Excitation, Convolution Integral, Use of Laplace Transforms, Pulse Excitation and Rise Time, Shock Response Spectrum, Shock Isolation.

UNIT III

Two-Degree-of-Freedom Systems, Normal Mode Analysis, Coordinate Coupling and Principal Coordinates, Forced Harmonic Vibration, Vibration Absorbers and Vibration Dampers, Generalized Coordinates, Natural Frequencies and Mode Shapes, Modal Analysis, Multi-degree-of-Freedom Systems

UNIT IV

Continuous Systems, Longitudinal Vibration of a Bar, Equation of Motion and Solution, Orthogonality of Normal Functions, Lateral Vibration of Beams, Equation of Motion, Initial Conditions, Boundary Conditions, Effect of Axial Force, Effects of Rotary Inertia and Shear Deformation, Whirling of Shafts, Critical Speeds, Balancing of Rotating Shafts, Single-Plane Balancing, Two-Plane Balancing

Text Book:

1. Grover, G. K., Mechanical Vibrations, 7th edition, Nem Chand and Bros, New Delhi, India 1996.

Reference Books:

1. Thomson, W. T., Theory of Vibrations with applications, Fifth Edition, Pearson Education, 2004.
2. Rao, S. S., Mechanical Vibrations, Sixth Edition, Pearson Education.

<table>
<tr><td rowspan="3">Subject: Industrial Engineering-1
(Code: MET304)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Mechanical Engineering
3rd Year & 5th Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

COURSE OUTCOMES:

1. Understanding the concept and applications of industrial engineering with a focus on productivity, work design and work study.
2. Analysing & applying the method study techniques in relation to a particular job environment.
3. Analysing & evaluating various engineering work measurement techniques designed to establish the time for a qualified worker to carry out a specific job at a defined level of performance.
4. Attain a grasp of the fundamental principles of experimental design, collection of data related to work study, their analysis and interpretation.

UNIT I

Concept of industrial productivity**:** Introduction and significance of Industrial engineering with brief explanation of its techniques, Functions of Industrial Engineering, Definitions and explanation of Productivity with significance in Industries, Productivity measurements, Factors affecting productivity, Basic work content and excess work content, Industrial applications to calculate total and partial productivities, Introduction to Work study and its basic procedures, definitions and concept of work study with examples, Human factor in the application of work study, Factors for selecting the work study, Ergonomics**:** scope and objectives of ergonomics, application of human factors in engineering work place design, etc.

UNIT II

Introduction to Method study and the selection of jobs, Record, Examine and Develop, Objectives and basic procedure of Method study, Recording techniques (Process Charts (PC), and Diagrams),Outline PC, Flow process charts, Two hand process charts, MAC (??), Simo chart, Flow diagram, String diagram, Cycle graph, Chronocycle graph, Travel chart, Define, Install and Maintain, the principles of motion economy,

UNIT III

Work measurement and its applications, Time study, Work Sampling, Rating and their methods, Breaking the jobs into Elements, types of Elements, Allowances and their calculations, Calculation of Standard time, Examples of Time study, PMT (??) systems, synthetic data, Various applications and examples.

Text Book:

1. Barnes, R.L., "Motion and Time Study, Design & Measurement of Work*" 7th edition, John Wiley & Sons, New York, 1980.*

Reference Books:

1. International Labor Office, Geneva, "Introduction to Work Study" 4th Edition, Geneva, *1985*.

2. Currie R.M, "Work study", ELBS *& Pitman, London, 1977.*

3. Mundel, M.E., "Motion and Time Study", 5th Edition*, Prentice Hall, Englewood Cliff, NewYork, 1978.*

<table>
<tr><td rowspan="3">Subject: Internal Combustion Engines (IC Engines) (Code: MET305)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Mechanical Engineering 3rd Year & 5th Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

Prerequisites: Thermodynamics, Heat Transfer

Course Outcomes: At the end of the course, the student should be able to:

CO1:	To understand the internal combustion engine design as the largest prime mover for all applications in the world.
CO2:	To understand combustion related characteristics of engine and its fuels.
CO3:	To understand the essential systems of IC engines.
CO4:	To understand numerical on engine design, engine emissions, emissions measurement and its control.

Unit 1

Introduction : Engine classification.

Design and operating parameters: Geometry and geometrical properties, working principle of Two stroke and Four stroke engines, Analysis of air-standard cycles, fuel-air cycles and actual engine cycles, Thermodynamics of actual working fluids, Air capacity of four stroke engines: Ideal air capacity , Volumetric efficiency , ideal induction process , actual induction process, Effect of operating conditions on volumetric efficiency, Effect of design on volumetric efficiency , estimating air capacity. Valve and port timing diagram.
Supercharging and Scavenging in IC engine : Methods of supercharging and turbo-charging in SI and CI engine, limits of supercharging in SI and CI engine. Scavenging in two stroke cycle engines, scavenging parameters and efficiency

Unit 2

Combustion in SI and CI Engine: Classification of fuel, solid, liquid and gaseous fuels, fuel properties and fuel rating, Alternative fuels, mixture requirements, characteristics of SI and CI engine fuels. Combustion and detonation: chemistry of combustion, normal combustion in S.I engines , pre- ignition and auto-ignition comparison, detonation in S.I engines, combustion in C.I engines, detonation in C.I engines, Methods of reducing detonation , preliminary detonation, preliminary facts about fuel and dopes, octane and cetane numbers, effect of design on detonation. Mixture requirements: Steady running, mixture requirements, transient mixture requirements, mixtures requirements for fuel injection engines, mixture requirements for S.I engines. Use of combustion charts for burned mixture Appropriate treatment of fuel air mixtures.

Unit 3

Fuel Injection system: Types of carburetor, mixture requirements, single point and multipoint injection system in SI engine, rate of fuel injection in CI engine, fuel injection pumps and nozzle. Current injection systems in I C engines.

Ignition System: Battery ignition, Magneto ignition and Electronic ignition, factors affecting spark advance, spark advance mechanism. Current ignition systems.

Engine friction and lubrication: Components of engine friction, friction mean effective pressure, Blow by losses, effect of engine variables on friction, side thrust on piston. lubrication principle, types of lubrication ,properties of lubricant.

Heat transfer and Cooling system: Engine temperature distribution, heat transfer consideration, gas temperature variation, effects of operating variables on heat transfer , air cooling and liquid cooling systems, concept of adiabatic engine, Numerical on heat transfer in IC engines.

Unit 4

Engine Testing and performance: Measurement of indicated power, brake power, fuel consumption, air flow rate, engine speed, spark timing, performance characteristics, Numerical on engine design, determination of main dimensions, Numerical on two stroke engines and four stroke engines. Numerical on heat transfer in IC engines, Engine design and principles of similitude. Numerical on alternative fuels, Numerical on diesel fuel injection system, Numerical on verification of engine commercial specifications.

Exhaust Emissions: Pollutants from IC engines. mechanism of pollution formation, methods of emission control, Effect of alternative fuels, Emission norms.

Measurement Of Exhaust Emissions. NDIR, FID, CLA, measurement of exhaust smoke, gas chromatography, effect of operating variables on SI and CI engine pollutant.

Text Book:

1. Heywood, John B. Internal Combustion Engine Fundamentals. McGraw-Hill Book Company.

Reference Books:

1. V. Ganeshan: I. C. Engines: Tata McGraw Hill, New Delhi, 4/e
2. W. W. Pulkrabek: Engineering Fundamentals of I. C. Engines, Prentice Hall India
3. M K Gajendra Babu and K A Subramanian; Alternative Transportation Fuels; CRC Press.

<table>
<tr><td rowspan="3">Subject: Microprocessors in Automation
(Code: ECT349)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Mechanical Engineering
3rd Year & 5th Semester</td><td colspan="3">Total Course Credit: 3</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>0</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

Prerequisites: Basic Electronics

Course Outcomes: At the end of the course, the student should be able to:

CO1	Develop the basic understanding of Microprocessor and its programming
CO2	To introduce basic concepts of interfacing memory and peripheral devices to microprocessor and microcontroller.
CO3	Develop the basic understanding of Microprocessor and its programming
CO4	To design system utilizing microprocessor and microcontroller

Details of the syllabus:

Unit-1:

Fundamental of Microprocessors and Microcontroller: Historical background; Organization & Architectural Features

Unit-2:

The Instruction Set: Instruction format, addressing modes; Assembly language programming of 8085 microprocessor and 8051 microcontroller.

Unit-3:

Interfacing: Interfacing of memory devices; Data transfer techniques and I/O ports; Interfacing of keyboard and display devices; Programmable Interrupt and DMA controllers; Interfacing of sensors, transducers, actuators, A/D & D/A Converters

Unit-4:

Building complete System: Data acquisition systems; Standard Interfaces – RS232, USB; Development aids and troubleshooting techniques; Application examples; Advanced microprocessors and microcontrollers

Text Books:

1. Gaonkar R.S., “Microprocessor Architecture, Programming and Applications”, 5th Ed., Penram International, 2007
2. Ayala K. J., The 8051 Microcontroller Architecture, Programming & Applications, Penram
3. Mazidi and Mazidi, Microcontroller and Embedded Systems, Pearson Education
4. Kapadia, R., 8051 Microcontroller and Embedded Systems, Jaico

Reference Books:

1. Kenneth J Ayala, The 8051 Microcontroller , (3/e), Thomson Delmar Learning, 2004.
2. I. Scott MacKenzie and Raphael C.W. Phan. The 8051 Microcontroller.(4/e), Pearson education, 2008.

<table>
<tr><td rowspan="3">Subject:
Heat Transfer Lab
(Code: MEL310)</td><td rowspan="3">Year & Semester: B. Tech
Mechanical Engineering
3rd Year & 5th Semester</td><td colspan="3">Total Course Credit: 1</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>0</td><td>0</td><td>2</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Continuous Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>60 Marks</td><td colspan="3">40 Marks</td></tr>
</table>

After the completion of course, students will be able,

CO1	Acquire a thorough outlook regarding the steps to design and conduct experiments for measuring specific physical variables
CO2	To apply the concepts learnt in Heat Transfer theory subject to do hands on experiments
CO3	To calculate the thermal conductivity, heat transfer coefficient, and other parameters relevant in heat transfer
CO4	Communicate effectively in completing written reports of laboratory work

List of Experiments

1. To determine the thermal conductivity of a metal bar
2. To determine the thermal conductivity of a liquid
3. To study the heat transfer through the insulating medium
4. To study heat conduction in a composite wall
5. To study heat transfer from a pin fin
6. To study heat transfer in natural convection
7. To study heat transfer in forced convection
8. To study the heat transfer phenomena in a heat exchanger with parallel / counter flow arrangements
9. To determine Stefan Boltzmann constant

<table>
<tr><td rowspan="3">Subject:
Mechanism and Vibration Lab
(Code: MEL311)</td><td rowspan="3">Year & Semester: B. Tech Mechanical Engineering
3rd Year & 5th Semester</td><td colspan="3">Total Course Credit: 1</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>0</td><td>0</td><td>2</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Continuous Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>60 Marks</td><td colspan="3">40 Marks</td></tr>
</table>

COURSE OUTCOMES:

1. The student should be able to prepare technical reports and documents detailing the experimental methodology.
2. Determine the time period of a simple and compound pendulum and visualize the basic characteristics of a simple harmonic motion.
3. Determine the mass moment of inertia (ROG) of irregularly shaped objects using bifilar and trifilar suspensions.
4. Analyze the free and forced vibration characteristics of an equivalent spring mass system and determine its frequency response function.

1. Determine the time period of a simple pendulum. Verify that the time period is

independent of the mass of the bob.

2. Determine the radius of gyration of a compound pendulum.
3. Determine the radius of gyration of a given bar by using a Bifilar suspension.
4. Study the undamped free vibration of an equivalent spring mass system.
5. Study the forced vibration of an equivalent spring mass system.
6. Study the torsional vibration of a single rotor shaft system.
7. Determine the frequency response function of an equivalent spring- mass- dashpot system.
8. Pressure profile measurement on Journal bearing.

Semester-VI

S. No.	Course Code	Course Title	Hours Per Week			Total Contact Hours	Credits
			L	T	P		
1.	MET351	Production Engineering	**3**	**1**	**0**	**4**	**4**
2.	MET352	Mathematical Methods	**3**	**1**	**0**	**4**	**4**
3.	MET353	Control Systems	**3**	**1**	**0**	**4**	**4**
4.	MET354	Fluid Mechanics – II	**3**	**1**	**0**	**4**	**4**
5.		**Elective I**	**2**	**1**	**0**	**3**	**3**
	MET3050	Finite Element Method					
	MET3051	Additive Manufacturing Processes					
	MET3052	Advanced Thermodynamics					
6.		**Elective II**	**2**	**1**	**0**	**3**	**3**
	MET3053	Introduction to MEMS					
	MET3054	Linear Optimization in Engineering					
	MET3055	Advanced Fluid Mechanics					
7.	MEL361	Applied Thermodynamics Lab	**0**	**0**	**2**	**2**	**1**
8.	MEL362	Industrial Engineering – I Lab	**0**	**0**	**2**	**2**	**1**
9.	MEI364	Industrial Training	**-**	**-**	**-**	**-**	**1**
						Total Credits	**25**

<table>
<tr><td rowspan="3">Subject: Production Engineering
(Code: MET351)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Mechanical Engineering
3rd Year & 6th Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

Course Outcomes: At the end of the course, a student should be able to:

CO1: Determine the shear angle and cutting force in machining and understand the basics of metal cutting.
CO2: Estimate tool life and explain the tool wear mechanisms and abrasive machining process.
CO3: Analyze the forming process behavior for conventional and advanced metal forming processes.
CO4: Understand the basics of limits, fits and tolerances in manufacturing.

Detailed Syllabus:

UNIT I

Introduction to machining; Orthogonal cutting; Oblique cutting; Types of chips; Mechanics of chip formation; chip breakers; Mechanics of Metal Cutting: Merchant's circle diagram; Determination of cutting and thrust forces; Coefficient of friction; strain rate; Measurement of shear angle, Thermal aspects of machining, Numerical problems.

UNIT II

Mechanisms of tool wear; Types of tool wear, Tool life: Variables affecting tool life-Cutting conditions; Tool angles specification systems; Tool materials; Desirable Properties of Cutting Tool; Determination of tool life; Machinability, Economics of machining.
Abrasive Machining Process: Introduction; Grinding: Characteristics of a grinding wheel; Specification of grinding heels; Mechanics of grinding process; Grinding operations; Wheel wear; Surface Finish; Selection of grinding wheels.

UNIT III

Metal Forming: Hot and cold working, Rolling; Forging; Extrusion; Sheet metal working. Introduction to high energy rate forming processes, their advantages and application. Electromagnetic forming, Explosive forming, Electrohydraulic forming.

UNIT IV

Metrology: Introduction to Metrology, Accuracy and Precision. Limits, fits and tolerances, need of providing tolerance, unilateral and bilateral system, Taylor's principles of gauge design, Sine bars and gauge blocks manufacturing method and their applications, Numerical problems.

Text Book:

1. Manufacturing Science-A. Ghosh and A.K. Malik, Affiliated East Press, New-Delhi.

Reference Book:

1. Campbell, J.S., Principles of Manufacturing Materials and Processes, McGraw-Hill, New-York,
2. Engineering Metrology and Measurements by N.V. Raghavendra and L. Krishnamurthy, 1st Edition, Oxford University Press
3. Rao, P.N., Manufacturing Technology, Volume 2, McGraw-Hill Education, New Delhi.
4. Lindberg, R.A., Processes and Materials of Manufacturing, Allyn and Bacon, Boston

<table>
<tr><td rowspan="3">Subject: Mathematical Methods
(Code: MET352)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Mechanical Engineering
3rd Year & 6th Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

COURSE OUTCOMES:

1. Able to solve non-linear equations using, R.F, Newton Rapson methods.
2. Able to solve linear system of equations using Gauss elimination, Gauss-Jourdan, Gauss siedel & LU decomposition
3. Able to use interpolation formulas; and linear & non linear curve fitting.
4. Able to use numerical differentiation & integration methods. Solve ODEs & PDEs using numerical methods.
5. Able to develop computer programmes for the above methods and interpret them graphically.

UNIT I

Flow charts. Computer languages. Constants and variables. Arithmetic expressions. Input/ output, control statements. Introduction to programming.Types of errors. Computational algorithms and computer arithmetic. Iterative methods. Solution of equations: Bisection method, Regula-falsi method, Newton Raphson method. Solution of linear system of equations: Gauss elimination, Gauss-Jordan, Gauss- Siedel method, LU decomposition.

UNIT II

Interpolation and approximation of functions, Newtons forward formula (equal and unequal intervals) Curve fitting (straight line, nonlinear, exponential) differentiation, integration (Trapezoidal/Simpson’s rule, Weddle’s) and program.

UNIT III

Numerical solution of ordinary different equations. Runge- Kutta methods, Types of PDEs, boundary value problems, solution of parabolic PDEs using finite differences and program.

- Examples to be taken from Mechanical engineering applications.

Text Book:

1. Sastry,S. “ Numerical Methods”, *Printice Hall of India, New Delhi*.

2. Chapra & Chapra Numerical methods for Engineers. Mc. Graw Hill.

Reference Books:

1. Veerarajan, “ Numerical Methods”, *Tata Mc-GrawHill, New Delhi, 2000.*

<table>
<tr><td rowspan="3">Subject: Control Systems
(Code: MET353)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Mechanical Engineering
3rd Year & 6th Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

Course Outcomes: At the end of the course, a student should be able to:

CO1: Develop the mathematical models of LTI dynamic systems, determine their transfer functions, describe quantitatively the transient response of LTI systems, interpret and apply block diagram representations of control systems and understand the consequences of feedback.
CO2: Use poles and zeroes of the transfer functions to determine the time response and performance characteristics and design PID controllers using empirical tuning rules.
CO3: Determine the stability of linear control systems using the Routh-Hurwitz criterion and classify systems as asymptotically and BIBO stable or unstable.
CO4: Determine the effect of loop gain variations on the location of closed-loop scales, sketch the root locus and use it to evaluate parameter values to meet the transient response specification of closed loop systems.
CO5: Define the frequency response and plot asymptotic approximations to the frequency response function of a system. Sketch a Nyquist diagram and use the Nyquist criterion to determine the stability of a system.

Detailed Syllabus:

UNIT I

Introduction to Control Systems, Examples of Control Systems, Closed-Loop Control Versus Open-Loop Control, Laplace Transforms, Transfer Functions and Block Diagrams, Mathematical Modeling of Control Systems, Differential Equation or Time-Domain Models of Linear Time-Invariant (LTI), Transfer Function or s-Domain Models, Poles and Zeros of the Transfer function, Convolution Integral and Impulse-Response Function, Mathematical Modeling of Mechanical Systems and Electrical Systems

UNIT II

Transient and Steady-State Response Analyses, Transient Response Analysis of First-Order Systems, Second-Order Systems and Higher-Order, Systems, Performance characteristics of control systems, Transient Response Specifications, Rise Time, Peak Time, Maximum, Overshoot, Settling Time, Steady-State Errors in Unity-Feedback, Control Systems, Basic Control Actions, Effects of Proportional, Derivative and Integral Control actions on system performance, PD, PI, and PID Controllers

UNIT III

Stability of Linear Time-Invariant (LTI) Systems, Asymptotic Stability, Bounded Input Bounded Output (BIBO) Stability, Routh's Stability Criterion, Control Systems Analysis and

Design by the Root-Locus Method, Some Developmental Concepts, Rules of Construction, Plotting Root Loci with MATLAB, Root-Locus Approach to Control-Systems Design

UNIT IV

Control Systems Analysis and Design by the Frequency-Response Method, Obtaining Steady-State Outputs to Sinusoidal Inputs, Bode Diagrams, Log-Magnitude-versus-Phase Plots, Integral and Derivative Factors, first-Order Factors, Quadratic Factors, Polar Plots, Nyquist Stability Criterion, Experimental Determination of Transfer Functions, Control Systems Design by Frequency-Response Approach

Text Book:

K. Ogata, Modern Control Systems, Prentice-Hall of India, 5th edition, 2010 (ISBN 10: 0-13-615673-8)

Reference Books:

Norman S. Nise, Control Systems Engineering, Fourth Edition, 2004, John Wiley and Sons

<table>
<tr><td rowspan="3">Subject: Fluid Mechanics-II (Code: MET354)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Mechanical Engineering 3rd Year & 6th Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

Course Outcomes: At the end of the course, student will be able to:

CO1	Understand the working of gas turbine plant components and analyse their performance.
CO2	Understand the working of centrifugal and axial air compressors and analyze their performance.
CO3	Understand the working of hydraulic turbines and analyze their performance.
CO4	Understand the working of hydraulic pumps and analyze their performance.

Unit-I

Review of Basics: Introduction to Prime Movers, Gas Turbines, Review of Basic principles - Thermodynamics, Review of Basic principles - Fluid Dynamics and Heat Transfer, Fundamentals of Rotating Machines - Energy Equation, Dimensional Analysis, Aerofoil Theory.
Ideal Gas Turbine Cycles: Analysis of Ideal Gas Turbine Cycles, Simple Cycle, Regeneration Cycle, Reheat Cycle, inter cooling Cycle.
Practical Gas Turbine Cycles: Analysis of Practical Gas Turbine Cycles, Methods of accounting for component losses, Efficiencies, change in the composition of the working fluid. Combustion Chambers:Gas turbine combustion systems - Introduction, Geometry, Factors affecting Design & Performance, Requirements of the Combustion Chamber, Gas Turbine Combustion Emissions.

Unit-II

Centrifugal Compressors: Centrifugal Compressors- Principle of Operation, T-s diagram, Energy equation, velocity triangles, types of blades. Analysis of Flow, Performance Characteristics.
Axial Flow Compressors: Axial Flow Compressors - Construction, Principle of Operation, T-s diagram, Energy equation, velocity triangles. Analysis of Flow. Work done factor, Stage efficiency, Degree of reaction, Performance characteristics.

Unit-III

Hydraulic Turbines: Principle of impingements of jets, Euler equation, classification of Hydraulic Turbines, Constructional Details, Analysis, Efficiencies & Design Parameters of Impulse (Pelton Turbine) and Reaction Turbines (Francis, Kaplan& Propeller Turbine), Draft Tube, Cavitation, Governing of Hydraulic Turbines, Characteristics of the Hydraulic Turbine

Unit-IV

Centrifugal pumps: Advantages of Centrifugal Pumps over Reciprocating Pumps, Construction and Working of a Centrifugal Pump, Classification of Centrifugal Pumps, Different Heads of Centrifugal Pumps, Different Efficiencies of a Centrifugal Pump, Analysis of a Centrifugal Pump, Minimum

Starting Speed of a Centrifugal Pump, Maximum Suction Lift and Net Positive Suction Head, Cavitation, Priming, Pumps in Series and in Parallel

Fluid System: Hydraulic press, Hydraulic accumulator, hydraulic intensifier, Fluid coupling, torque convertor, hydraulic ram, hydraulic actuator, airlift pump.

Reading:

1. Ganesan, V., Gas Turbines 3/e, Tata McGraw Hill Book Company, New Delhi, 2010.
2. Vasandani, V.P. and Kumar, D.S., Treatise on Heat Engineering, Chand and Co Publishers, New Delhi, 2011.
3. Saravanmuttoo, H.I.H., Rogers, G.F.C. and Cohen H., Gas Turbine Theory, 6/e. Pearson Prentice Education, 2008.
4. Applied Thermodynamics for Engineering Technologists 5th Edition (English, Paperback, Eastop T.D.).

<table>
<tr><td rowspan="3">Subject: Elective-I
Finite Element Methods
(Code: MET3050)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech
Mechanical Engineering
3rd Year & 6th Semester</td><td colspan="3">Total Course Credit: 3</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>2</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

Course Outcomes: Upon successful completion of this course students should be able to:

1. Understand the concepts behind formulation methods in FEM.

2. Identify the application and characteristics of FEA elements such as bars, beams, plane and iso-parametric elements.

3. Develop element characteristic equation and generation of global equation.

4. Able to apply suitable boundary conditions to a global equation for bars, trusses, beams, circular shafts, heat transfer, fluid flow problems and solve them & find displacements, stress and strains induced.

UNIT I

Basic Concept, Historical background, Engineering applications, general description, Comparison with other methods. Need for weighted-integral forms, relevant mathematical concepts and formulae, weak formulation of boundary value problems, variational methods, Rayleigh-Ritz method, and weighted residual approach.

UNIT II

Model boundary value problem, finite element discretization, element shapes, sizes and node locations, interpolation functions, derivation of element equations, connectivity, boundary conditions, FEM solution, post-processing, compatibility and completeness requirements, convergence criteria, higher order and isoparametric elements, natural coordinates, Langrange and Hermite polynomials.

UNIT III

External and internal equilibrium equations, one-dimensional stress-strain relations, plane stress and strain problems, axis-symmetric and three dimensional stress-strain problems, strain displacement relations, boundary conditions, compatibility equations, computer programs.

Variational approach, Galerkin approach, one-dimensional and two-dimensional steady-state problems for conduction, convection and radiation, transient problems.

Inviscid incompressible flow, potential function and stream function formulation, incompressible viscous flow, stream function, velocity-pressure and stream function-vorticity formulation, Solution of incompressible and compressible fluid film lubrication problems.

Text Books:

1. Logan, D. L., A first course in the finite element method,6th Edition, Cengage Learning, 2016.

2. Rao, S. S., Finite element method in engineering, 5 th Edition, Pergaman Int. Library of Science, 2010.

3. Chandrupatla T. R., Finite Elements in engineering, 2nd Edition, PHI, 2013.

Reference Books:

1. J.N.Reddy, “Finite Element Method”- McGraw -Hill International Edition.

2. Bathe K. J. Finite Elements Procedures, PHI. 2. Cook R. D., et al. “Concepts and Application of Finite Elements Analysis”- 4th Edition, Wiley & Sons, 2003.

<table>
<tr><td rowspan="3">Subject: Elective-I
Additive Manufacturing Processes
(Code: MET3051)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech
Mechanical Engineering
3rd Year & 6th Semester</td><td colspan="3">Total Course Credit: 3</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>2</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

COURSE OUTCOMES: At the end of this course, the students shall be able to:

1. Understand the basics of additive manufacturing (AM) and working principles of different AM processes.
2. Explore the applications of different AM processes in various fields.
3. Analyze various AM processes to understand their relative merits and demerits.
4. Design and develop functional models using different AM techniques.

Unit-I

Introduction to Additive Manufacturing: Introduction to AM, AM evolution, AM vs traditional manufacturing, advantages and limitations of AM over conventional manufacturing, nomenclature of AM machines, prototyping, tooling and manufacturing. Classification of AM processes, common AM processes, generalized AM process chain and steps in AM, types of materials for AM.

Unit-II

Vat Photo polymerization AM Processes: Introduction, materials for AM processes utilizing Vat Photo polymerization, Stereo-lithography (SL), photo polymerization process, process modeling, variants and classification of VAT photo polymerization process, Advantages and drawbacks of vat photo polymerization processes.

Powder Bed Fusion (PBF) AM Technique: Introduction to PBF, materials, powder fusion mechanism, process parameters and modeling, powder handling, powder fusion techniques, PBF process variants, Advantages and drawbacks of PBF.

Extrusion Based AM Processes: Introduction, basic principles of extrusion-based processes, Fused Deposition Modeling (FDM), materials, Bio extrusion, Contour Crafting, Non-Planar systems, RepRap FDM systems, process benefits and drawbacks.

Unit-III

Material Jetting (MJ) and Binder Jetting (BJ) AM Processes: Introduction to MJ and BJ, materials, process description to MJ and BJ, variants of MJ and BJ, comparison between MJ and BJ, benefits and drawbacks.

Sheet Lamination AM Processes: Introduction, Variants of sheet lamination, Laminated Objected Manufacturing (LOM), Ultrasonic additive manufacturing (UAM), benefits and drawbacks of UAM.

Directed Energy Deposition (DED) AM Processes: Introduction to DED, process description, classification of DED techniques, benefits and drawbacks of DED.

Recommended Texts:

1. Manu Srivastava, Sandeep Rathee, Sachin Maheshwari, TK Kundra**,** "Additive Manufacturing: Fundamentals and Advancements", Ist ed.2019, Boca Raton: CRC Press, Taylor & Francis group.

2. Ian Gibson, David W Rosen, Brent Stucker., "Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing", 2nd Edition, Springer, 2015.

Recommended References:

1. Sandeep Rathee, Manu Srivastava, Sachin Maheshwari, TK Kundra, Arshad Noor Siddiquee, "Friction Based Additive Manufacturing Technologies: Principles for Building in Solid State, Benefits, Limitations, and Applications", Ist ed.2018, Boca Raton: CRC Press, Taylor & Francis group.

2. Chua Chee Kai, Leong Kah Fai, "3D Printing and Additive Manufacturing: Principles & Applications", 4th Edition, World Scientific, 2015.

3. D.T. Pham, S.S. Dimov, Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer 2001.

4. Andreas Gebhardt, Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing, Hanser Publishers, 2011.

<table>
<tr><td rowspan="2">Subject: Elective-I
Advanced Thermodynamics
(Code: MET3052)</td><td colspan="2" rowspan="2">Year & Semester: B. Tech
Mechanical Engineering
3rd Year & 6th Semester</td><td colspan="3">Total Course Credit: 3</td></tr>
<tr><td>L
2</td><td>T
1</td><td>P
0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

After the completion of course, students will be able,

CO1	To extend the in-depth knowledge in the application of the laws of thermodynamics
CO2	To apply concepts of entropy generation and exergy to practical applications/systems
CO3	To have a coherent knowledge about the evaluation of the thermodynamic properties
CO4	To identify, formulate and solve a wide range of real world problems involving energy transfer

Unit 1

Scope and methods of thermodynamics, Review of Thermodynamics, Mathematical background, Macroscopic and Microscopic approaches in thermodynamics, Energy and first law of thermodynamics, First law for closed and open systems, Broadening understanding of energy transfer by work and heat, Structured presentation of First law of Thermodynamics.

Unit 2

Second law of thermodynamics, Traditional formulation of Second law of thermodynamics, logical relation between alternative statements of the second law, Mathematical formulation of second law of thermodynamics, Entropy maximum and Energy Minimum principle, Born-Caratheodory formulation of second law.

Unit 3

Entropy Generation, Concept of Exergy of system, Exergy balance of closed and open systems, Second Law efficiency (of heat engines, heat pumps, refrigerators, work producing and consuming devices, heat exchangers), Thermoeconomics, Exergy account of a vapour power plant (Case study), Thermodynamics of a Biological System.

Unit 4

Thermodynamic properties of pure fluid, ideal gas properties, State relationships for real gases and liquids, Two-constant and Multiconstant Equation of state, Virial Equations, Vander Waals Equation of State, Redlich-Kwong Equation of state, Compressibility charts, Generalized Equation of state, Maxwell's relations, Generalized relations, Evaluation of Thermodynamic properties, p-v-t relations for gas mixtures, Multicomponent systems, Chemical potential (Fugacity).

Textbooks:

1. Bejan, A., "Advanced Thermodynamics" John Wiley & Sons, 2006.
2. Moran, M.J., Shapiro, H.N., Boettner, D.D., Bailey, M.B., "Principles of Engineering Thermodynamics", Wiley India, 2017.

Reference Books:

1. Kestin, J., "A Course in Thermodynamics", McGraw Hill, 1979.
2. Wark, K., "Advanced Thermodynamics", McGraw Hill, 1995.

<table>
<tr><td rowspan="3">Subject: Elective-II
Introduction to MEMS
(Code: MET3053)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech
Mechanical Engineering
3rdYear & 6thSemester</td><td colspan="3">Total Course Credit: 3</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>2</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

After the completion of course, students will be able,

CO1: Demonstrate a sound background in the area of microfabrication, to the extent that the student should be able to critically judge a fabrication process and synthesize a new one for future applications.
CO2: Become acquainted with common design and fabrication processes of MEMS through studies of classical and concurrent cases.
CO3: Evaluate and conceptualize several intersecting points in study of MEMS devices, such as design, fabrication, performance, robustness and cost, among others, involved in successfully developing integrated MEMS devices.

Detailed Syllabus:

UNIT I

Definition of MEMS, Scaling and Miniaturization Concepts, Silicon as a MEMS Material, Mechanical Properties of Silicon, Fabrication Technologies, Introduction to Micro-Fabrication, Silicon Based MEMS Processes, Surface Micromachining, Sacrificial Etching Process, Bulk Micromachining and Silicon Anisotropic Etching, Bulk Versus Surface Micromachining, Mechanical Components in MEMS.

UNIT II

Review of Essential Electrical and Mechanical Concepts, Conductivity of Semiconductors, Review of Solid Mechanics for Design of Mechanical Components, Crystal Planes and Orientation, Mechanical Properties of Silicon and the related Thin Films.

UNIT III

Review of Electrostatics and Electrodynamics, Electrostatic Sensing and Actuation, Analysis of Comb Drives, Dynamics of Comb Drives, Electrostatic sensing and Actuation, Piezoelectric Sensing and Actuation, Piezoresitive Sensing, Thermal Sensing and Actuation, Scaling Laws, Instrumentation for MEMS testing and Characterization

Text books:

1. Chang Liu, Foundations of MEMS, 2nd edition, Pearson, 2012

Reference Books:

1. Senturia,S.D., “Microsystem Design”, Kluwer Academic Publisher,2000.

2. Nadim M, An Introduction to Microelectromechanical Systems Engineering, Artech House, 1999

<table>
<tr><td rowspan="3">Subject: Elective-II
Linear Optimization in Engineering
(Code: MET3054)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech
Mechanical Engineering
3rd Year & 6th Semester</td><td colspan="3">Total Course Credit: 3</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>2</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

After the completion of course, students will be able,

S.No.	Course Outcomes
CO1	Develop critical thinking and objective analysis of real-life decision problems which could be analyzed under the ambit of Operations Research.
CO2	Formulate and solve linear programming problems using appropriate techniques and models, interpret the results obtained and translate solutions into directives for action.
CO3	Realize the project life cycle and perform project planning activities that accurately forecast project costs, timelines, and quality in order to implement processes for successful resource, time, communication, risk and change management.
CO4	Analyze and solve real life industrial engineering problems, using mathematical tools, arising from a wide range of applications.

Detailed Syllabus:

UNIT I

Overview of Operations Research (OR), OR Methodology and techniques, Introduction to Linear Programming (LP), Application of LP techniques in Production management, graphical solutions, the simplex method, Duality and Sensitivity analysis, transportation model problems and their variants, assignment model problems.

UNIT II

Project planning and scheduling, CPM & PERT, Project crashing and recourse allocation problems, decision theory, steps in decision making, decision making under uncertainty and under risk, marginal analysis, decision trees.

UNIT III

Flow shop scheduling, Job shop scheduling, Queuing theory and their applications, Waiting line models and their applications, introduction and basic concepts of Simulation.

Text Books:

1. Taha, H.A., "Operation Research- an Introduction", 6th edition, Prentice Hall of India, New Delhi, 2000.

Reference Books:

1. Joseph Ecker, Michael K, "Introduction to Operations Research" John Wiley & Son, 1998.
2. Hillier &Lieberman, "Introduction to Operations Research", McGrawHill, Singapore, 2001.
3. Gupta M.P, Khanna R.B., "Quantitative Techniques for Decision Making", Prentice Hall of India, New Delhi, 2008.

<table>
<tr><td rowspan="3">Subject: Elective-II
Applied Fluid Mechanics
(Code: MET3055)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech
Mechanical Engineering
3rd Year & 6th Semester</td><td colspan="3">Total Course Credit: 3</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>2</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

After the completion of course, students will be able,

CO1	To have a good knowledge of the methods and techniques in viscous flows theory and be in a position tointerpret viscous flow phenomena
CO2	To writeNavier-Stokes equations (conservation laws for mass, momentum, and energy) for simple fluids
CO3	To solve for velocity and pressure fields in a viscous flow subjected to steady and transient conditions and formulate boundary layer approximations
CO4	To identify, formulate and solve flow problems by applying knowledge of fluid mechanics and mathematics

UNIT I

Introduction, Concept of a fluid, Concept of Viscosity, Concept of Continuum, Properties of a fluid, Historical outline, Flow analysis Techniques, Eulerian and Langrangian flow description, Classification of fluid flows, Velocity and acceleration field, Material derivative, Control Volume and differential element approach, Reynolds Transport Theorem, Conservation of mass, Linear Momentum Equation, Energy Equation, Fluid Element kinematics, Linear motion and deformation, Angular motion and deformation.

UNIT II

Vectors and Tensors, Representation of second order tensor, Addition, subtraction and multiplication of tensors, Transpose of a tensor, Symmetric and Unsymmetric tensor, Unit tensor, Dyadic product, Divergence, Curl, Gradient of a vector and tensor, Significance of Gradient of velocity vector, Deformation, rotation, Divergence Theorem, Constitutive Equations for fluids, Stress Tensor for a simple flow, Stoke's Principle, Navier-Stokes Equation.

UNIT III

Exact Solutions of the Navier-Stokes Equations, Flow between through a straight stationary channel, Couette Flow, Hagen-Poiseulle flow, Flow between two concentric rotating cylinders, Axially moving concentric cylinders, Unsteady parallel flow (Stoke's first problem), Flow near an oscillating flat plate (Stoke's second problem), start-up of Couette flow, Transient axisymmetric Poiseulle flow, Flow of two immiscible fluids in a channel, Fully developed flow of a power law fluid, Superposition of Poiseuille and Couette flows.

UNIT IV

Laminar Boundary layers, Boundary-layer equations, Flow over a Flat plate, Blasius flow, Momentum-Integral Equation for the Boundary layer, Approximate methods for Boundary layer equations, Karman-Pohlhausen Method for Flow over a Flat Plate, Turbulent boundary layers, Characteristics of Turbulent flow, Laminar-Turbulent Transition, Engineering implications of turbulence, Correlation functions, Reynolds decomposition, Governing Equations for Turbulent flow, Measurement of Turbulence quantities, Shear-stress models, Prandtl's Mixing Length Hypothesis.

Textbooks:

1. White, F.M., "Viscous Fluid Flow", McGraw Hill, 2013.
2. Schlicting, H., "Boundary Layer Theory", McGraw Hill, 1979.

Reference Books:

1. Muralidhar, K., Biswas, B., "Advanced Engineering Fluid Mechanics", Narosa Publishing House, 2015.
2. Graebel, W.P., "Advanced Fluid Mechanics", Academic Press, 2009.
3. Aris, R., "Vectors, Tensors and Basic Equations of Fluid Mechanics", Dover Publications, 1962.
4. Munson, B.R., Young, D.F., Okiishi, T.H., Fundamentals of Fluid Mechanics, Wiley, 2017.

<table>
<tr><td rowspan="3">Subject:
Applied Thermodynamics Lab
(Code: MEL361)</td><td rowspan="3">Year & Semester: B. Tech
Mechanical Engineering
3rd Year & 6th Semester</td><td colspan="3">Total Course Credit: 1</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>0</td><td>0</td><td>2</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Continuous Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>60 Marks</td><td colspan="3">40 Marks</td></tr>
</table>

Prerequisites: Thermodynamics, Fluid Mechanics, Applied Thermodynamics, Hierodulic machines

Course Outcomes: At the end of the course, the student should be able to:

CO1: To investigate the performance and emission testing of SI Engine.

CO2: To investigate the performance and emission testing of CI Engine.

CO3: To acquire knowledge of working principle of compressors.

CO4: To gain knowledge of Turbines,

List of Experiments:

1. Study of different internal combustion engine models.
2. Experimental study of characteristic performance curves & emission of spark ignition engine using gasoline as fuel.
3. Experimental study of characteristic performance curves & emission of compression ignition engine using diesel as fuel.
4. Study of working of compressors using different compressor models.
5. Experimental study of characteristic performance curves of single cylinder reciprocating compressors.
6. To study the constructional details of hermetically sealed reciprocating compressor.
7. Study of the Pelton wheel Turbine.
8. Study of the Francis Turbine.

<table>
<tr><td rowspan="3">Subject:
Industrial Engineering-I Lab
(Code: MEL362)</td><td rowspan="3">Year & Semester: B. Tech
Mechanical Engineering
3^{rd} Year & 6^{th} Semester</td><td colspan="3">Total Course Credit: 1</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>0</td><td>0</td><td>2</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Continuous Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>60 Marks</td><td colspan="3">40 Marks</td></tr>
</table>

COURSE OUTCOMES:

1. Demonstrate human factors/ergonomic principles (HF/E) that influence the design, performance and safety of work systems.
2. Apply HF/E guidelines and use standard HF/E in the design of work systems.
3. Model work systems using standard techniques, such as flow diagrams, process charts, operation charts, activity charts, block diagrams, and process maps, for purposes of work system documentation, analysis, and design.
4. Determine the time required to do a job using standard data, occurrence sampling, time study, and predetermined time systems.

List of Experiments:

1. Ergonomic design study (Present/proposed/new) of a product, equipment or work environment (human-machine interface) – (This involves about four to five laboratory classes / sessions)
2. To assembly a product (electrical holder, etc.), record the cycle time and draw learning curve of the operator performing the assembly.
3. Draw Out line process chart and two hand flow process charts for the assembly performed in experiment no. 2, and analyse the present method and also suggest improved method/s.
4. Study and draw of flow process charts (some suitable assembly operation)
5. Study and draw multi activity chart of a suitable method and propose better method/s.(Man and machine)
6. Study suitable movements/travel of man, material or equipment, and draw string diagram, travel chart and flow diagrams.
7. To calculate the standard time of a suitable job, using predetermined time standard techniques.

<table>
<tr><td rowspan="3">Subject:
Industrial Training
(Code: MEI364)</td><td rowspan="3">Year & Semester: B. Tech
Mechanical Engineering
3rd Year & 6th Semester</td><td colspan="3">Total Course Credit: 1</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>0</td><td>0</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td></td><td colspan="3"></td></tr>
<tr><td></td><td colspan="3"></td></tr>
</table>

CO1	To study the concept of Facility, Location & Layout & implement in their Industrial training Project work.
CO2	An understanding of the impact of engineering solutions and industrial safety in a global and social context.
CO3	Develop the ability to work as an individual and in group with the capacity to be a leader or manager as well as an effective team member.
CO4	Demonstrate competence in mechanical engineering fields through problem identification, formulation and solution.

Semester-VII

S. No.	Course Code	Course Title	Hours Per Week			Total Contact Hours	Credits
			L	T	P		
1.	MET401	Mechatronics and Measurement Systems	**3**	**1**	**0**	**4**	**4**
2.	MET402	Industrial Engineering - II	**3**	**1**	**0**	**4**	**4**
3.	MET403	Machine Design	**3**	**1**	**0**	**4**	**4**
4.		**Elective-III**	**3**	**1**	**0**	**4**	**4**
	MET4001	Advanced Mechanics of Solids					
	MET4002	Material Testing Inspection & Characterization					
	MET4003	Refrigeration & Air conditioning					
5.		**Elective-IV**	**3**	**1**	**0**	**4**	**4**
	MET4004	Basic Fracture Mechanics					
	MET4005	Advanced Manufacturing Technology					
	MET4006	Conduction heat Transfer					
	MET4007	Online Course					
6.	MEL411	Mechatronics and Measurement Systems Lab	**0**	**0**	**2**	**2**	**1**
7.	MEL412	Industrial Engineering – II Lab	**0**	**0**	**2**	**2**	**1**
8.	MEP413	Major Project – Stage I	**0**	**0**	**6**	**6**	**2**
9.	MES414	Seminar	**0**	**0**	**4**	**4**	**1**
						Total Credits	**25**

<table>
<tr><td rowspan="3">Subject: Mechatronics and Measurement Systems (Code: MET401)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Mechanical Engineering 4rd Year & 7th Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

COURSE OUTCOMES:

CO1: Describe the various static and dynamic characteristics of instruments and explain their effect on instrument behavior.
CO2: Explain the principle of sensors/transducers and describe a suitable calibration procedure for a particular instrument.
CO3: Identify advantages and limitations of measuring systems and comment on their suitability for a particular application
CO4: Explain some of the typical methods employed to measure motion, temperature, force, pressure, and flow

UNIT I

Measurement and Instrumentation; definitions, significance, Fundamental methods, generalized measurement system, Functional elements, Types of input quantities, standards, calibration, uncertainty, Errors, Classification of instruments, Input-output configuration, Interfering and modifying inputs, methods of correction, Generalized performance characteristics, static characteristics, static calibration, Dynamic characteristics, zero and first order instruments, time constant, Second-order instruments, transient response characteristics. Relative and absolute motion devices, relative displacement, Resistive potentiometers, bridge circuit, LVDT, Variable inductance and variable capacitance pick-ups, Piezoelectric transducers, fibre optic displacement transducer, Resistance strain gage, Relative velocity-translational and rotational, Mechanical revolution counters and timers, stroboscopic method, Moving coil and moving magnet pickups, DC and AC tachometers, Eddy current drag-cup tachometer, acceleration measurement.

UNIT II

Hydraulic and pneumatic load cells, flapper nozzle principle, Force transducers with elastic members, Proving ring transducer, cantilever beam transducer, electromagnetic balance, Dynamometers – Absorption, driving and transmission type, reaction forces in shaft bearings, prony brake, eddy current brake dynamometer, Instruments for high, mid and low pressure measurement, dead weight and null type, Elastic element gages, Differential pressure cell, high pressure measurement, Low pressure measurement –, Pirani gages & McLeod pressure gauge.

UNIT III

Orifice meters, Venturimeter, Pitot tube, Flow nozzle, Variable area meters, rotameter, design and accuracy, Positive displacement flow meter, turbine flow meter, Electromagnetic flow meter, ultrasonic flow meters, Temperature sensing techniques, liquid-in-glass and bimetallic thermometers, Pressure thermometers, electrical resistance thermometers, Thermistors, Thermocouples, thermopiles, Radiation pyrometers, Optical pyrometer.

Text Book:

1. Beckwith, B., "Mechanical Measurements", 6th edition, *Pearson Education Int. ,2008*.

Reference Book:

1. Nakra B.C. "Instrumentation, Measurements & Analysis", 2nd edition, *Tata McGrawHill, N.Delhi, 2008.*

2. Doeblin, E.O., "Measurement systems",5th edition, *McGraw Hill, New Delhi, 2004.*

<table>
<tr><td rowspan="3">Subject: Industrial Engineering-II
(Code: MET421)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Mechanical Engineering
4rd Year & 7th Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

COURSE OUTCOMES:

1. Grasp the concept of organizational design with emphasis on organization principles & work design.
2. Analyse & design facility location and layout using various techniques and softwares.
3. Demonstrate the ability to use the methods of statistical quality control and process control for effective designing of Industrial Quality Monitoring Systems.
4. Demonstrate the ability to apply the techniques of material management and inventory control for effective designing and systematic implementation of various MM methods and inventory systems in manufacturing set-up.

UNIT I

Factory organization**:** Introduction to Plant organization, Principles of Organizational structure, Organization charts, Types of Organizations, Developing an organization structure, Results of good organization,, Informal organization, advantages and disadvantages.

Location and Layout analysis: Introduction to Facility location problems, Factors affecting the plant location. Break even analyses and their application, Subjective, qualitative and semi- Quantitative techniques of facility location, Single facility Location problem, Minimax Location problem, Gravity problem and their applications. Line balancing, Introduction to facility layout and their objectives, Classification of Layouts, with advantages and disadvantages of each, Layout design procedures(CRAFT,CORELAP,ALDEP), Material handling systems, Make or Buy decisions, Planning and control of Batch Production,. Characteristics of Batch Production, Determination of Batch size, Minimum Cost batch Size, Maximum Profit Batch size, Sequencing and scheduling for Batch Production, Line of Balance technique.

UNIT II

Inspection and quality control**:** Concept and Definition of Quality, Concepts of Inspection and quality control, Objectives of inspection, Function of Inspection and their types, Concept of statictical quality control (SQC), Process variation, Sampling inspection. Concepts and types of Control charts, Acceptance sampling, application of control charts and sampling plans.

UNIT III

Materials management and inventory control**:** Integrated materials management and their components, Functions and objectives of material management, Introduction and concepts of Inventory management, Purchase model with instantaneous replenishment and without shortage, Manufacturing model without shortages, Purchase model with shortages, Manufacturing model with shortages, Probabilistic inventory concepts with lead time., Selective inventory management- ABC , FSN, VED analyses.

Text Book:

1. Everett, E.A., Ronald J.E, "Production and Operations Management" *Prentice Hall of India, 5th edition, New Delhi, 2001.*

Reference Books:

1. Claude, S.G., "Management for Business & Industry" *Prentice Hall of India*, New Delhi, 2000.
2. Everett, E.A., Ronald J.E, "Production and Operations Management", *Prentice Hall of India, 5th Edition, New Delhi, 2001.*
3. Grant, E.L; Leavenworth R.S, "Statistical Quality Control", *Tata Mcgraw Hill, 7th Edition*, New Delhi, 1996.
4. Apple, J.M, "Plant Layout & Material Handling", *John Wiley & Sons, New York.*
5. Maynard, Industrial Engineering Hand Book, *McGraw Hill, New York.*

<table>
<tr><td rowspan="2">Subject: Machine Design (Code: MET403)</td><td colspan="2" rowspan="2">Year & Semester: B. Tech Mechanical Engineering 4rd Year & 7th Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L
3</td><td>T
1</td><td>P
0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

COURSE OUTCOME:

1. Analyse the stress and strain of mechanical components.
2. Demonstrate knowledge of basic machine elements used in machine design.
3. Design machine elements to perform functions in order to obtain desired objectives under various operating conditions.
4. Conduct a failure analysis for the design of mechanical components to select the suitable materials and manufacturing considerations.

UNIT I

Design of friction elements, various types of brakes, design equations for various types of brakes, design analysis of all types of brakes, e.g., band brake, long shoe brake, etc. design analysis of all types of clutches, design of couplings and keys for shafts, etc, design and analysis of flat and V-belt, equations for power, slip, etc, design of chain drive.

UNIT II

Introduction to gear design, design of spur gear, equation for σ_b and σ_c for spur gear, design analysis for bending, force analysis for Helical gear, design analysis for helical gear, design of bevel gear, determination of bearing forces, horizontal and vertical shafts, design analysis for bevel gear , design analysis for worm gear.

UNIT III

Introduction to Plain bearings, Bearing surface at Micro level, Derivation of Energy equation and PV factor , PV graph, Values of PV , Derivation of Wear coefficient equation, Step-by-step procedure for Plain bearing design, Self lubricating bearings and use of clearance for life of bearing, Design of Hydrodynamic bearings, Derivation of Reynolds equation for three dimensional case, Journal bearing geometry,Variation of viscosity with pressure and temperature, Viscosity index, Sommerfeld number, Analysis of ho, h_{min}, Q_{in}, Q_{loss}, T_{in} , T_{out}, Introduction to Rolling element bearings, Design of AFB (??) , Equations for L_{10} life, Static loading and dynamic loading ,Use of AFB catalogue, Determination of Load based on radial and thrust load for ball bearings, Derivation of Load equation for Tapered AF bearings, Design analysis on the basis of loads and selection of AFB from a catalogue.

Text Books:

1. Mot, R.L., “Machine Elements in Mechanical Design”, *Maxwell Macmillan Intl. edition N.York , USA, 1992.*
2. Shigley, J.E., “Machine Engineering Design*”, McGraw Hill, higher education,2004.*

Reference Books:

Shigley, J.E., Mischke, C. Brown T., “Standard Hand book of Machine Design” *McGraw Hill.*

<table>
<tr><td rowspan="3">Subject: Elective-III Advanced Mechanics of Solids
(Code: MET4001)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Mechanical Engineering
4rd Year & 7th Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

Pre-requisite(s): Strength of Materials

Course Outcomes:
At the end of the course, a student should be able to:
CO1 Understand the concept of tensor.
CO2 Analyse advanced concept of stress and strain in structural problems.
CO3 Apply the concept of different elastic functions to solve complex problems.
CO4 Evaluate the influence of various geometric and loading parameters in plane stress and plane strain problems.

UNIT 1

Mathematical Preliminaries: Introduction to tensor algebra: symmetric and skew-symmetric tensor, summation convention, eigenvalue and eigenvector of tensor, spectral theorem, polar decomposition theorem, product of tensor, principal invariants of tensor, coordinate transformation of tensor, Tensor calculus: gradient, divergence, curl, differentiation of scalar function of a tensor. (8 L)

UNIT 2

Analysis of Stress and Strain: Definition and notation of stress, Cauchy stress tensor, equations of equilibrium, principal stresses and stress invariants, stress deviator tensor, octahedral stress components, General deformations, small deformation theory, strain transformation, principal strains, spherical and deviatoric strains, Strain-displacement relations, strain compatibility, stress and strain in curvilinear, cylindrical, and spherical coordinates, fundamental equations of plasticity. (8 L)

UNIT 3

Problem formulation and solution strategies: Field equations, boundary conditions, stress and displacement formulation, Beltrami-Michell compatibility equations, Lame-Navier's equations, principle of superposition, uniqueness theorem, Saint-Venant's principle, Brief descriptions about general solution strategies - direct, inverse, semi-inverse, analytical, approximate, and numerical methods. (8 L)

UNIT 4

Two-dimensional problems: Plane stress and plane strain problems, generalized plane stress, Antiplane strain, Airy stress function, polar coordinate formulation and solutions, Cartesian coordinate solutions using polynomials and Fourier series method. (8 L)

Text Books:
1. Elasticity, Theory, Applications, and Numerics by Martin H. Sadd
2. Theory of Elasticity by Stephen Timoshenko and , J. N. Goodier
3. Advanced Mechanics of Solids, Otto T. Bruhns, Springer publications.

Reference Books:
1. Continuum Mechanics, A.J.M Spencer, Dover Publications, INC
2. Advanced Mechanics of Materials by H. Ford and J. M. Alexander 3. The Linearized Theory of Elasticity, W. S. Slaughter, Springer Science + Business Media, LLC

Subject: Elective-III Materials Testing Inspection and Characterization (Code: MET4002)	**Year & Semester: B. Tech Mechanical Engineering 4rdYear & 7thSemester**		**Total Course Credit: 4**		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term	Class Assessment	End-Term		
	30 Marks	10 Marks	60 Marks		

COURSE OUTCOMES:

By successful completion of this course, the student will be able to

1. Understand various destructive and non destructive methods of testing materials.
2. Explain the principles of metallurgical microscope, X-ray Diffractrometer (XRD), Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), Thermal analysis and dilatometer.
3. Describe the various sample/specimen preparation techniques for XRD, SEM, TEM and thermal analysis and quantitative metallography.
4. Apply knowledge to select appropriate tool to characterize the material by knowing its merits and demerits.

UNIT I

Purpose and importance of destructive tests – Concepts, and method of Tensile, hardness, bend, torsion, fatigue and creep testing.

UNIT II

Purpose and limitations of NDT, Concepts, operating principles, liquid penetrant test, magnetic particle testing, eddy current testing, ultrasonic testing radiography, acoustic emission, thermal imaging method. Comparison of NDT methods and selection of NDT methods.

UNIT III

Tools of characterisation - Light microscopy, basic principles and special techniques. X-ray diffraction and its applications in materials characterization.

Electron microscopy, Construction, operation and applications of scanning electron microscope (SEM), transmission electron microscope (TEM)

UNIT IV

Thermal analysis: Thermo gravimetric analysis, differential thermal analysis, differential scanning calorimetry &dilatrometry.

TEXT BOOKS:

1. Non-destructive testing, B.Hull And V.John, Macmillan, 1988.
2. Modern Physical Metallurgy and Materials Engineering, R. E. Smallman, R. J. Bishop, sixth edition, Butterworth-Heinemann, 1999.
3. Materials Characterisation, P.C.Angelo, Elsevier (India) Pvt. Ltd, Haryana, 2013,

<table>
<tr><td rowspan="3">Subject: Elective-III
Refrigeration and Air Conditioning
(Code: MET4003)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech
Mechanical Engineering
4rd Year & 7th Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

Course Outcomes:

1. To Identify the need and importance of various refrigeration and air conditioning cycles, the typical and some advanced and innovative schematic designs, and the goals of R&AC systems.
2. To design the VCRS and VARS with improving performance parameters.
3. To describe the working of different types of air conditioning systems.
4. To evaluate the actual applications of R&AC.

UNIT-I

Introduction

Basics of refrigerator and heat pump, Carnot refrigeration and heat pump, units of refrigeration, COP of refrigerator and heat pump, Carnot COP, Ice refrigeration, evaporative refrigeration, refrigeration by expansion of air, refrigeration by throttling of gas, vapor refrigeration system, steam jet refrigeration, thermo- electric cooling, adiabatic demagnetization

Basic Principle of operation of air refrigeration system, Bell Coleman air refrigerator, advantages of using air refrigeration in air craft, disadvantage of air refrigeration in comparison to other cold producing methods, simple air refrigeration in air craft, simple evaporative type, air refrigeration in air craft, necessity of cooling the air craft.

UNIT-II

Vapor Compression refrigeration system

Simple vapour compression cycle, Methods of improving COP, flash chamber, flash inter cooler, optimum inter stage pressure for two stage refrigeration system, single expansion and multi expansion cases, basic introduction of single load and multi load systems, cascade systems, Nomenclature of refrigerants.

Vapor absorption refrigeration system and special topics

Basic absorption system, COP and maximum COP of the absorption system. Actual NH_3 absorption system, function of various components, Li-Br absorption system, Selection of refrigerant and absorbent pair in vapor absorption system, Electro-Lux refrigerator, comparison of compression and absorption refrigeration system, , desirable properties of refrigerants, cold storage and Ice Plants.

UNIT-III

AIR CONDITIONING

Psychrometric properties of moist air, By- pass factor of coil, sensible heat factor, ADP of cooling coil, Air washer. Air conditioning systems: Classification, factors affecting air conditioning systems, comfort air conditioning system, winter air conditioning system, summer Air Conditioning system, year-round air-conditioning system, unitary air conditioning system, central air conditioning system, Room sensible heat factor, Grand sensible heat factor, effective room sensible heat factor, Industrial application of Air conditioning.

Text Books:

1. Refrigeration and Air Conditioning - C.P. Arora, Tata McGraw-Hill
2. Refrigeration and Air- Condition by W. Stoecker Mc Graw Hill

Reference Books:

1. Basic Refrigeration and Air Conditioning- Ananthana and Rayanan, McGraw-Hill
2. Refrigeration and Air Conditioning- Arora and Domkundwar, Dhanpat Rai.

<table>
<tr><td rowspan="3">Subject: Elective-IV
Basic Fracture Mechanics
(Code: MET4004)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech
Mechanical Engineering
4rdYear & 7thSemester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

COURSE OUTCOMES:

1. Identify and describe different failure mechanisms in materials and engineering structures.
2. Explain how a crack affect an engineering structure and describe the state of stress and strain that may arise in the vicinity of the crack front in different materials
3. Evaluate fracture toughness for structures with cracks using LEFM and EPFM techniques.
4. Analyze the crack growth in materials subjected to fatigue loads.

UNIT I

Mechanisms of fracture and crack growth, cleavage fracture, ductile fracture, fatigue cracking, Summary of basic problems and concepts in fracture, a crack in a structure, theoretical strength of a material, Inglis's solution, crack tip stresses, the Griffith criterion, Modified Griffith's theory

UNIT II

The elastic crack-tip stress field, Stress Intensity factor, the effect of finite size, Some special cases, elliptic cracks the energy principles, the concept of energy release rate, the criterion for crack growth, the crack resistance, the concept of J-integral, crack opening displacement criterion, K_{IC} and G_{IC} test methods

UNIT III

Crack-tip plastic zone, Irwin's plastic zone correction, The Dugdale approach, Plane stress versus plane strain, plastic constraint factor, the thickness effect, application of von Mises and Tresca yield criteria to obtain plasticity effected regions, Fatigue failure, S-N curve, Crack initiation and propagation, effect of overload, crack closure, Environmental assisted cracking, service failure analysis

Text Book:

1. Anderson T.L., "Fracture Mechanics Fundamentals and applications", *CRC, Taylor & Francis, 2005.*

Reference Book:

1. Janssen, M. J., Zuidema, J., Wanhill R.J.H., "Fracture Mechanics", *Spon Press, 2004*.
2. Prashant Kumar, "Elements of Fracture Mechanics", *McGraw Hill Education, 2017*

<table>
<tr><td rowspan="3">Subject: Elective-IV
Advanced Manufacturing Technology
(Code: MET4005)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech
Mechanical Engineering
4rd Year & 7th Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

CO1	Identify the use of advanced manufacturing processes in industries and explain the process of micro machining.
CO2	Identify the need of super finishing processes and understand the process of super finishing.
CO3	Understand the process of non-conventional forming.
CO4	Apply knowledge to select appropriate surface processing technique to get the desired surface properties.

UNIT I

Introduction to Advanced manufacturing processes, Advantages of advanced manufacturing processes. Advances in Machining: High speed machining, hard turning. Micro machining: Introduction and need of micro machining, Diamond Micro- grinding/turning, Abrasive Micro machining, Ultrasonic Micromachining, Electric-discharge Micro-machining, Laser Micro-machining, Electrochemical Micro-machining.

UNIT II

Super finishing processes: Introduction to finishing processes, Need and application of superfinishing processes, Abrasive flow finishing, Magnetic Abrasive flow finishing, Magneto rheological abrasive flow finishing.

UNIT-III

Advances in forming: Introduction and application of non-conventional forming, need of non-conventional forming, Electro Magnetic forming, Hydro forming, explosive forming. Advantages of non-conventional forming.

UNIT IV

Surface processing: Introduction and need of surface processing, surface properties, cladding, chemical vapour deposition, physical vapour deposition, shot peening, surface modification by severe plastic deformation. Strategies for improving surface properties.

Text books:	• A. Ghosh and A.K. Malik,Manufacturing Science-, Affiliated East Press, New-Delhi. • Degarmo, E.P., Black, J.T. and Kohser, R.A, Materials and Processes in Manufacturing, Prentice Hall of India, 2006.
Reference books:	• Rao, P.N., Manufacturing Technology, Volume 2, McGraw-Hill Education, New Delhi. • Serop K. Steven, “Manufacturing Processes for Engineering Materials”, Prentice Hallof India,2004

<table>
<tr><td rowspan="3">Subject: Elective-IV
Conduction Heat Transfer
(Code: MET4006)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech
Mechanical Engineering
4^{rd}Year & 7^{th}Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

COURSE OUTCOME

CO1 To formulate and solve one dimensional steady state heat conduction problems

CO2 To formulate and solve two-dimensional steady state and transient heat conduction problems

CO3 To solve heat conduction problems involving phase change

CO4 To identify, formulate and solve real world problems related to heat conduction

UNIT I

Introduction, Fourier's law of heat conduction, thermal conductivity, Differential formulation of heat conduction in rectangular, cylindrical and spherical coordinates, General boundary conditions and initial condition, non-dimensional analysis of the heat conduction equation, heat conduction for anisotropic medium, one-dimensional steady state heat conduction, Extended surfaces, Constant area fins, Variable area fins, moving fins, Bessel differential equations and Bessel functions.

UNIT II

Two-dimensional steady state heat conduction, Separation of variable method, Homogeneous differential equations and boundary conditions, Sturm-Liouville boundary valve problems, Non-homogeneous differential equations, Non-homogeneous boundary conditions, Method of superposition, Solution to problems in Cartesian and cylindrical coordinates, Unsteady heat conduction, lumped heat capacity system, Non homogeneous equations and boundary conditions, Transient conduction in plates, Transient conduction in cylinders, Transient conduction in spheres, Duhamel's Superposition Integral, Conduction in Semi-infinite regions.

UNIT III

Heat conduction involving phase change, Moving interface boundary condition, non-linearity of the interface energy equation, Simplified model (Quasi-Steady approximation), Exact solutions, Stefan's solution, Solidification of semi-infinite region, Melting of semi-infinite region.

UNIT IV

Heat Transfer in living tissue, Mathematical modeling of vessel-Tissue heat transfer, Microscale heat conduction, physics of energy carriers, Limitations of Fourier's law, Hyperbolic heat conduction, Solutions and approximations for the microscale heat transfer, Inverse heat transfer, parameter estimation, applications to heat transfer, method of sensitivity coefficients, Least squares approach, linear and non-linear inverse problems.

Textbooks:

1. Jiji, L.M., "Heat Conduction", Springer, 2009.
2. Kakac, S., Yener, Y., Naveira-Cotta, C.P., "Heat Conduction", CRC Press, 2018.

Reference Books:

1. Ozisik, M.N., Hahn, D.W., "Heat Conduction", John Wiley, 2012.

2. Muralidhar, K., Banerjee, J., "Conduction and Radiation", Naraosa Publishing House, 2010.
3. Poulikakos, D., "Conduction Heat Transfer", Prentice Hall, 1993.

<table>
<tr><td rowspan="3">Subject: Elective-IV
Online Course
(Code: MET4006)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Mechanical Engineering
4rd Year & 7th Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
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ONLINE COURSE

<table>
<tr><td rowspan="3">Subject:
Mechatronics and Measurement System Lab (Code: MEL411)</td><td rowspan="3">Year & Semester: B. Tech Mechanical Engineering
4rd Year & 7th Semester</td><td colspan="3">Total Course Credit: 1</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>0</td><td>0</td><td>2</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Continuous Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>60 Marks</td><td colspan="3">40 Marks</td></tr>
</table>

COURSE OUTCOME:

1. Identify and use basic modern tools for measurement of electrical and electronic signals.
2. Identify and use different types of sensors and actuators for designing a mechatronic product.
3. Design basic circuits utilizing modern electrical and electronic components including operational amplifiers and integrated circuits.
4. Write basic microcontroller programs for controlling a mechatronic product.

LIST OF EXPERIMENTS

1. Sensor/Actuator - Interfacing, calibration, frequency domain characterization, MATLAB serial interface, and serial LCD display
2. Design of electropneumatic circuits for L (??) and square cyles using PLC's.
3. Sorting of components on an intelligent a conveyor system.
4. Modelling of DC Motor System.
5. DC Motor position tracking.
6. DC Motor position set-point control via PID controller, using relay automatic tuning technique7.
7. Disection of an existing system.
8. Demonstration of recent projects on Mechatronics.
9. Mini Project on Independent modeling, analysis, and design of a mechatronic control system (Select one “mechatronic plant” from the Quanser, rotary family).

<table>
<tr><td rowspan="2">Subject:
Industrial Engineering - II Lab
(Code: MEL412)</td><td rowspan="2">Year & Semester: B. Tech Mechanical Engineering
4rd Year & 7th Semester</td><td colspan="3">Total Course Credit: 1</td></tr>
<tr><td>L
0</td><td>T
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2</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Continuous Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>60 Marks</td><td colspan="3">40 Marks</td></tr>
</table>

COURSE OUTCOMES:

1. Present a numerical and graphical characterization of quantitative data assuming the quantitative data are observations from a normal distribution to compute the Probability of specific numerical outcomes. Construct and interpret normal Probability plots of quantitative data.
2. Construct, implement and interpret X-bar and R control charts for variables from Standards and from data; and demonstrate how to use the corresponding OC curves.
3. Construct, implement and interpret p, c, and u control charts for attributes from Standards or data; and demonstrate how to use the corresponding OC curves.
4. Demonstrate and simulate layouts to determine optimum material flow rate and cycle time of a job using witness software.

List if experiments:

1. To study the layout of a shop in an organization and draw existing and proposed layouts.
2. To measure the variable characteristics (diameter of pins, with micrometer) and prepare a frequency histogram. Calculate values of X bar and sigma.
3. Verify that when random samples are taken from a lot with a certain percentage of defective, same %age lands to appear in random sampling by using Shewart's kit.
4. Simulate an inspection situation with the help of a Schewhart's bowl and plot X bar, and R charts using computed data.
5. To conduct Process capability study of a machine tool and to specify the tolerances for a job.
6. To verify the theorem "the standard deviation of the sum of any number of independent variables is the square root of the sum of the squares of the S.Ds of the independent variable. Determine statistically, the permissible tolerance of mating components, when the tolerance of the assembly is given.
7. To draw control chart for percent defectives after inspecting a sample and sorting out the defective units.

<table>
<tr><td rowspan="3">Subject: Major Project – Stage I
(Code: MEP413)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Mechanical Engineering
4rdYear & 7thSemester</td><td colspan="3">Total Course Credit: 2</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>0</td><td>0</td><td>6</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Supervisor</td><td colspan="3">End-Term</td></tr>
<tr><td>20 Marks</td><td>40 Marks</td><td colspan="3">40 Marks</td></tr>
</table>

CO1 Identify a topic in advanced areas of Mechanical Engineering.

CO2 Review literature to identify gaps and define objectives & scope of the work.

CO3 Generate and implement innovative ideas for social benefit.

CO4 Develop prototypes/models, experimental set-up and software systems necessary to meet the objectives.

<table>
<tr><td rowspan="3">Subject: Seminar
(Code: MES414)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Mechanical Engineering
4rd Year & 7th Semester</td><td colspan="3">Total Course Credit: 1</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>0</td><td>0</td><td>4</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>-</td><td>Presentation</td><td colspan="3">Report Submission</td></tr>
<tr><td>-</td><td>60 Marks</td><td colspan="3">40 Marks</td></tr>
</table>

CO1	Review literature on a given advanced topic related to the specific stream.
CO2	Summarise the concept of the chosen topic systematically after considerable study of the content from primary as well as secondary sources
CO3	Learn and present the structure and format of technical reports as per specified norms
CO4	Interpret graphs of various kinds and discuss the concept & conclusion in an open seminar.

Semester-VIII

S. No.	Course Code	Course Title	Hours Per Week			Total Contact Hours	Credits
			L	T	P		
1.	MET451	Operations Research	**3**	**1**	**0**	**4**	**4**
2.		**Elective-V**	**3**	**1**	**0**	**4**	**4**
	MET4056	Theory of thin plates & shells					
	MET4057	Entrepreneurship development & Risk Management					
	MET4058	Power Plant Engineering					
3.		**Elective-VI**	**3**	**1**	**0**	**4**	**4**
	MET4059	Theory of Elasticity					
	MET4060	Advanced welding & Allied Processes					
	MET4061	Renewable Energy Systems					
4.		**Elective-VII**	**3**	**1**	**0**	**4**	**4**
	MET4062	Mechanics of Composite Materials					
	MET4063	Value Engineering					
	MET4064	Design of fluid Thermal Systems					
	MET4065	Online Course					
5.	MEP463	Major Project – Stage II	**0**	**0**	**18**	**-**	**9**
						Total Credits	**25**

<table>
<tr><td rowspan="2">Subject: Operation Research (Code: MET451)</td><td colspan="2" rowspan="2">Year & Semester: B. Tech Mechanical Engineering 4rdYear & 8thSemester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L
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0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

COURSE OUTCOMES:

1. Illustrate knowledge of fundamental concepts about operation research.
2. Compare and categorize the knowledge of different approaches to operational performance improvement.
3. Appraise the ability to work effectively in a team and in group and use of business tools.
4. Outline the various Japanese techniques for justify the knowledge and performance improvement in industrial cost control.

UNIT I

Introduction to Operations Research: Basics definition, scope, objectives, phases, models and limitations of Operations Research. Linear Programming Problem – Formulation of LPP, Simplex Method, Graphical solution of LPP., Artificial variables, big-M method, two-phase method, degeneracy and unbound solutions.

UNIT II

Transportation Problem. Formulation, solution, unbalanced Transportation problem. Finding basic feasible solutions – Northwest corner rule, least cost method and Vogel's approximation method. Optimality test: the stepping stone method and MODI method.

UNIT III

Assignment model. Formulation. Hungarian method for optimal solution. Solving unbalanced problem. Traveling salesman problem and assignment problem. Sequencing models. Solution of Sequencing Problem – Processing and Jobs through 2 Machines – Processing n Jobs through 3 Machines – Processing 2 Jobs through m machines – Processing n Jobs through m Machines.

UNIT IV

Inventory models. Inventory costs. Models with deterministic demand – model (a) demand rate uniform and production rate infinite, model (b) demand rate non-uniform and production rate infinite, model (c) demand rate uniform and production rate finite.

Replacement Models. Replacement of Items that Deteriorate whose maintenance costs increase with time without change in the money value. Replacement of items that fail suddenly: individual replacement policy, group replacement policy.

TEXT BOOKS:

1. P. Sankara Iyer, "Operations Research", Tata McGraw-Hill, 2008.
2. A.M. Natarajan, P. Balasubramani, A. Tamilarasi, "Operations Research", Pearson Education, 2005.

REFERENCE BOOKS:

1. J K Sharma., "Operations Research Theory & Applications , 3e", Macmillan India Ltd, 2007.
2. P. K. Gupta and D. S. Hira, "Operations Research", S. Chand & co., 2007.

3. J K Sharma., "Operations Research, Problems and Solutions, 3e", Macmillan India Ltd.
4. N.V.S. Raju, "Operations Research", HI-TECH, 2002.

<table>
<tr><td rowspan="2">Subject: Elective-V
Theory of Thin Plates and Shells
(Code: MET4056)</td><td colspan="2" rowspan="2">Year & Semester: B. Tech Mechanical Engineering
4rd Year & 8th Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L
3</td><td>T
1</td><td>P
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<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

Course Outcomes:

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

1. Use analytical methods for the solution of thin plates and shells.
2. Use analytical methods for the solution of shells.
3. Apply the numerical techniques and tools for the complex problems in thin plates.
4. Apply the numerical techniques and tools for the complex problems in shells.

UNIT I

Introduction: Space Curves, Surfaces, Shell Co-ordinates, Strain Displacement Relations, Assumptions in Shell Theory, Displacement Field Approximations, Stress Resultants, Equation of Equilibrium using Principle ofVirtual Work, Boundary Conditions.

UNIT II

Static Analysis of Plates: Governing Equation for a Rectangular Plate, Navier Solution for Simply- Supported Rectangular Plate under Various Loadings, Levy solution for Rectangular Plate with other Boundary Conditions.

UNIT III

Circular Plates: Analysis under Axi- Symmetric Loading, Governing Differential Equation in Polar Co-ordinates. Approximate Methods of Analysis- Rayleigh-Ritz approach for Simple Cases in Rectangular Plates.

UNIT IV

Static Analysis of Shells: Membrane Theory of Shells- Cylindrical, Conical and Spherical Shells, Shells of Revolution with Bending Resistance - Cylindrical and Conical Shells, Application to Pipes and Pressure Vessels. Thermal Stresses in Plate/ Shell

Text books:

- Theory of Plates and Shells, Timoshenko S. and KriegerW., McGraw Hill.
- Stresses in Plates and Shells, UguralAnsel C., McGraw Hill.

References:

- Thin Elastic Shells, KrausH., John Wiley and Sons.
- Theory of Plates, ChandrashekharaK., Universities Press.
- Design and Construction of Concrete Shells, Ramaswamy G.S.

<table>
<tr><td rowspan="3">Subject: Elective-V
Entrepreneurship Development and Risk Management
(Code: MET4057)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Mechanical Engineering
4rdYear & 8thSemester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
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<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

COURSE OUTCOME:

On completion of the course, the students will be able to:

1. Understanding the dynamic role of entrepreneurship and small businesses
2. Organize and Manage a Small Business
3. Understand Financial Planning, Control and Strategic Marketing Planning
4. Explain New Product or Service Development and Business Plan Creation

UNIT-1

Introduction to Entrepreneurship: Meaning, Role of Entrepreneur, Entrepreneur Process: different approaches, Motivation for becoming an Entrepreneur. SME Concept, its role, status, prospects and policies for promotion of SMEs. Importance of Entrepreneurship: innovations, Qualities of successful Entrepreneur, Functions of an Entrepreneur, Types of Entrepreneur, Issues & Problems Entrepreneurial Practices, 11 Contribution of Entrepreneurs: Towards R&D, creates Wealth of Nation & Self prospect with Challenge, Entrepreneur Carrier: Different Stages, Entrepreneur Development Programmers (EDPs).

UNIT-II

Characteristics of Entrepreneurship: Risk taker, Perceptive, Curious, Imaginative, Persistent, Goal setting, Hardworking, Research & Management Skill, Soft skills and Feasibility, Women Entrepreneurship: Opportunities, promotion Hurdles and Prospects of women Entrepreneurs.Factors & Models of Entrepreneurial Development, Social Entrepreneurial Initiative: Solving social Problems, Business plan, Strategic Plan vs Business Plan, Technical and Financial Feasibility study and analysis of projects under self employment scheme including small entrepreneur. The World of Opportunity, Idea versus Opportunity, sources of ideas and idea generation techniques, sources of opportunities, identification and selection of opportunities, the Business Plan, Components of a business plan, How to develop a good business plan?, Role of Entrepreneurial Institutions in Entrepreneurship Development, Various Schemes and Incentives.

UNIT-III

Farm based enterprises for production and post production of Agri-produce: Crops: Cereals, Legumes, Oilseeds; Horticulture crops : Fruits and vegetables; Livestock production : Poultry, Fishery, Medicinal and Aromatic plants. Handlooms & Sericulture; Handicraft, coir, jute & leather Agro-Eco Tourism, Micro entrepreneurial skills development and good production practices, Role of Ministry of MSME, Registration Process of MSME, Emerging Technologies & Business Opportunities in India.

UNIT-IV

Risk Management: Risk Factor, Sensitivity Analysis, Vulnerability Analysis, External Risk, Internal Risk, Environmental Risk. Financial planning . Forecasting inputs and outputs, Components of the financial plan, Bootstrapping ,Venture and Growth Capital, Managing a Micro Enterprise, Human resource development for enterprise growth; delegation, motivation and leadership in microenterprises.

REFERENCE BOOKS

1. Byrd Megginson, Small Business Management An Entrepreneur’s Guidebook 7th ed, McGraw-Hill, Irwin
2. N. V. R. Naidu, Naidu I. K, Management and Entrepreneurship. International Pvt Ltd, 01- Jan-2008
3. Frank Martin and Marcus Thompson Palgrave, Social Enterprise Developing Sustainable Businesses Macmillan
4. David R. Stokes, Nicholas Wilson Cengage, Small Business Management and Entrepreneurship Learning EMEA, 2006 - Business & Economics
5. Donald F. Kuratko Cengage, Learning Entrepreneurship: Theory, Process, Practice Business & Economics 14-Nov-2008
6. Timmons, Jerry A., and Spinelli, Stephen, 2009. New Venture Creation: Entrepreneurship for the 21st Century, 8th Edition, Boston, MA: Irwin McGraw-Hill
7. Carree, M.A., and A.R. Thurik „Impact of Economic Growth,’Hand Book of Entrepreneurship Research, New York:Springer

<table>
<tr><td rowspan="3">Subject: Elective-V
Power Plant Engineering
(Code: MET4058)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech
Mechanical Engineering
4rd Year & 8th Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

Course Outcomes:

CO1	Identify the different types of power plants and understand the layout and working of steam power plant.
CO2	Understanding of hydroelectric power plant and coordination or combined operation of different types of power plants.
CO3	Able to describe the working operations of nuclear, diesel, gas power plants.
CO4	To apply & analyses the economics of power plant and able to decides the tariffs for different power plants.

UNIT I

Introduction:- Energy source for generation of electric power. Principle types of power plants, their special features and applications, major power plants in India.

Steam Power Plants :- Selection of site, general layout of the power plant, special features of the modern steam boilers, circulation principle, steam separation and purification, economizers and air pre-heater types and estimation of performance, super-heater and superheat control, feed water heaters, cooling tower , temperature and pressure control. Introduction to hydro electric power plant, types of hydro-electric plant in combination with steam plant, Runoff river plant in combination with steam plant, storage plant in combination with steam or nuclear plant, Coordination of hydro-electric and gas turbine stations, coordination of different types of power plants.

UNIT II

Nuclear Power Plants :- Nuclear fuel, nuclear energy by fission, main components of nuclear reactors, pressurized water, boiling water, liquid metal and gas nuclear reactors.

Diesel Power Plants :- Plant layout , two and four stroke cycle diesel engines, fuel injection, lubrication and cooling systems, supercharging and starting systems. Gas and Steam Turbine combined Cycles:- Simple gas and steam combined cycle power generation.

UNIT III

Economic Analysis of Power Plants and Tariffs :- The cost of electrical energy , selection of types of generating equipment , performance and operating characteristics of power plant , load division among generators , Tariff methods of electrical energy .Combined operation of different power plants :- Advantages of combined working , Load division among power stations , Storage

Text Book:

1. Rajput R.K., “A text book of power plant engineering”, *Laxmi Publication, Pvt. Ltd., New Delhi, 2007.*

Reference Books:

1. Thermal Engineering by Ballaney, Khanna Publisher
2. Thermal Engineering by Domkundar& Arora, Dhanpat Rai
3. Steam Turbine Theory & Practice by Kearton, W.J. Pitman.
4. Power Plant Engineering by Morse
5. Power Plant Engineering by Domkundwar
6. Power Plant Technology by El-Wakil

<table>
<tr><td rowspan="3">Subject: Elective-VI
Theory of Elasticity
(Code: MET4059)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech
Mechanical Engineering
4rdYear & 8thSemester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

Course Outcomes:

1. Explain the fundamental concept of stress & strain followed by an analytical expression relating the stress & strain in 3-D systems.
2. Apply the compatibility equations & boundary conditions to solve the problems of T.O.E in practices.
3. Analyze the structural members subjected to pure bending using the fundamental concept of stress,strain & elastic behaviours of materials.
4. Apply analytical techniques to predict the ffects of stress concentration in simple solids & structural components.

UNIT I

Introduction: Elasticity, stress components of stress and strain, Hooks law. Equations in polar coordinates, Plane stress and plane strain: Strain at a point, Mohr circle for strain rosette, differential equation of equilibrium, boundary conditions, compatibility equations, overview of Airys stress functions.

UNIT II

Two dimensional problems in rectangular coordinates: solution by polynomials, St Venants principles, determination of displacement, bending of beams, solution by Fourier series. Two dimensional problems in polar coordinates: Equations in polar coordinates, equation about 1-axis, and pure bending in curved bars.

UNIT III

Determination of strains and displacement, effect of circular hole on stress distribution in plate concentrated and vertical loading of a straight boundary, circular disc, general solution and its applications, Analysis of stress and strain in thee dimensions: stress at a point, principal stress, stress ellipsoid and stress director surface, homogenous deformation, strain at a point, principle strain rotation.

Text Books:

1. Timoshanko, S.P. and Goodier, J.N., "Theory of Elasticity," *Mc-Graw Hill Book Company, N.Y. , USA, 1970.*

Reference Books:

1. Love, A.E.H., "The Mathematical Theory of Elasticity," *Dover Publications, NewYork, USA, 1944.*

<table>
<tr><td rowspan="3">Subject: Elective-VI
Advanced Welding and Allied Processes
(Code: MET4060)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech
Mechanical Engineering
4rdYear & 8thSemester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

Course Outcomes:

CO1 Identify the use of welding processes in manufacturing industries.

CO2 Apply knowledge to select appropriate welding process based on the application.

CO3 Explain welding of plastics and underwater welding.

CO4 Understand the process of thermal spraying and thermal cutting.

UNIT I

Introduction to welding

Welding Principle, Application of welding in industries, Weld ability of Material, Arc welding consumables, Shielding gases and association mixtures. Weld bead geometry and shape factors. Weld dilution, weld joint configurations, liquation cracking, hot cracking. Automation in welding.

UNIT II

Fusion and Solid state welding

Fusion Welding Processes: Classification of fusion welding processes, Submerged Arc Welding, Electroslag welding, Plasma arc welding. Solid state welding: Introduction, Advantages of solid state welding over fusion welding processes, Explosive welding, Ultrasonic welding, Friction welding, Friction stir welding, Welding zones in FSW.

UNIT III

Welding of Plastics and Underwater welding

Plastics, Types of plastics,Welding of Plastic: Introduction, Classification of plastic welding, Hot plate welding, Hot gas welding, Ultrasonic welding, Friction welding, Applications of plastic welding. Underwater Welding: Need and application of underwater welding, Dry underwater welding, wet underwater welding. Advantages and Limitations of dry and wet underwater welding.

UNIT IV

Thermal Spraying and Thermal Cutting

Thermal spraying: Introduction,Thermal spray processes, Application of thermal spraying, Thermal Cutting of Metals: Introduction, Methods and applications.Oxy-Fuel Gas Cutting, cutting torch, Oxygen-Lance Cutting, Plasma Arc cutting.

Text books:

1. Manufacturing Science-A. Ghosh and A.K. Malik, Affiliated East Press, New-Delhi.
2. Introduction to Manufacturing Processes- John A. Schey, McGraw-Hill, New-York

Reference books:

1. Rao, P.N., Manufacturing Technology, Volume 2, McGraw-Hill Education, New Delhi.
2. Lindberg, R.A., Processes and Materials of Manufacturing, Allyn and Bacon, Boston
3. Khan N. Z, Siddiquee A. N. and Khan Z. A., Friction stir welding of dissimilar Aluminium alloys, CRC Press, Boca Raton, 2017.

<table>
<tr><td rowspan="3">Subject: Elective-VI
Renewable Energy Systems
(Code: MET4061)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech
Mechanical Engineering
4rd Year & 8th Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Class Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
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COURSE OUTCOMES:

1. To compare aware about different renewable energy resources.
2. To know the conversion of energy from one form to other.
3. To know the importance the solar radiation and its utilization.
4. To analyze of different energy conversion energy systems.

COURSE CONTENT:-

UNIT-I

Introduction

Introduction to energy, Relevance of energy in the development of country, conventional, non-conventional and renewable sources of energy. Status of conventional sources of energy and their conservation, Exploring renewable sources of energy.

UNIT-II

Solar Radiation and Applications of Solar Heat

Extraterrestrial solar radiation, components of radiation, geometry of earth and sun, geometry of collector and the solar beam, effects of earth's atmosphere, measurements of solar radiation, type of water heaters, selective surfaces, space heating, space cooling, water desalination, solar ponds, solar concentrators, thermos- electric power system, problems.

Photovoltaic Generation

Introduction, the silicon p-n junction, photon absorption solar radiation input, photovoltaic circuit properties and loads, limits to cell efficiency, solar cell construction, other types of photoelectric and thermo-electric generation.

UNIT-III

Hydro and Wind Powers

Principle of hydro power conversion, impulse turbine, reaction turbines, wind turbine types, linear momentum and basic theory, dynamic matching, characteristics of the wind, power extraction by a turbine, electricity generation, mechanical power, problems.

Bio-Fuels

Introduction, Bio fuels, classification, bio-mass production for energy farming, direct combustion for heat, pyrolysis (destructive distillation), alcoholic fermentation, anaerobic digestion for bio-gas, agrochemical fuel extractions.

UNIT-IV

Wave Energy and Tidal Power

Introduction, wave motion, wave energy and power, wave patterns, devices, the causes of tides, enhancement of tides flow power, tidal range, power, world tidal power sites.

OTEC and Geothermal Energy

Principles of Ocean Thermal Energy Conversion (OTEC), Claude cycle, Andersan cycle, Introduction to geothermal energy, dry rock and hot aquifer analysis, harnessing geothermal resources

Text Books:

1. Solar Energy by S P Sukhatme, Publisher Tata Mc Graw- Hill New Delhi

Reference Books:

1. Renewable Energy Rsources by john W. Twidell and Anthony D. Weir, published by E.& F. N. SponLtd,Lndon.
2. Renewable energy by Bent Sorensen by Academic press
4. Non-conventional Energy Sources by G D Rai by Khanna Publishers Delhi

Subject: Elective-VII Mechanics of Composite Materials (Code: MET4062)	**Year & Semester: B. Tech Mechanical Engineering 4rd Year & 8th Semester**		**Total Course Credit: 4**		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term	Class Assessment	End-Term		
	30 Marks	10 Marks	60 Marks		

COURSE OUTCOMES

On completion of this subject students will be able to:

1. To identify the properties of fiber and matrix materials used in commercial composites, as well as some common manufacturing techniques.
2. To predict the failure strength of a laminated composite plate
3. Understand the linear elasticity with emphasis on the difference between isotropic and anisotropic material behaviour.
4. Acquire the knowledge for the analysis, design, optimization and test simulation of advanced composite structures and Components.

UNIT -1

Definition and classification of composite materials: Polymer Matrix Composites, Metal Matrix Composites, Ceramic Matrix Composites, CarbonComposites. Reinforcements and Matrix Materials. Manufacturing Techniques of Composites: Fiber Reinforced Plastic (FRP) Processing: Layup and curing, fabricating process, open and closed mould process, Hand layup techniques; structural laminate bag molding, production procedures for bag molding; filament winding, pultrusion, pulforming, thermo-forming, injection molding, blow molding. Fabrication Process for Metal Matrix Composites (MMC's): Powder metallurgy technique, liquid metallurgy technique and secondary processing, special fabrication techniques.

UNIT -2

Density, Mechanical Properties; Prediction of Elastic Constants, Micromechanical Approach, Halpin-Tsai Equations, Transverse Stresses.Thermal Properties; Expression for Thermal Expansion Coefficients of Composites, Expression for Thermal Conductivity of Composites, Hygral and Thermal Stresses.Mechanics of Load Transfer 15 from Matrix to Fiber; Fiber elastic-Matrix Elastic, Fiber Elastic-Matrix Plastic. Load transfer in Particulate Composites. Numerical Problems.

UNIT -3

Elastic Constants of an Isotropic Material, Elastic Constants of a Lamina, Relationship between Engineering Constants and Reduced Stiffnesses and Compliances, Variation of Lamina Properties with Orientation, Analysis of Laminated Composites, Stresses and Strains in Laminate Composites, Inter-laminar Stresses and Edge Effects. Numerical Problems.

UNIT -4

Tensile and Compressive strength of Unidirectional Fiber Composites. Fracture Modes in Composites; Single and Multiple Fracture, Debonding, FiberPullout and Delamination Fracture. Strength of an Orthotropic Lamina; Maximum Stress Theory, Maximum Strain Criterion, Tsai-Hill Criterion, Quadratic Interaction Criterion, Comparison of Failure Theories.Fatigue; S-N Curves, Fatigue Crack Propagation Tests, Damage Mechanics of Fatigue, Thermal Fatigue. Creep behavior of Composites.

UNIT -5

Symmetric Laminates, Cross-ply laminates, Angle ply Laminates, Antisymmetric Laminates, Balanced Laminate. Failure Criterion for a Laminate.Design of a Laminated Composite.Numerical Problems.

TEXT BOOKS:

1. Autar K. Kaw, Mechanics of Composite materials, CRC Taylor & Francis, 2nd Ed, 2005
2. Composite Material Science and Engineering, Krishan K. Chawla, Springer, 3e, 2012 3. Robert M. Jones, Mechanics of Composite Materials, Taylor & Francis, 1999.

REFERENCE BOOKS:

1.MadhijitMukhopadhay, Mechanics of Composite Materials & Structures, Universities Press, 2004
2. Michael W, Hyer, Stress analysis of fiber Reinforced Composite Materials, Mc-Graw Hill International, 2009
3. Fibre Reinforced Composites, P.C. Mallik, Marcel Decker, 1993 4. Hand Book of Composites, P.C. Mallik, Marcel Decker, 1993

<table>
<tr><td rowspan="3">Subject: Elective-VII
Value Engineering
(Code: MET4063)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech
Mechanical Engineering
4^{rd}Year & 8^{th}Semester</td><td colspan="3">Total Course Credit: 4</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
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<tr><td>30 Marks</td><td>10 Marks</td><td colspan="3">60 Marks</td></tr>
</table>

S.No.	**Course Outcomes**
CO1	Develop critical thinking and the ability to improve resource efficiency and quality management by the application of VE/VA principles.
CO2	Develop the ability to Prioritize the functionality of a product and to improve its worth by eliminating the unwanted functions.
CO3	An ability to identify the customers requirement and solve problems for reducing cost while maintaining or improving performance and quality requirements of a product or service
CO4	An ability to convert the customer requirements to the functionality of the product

Detailed Content:

UNIT I:

Introduction to value engineering (VE) & value analysis (VA), Life Cycle of a product, Methodology of VE, Reasons for the existence of unnecessary costs. Quantitative definition of Value, use Value and Prestige value, Estimation of product Quality/Performance, Types of functions, Relationship between use functions and Esteem Functions in product design, Functional cost and functional worth, Effect of value improvement on profitability, Tests for poor value, Aims of VE systematic approach.

UNIT II

Elementary introduction to VE, Job plan functional approach to value improvement, Various phases and techniques of the job plan, Factors governing project selection, Types of projects, Life cycle costing for managing the total value, concepts in LCC, Present value concept, Annuity concept, net present value, Pay Back period, internal rate of return on investment (1RR), Examples and Illustrations. Creative thinking and creative judgement, positive or constructive discontent, Tangible and intangible costs of implementation, False material, Labour and overhead saving, VE/VA yardsticks, Relationship between savings and probability of success, Reliability Estimation, system Reliability, Reliability elements in series andparallel.

UNIT III

PHASES AND TECHNIQUES OF VE JOB PLAN:

General Phase, Information phase, Function phase, Creativity/Speculation Phase, Evaluation Phase, Investigation Phase and Recommendation Phase***:*** Value improvement recommendation theory, determination of cut-off point (cop), road blocks in implementation. Decision Matrix/Evaluation Matrix, Quantitative comparison of

Alternatives, Estimation of weights factors and efficiencies, Utility transformation functions, Bench marking, Perturbation of weight factors (sensitivity analysis), and Examples.
FAST Diagramming: Critical path of functions, HOW, WHY & WHEN Logic, Supporting and all time functions.

Reference Books:

1. Arthur E. Mudge, "Value Engineering- A Systematic Approach",*McGraw Hill Book Co.* 1971.
2. Miles L.D., "Techniques of value Analysis and Engineering", *McGraw Hill Book Co., New York, 1970.*
3. ASTME-American society for Tool and Manufacturing Engineers," Value engineering in Manufacturing", *Prentice Hall Inc. USA, 1967.*

Subject: Elective-VII Design of Fluid Thermal Systems (Code: MET4064)	**Year & Semester: B. Tech Mechanical Engineering 4rd Year & 8th Semester**		**Total Course Credit: 4**		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term	Class Assessment	End-Term		
	30 Marks	10 Marks	60 Marks		

COURSE OUTCOMES:
After the completion of course, students will be able,

CO1	To understand thermal system engineering design process
CO2	To learn the characteristics of the components of the thermal system and their effects on overall system performance
CO3	To simulate a thermal system and solve for a workable solution
CO4	To identify, formulate and solve a wide range of real world thermal related problems

UNIT 1

Introduction, Design versus Analysis, Synthesis versus Design, Optimal and Nearly Optimal designs, Life Cycle Design, Thermal design aspects, Concept, creation and assessment, Thermal system (Basic Characteristics, Analysis), some typical examples, formulation of the design problem, Steps in design process, Material selection.

UNIT 2

Modelling of thermal systems, types of models, Mathematical modeling, General procedure (Transient/steady state, spatial dimensions, lumped mass approximation, simplification of boundary conditions, negligible effects, idealizations, material properties, conservation laws, simplification of governing equations), final model and validation, physical modeling and dimensional analysis, curve-fitting, Numerical modeling and simulation, Solution procedures, methods for numerical simulation,

UNIT 3

Formulation of problem for optimization, optimized design, objective function, constraints, operating conditions versus hardware, optimization methods (Calculus methods, Search methods, etc.), Optimization of thermal systems, Considerations of Second law of Thermodynamics, Economic analysis, Estimation of total capital cost, principles of economic evaluation, Thermoeconomic analysis and evaluation.

UNIT 4

Applications with Thermodynamics, Heat and Fluid flow, Cogeneration system Exergy analysis, Thermal insulation, Fins, Electronic packages, Refrigeration, Power Generation, Energy Storage by Sensible heating.

Textbooks:

1. Bejan, A., Tsatsaronius, G., Moran, M., "Thermal Design and Optimization", John Wiley, 2013.
2. Stoecker, W.F., "Design of Thermal Systems", McGraw Hill, 2017.

Subject: Elective-VII Online Course (Code: MET4065)	**Year & Semester: B. Tech Mechanical Engineering 4rd Year & 8th Semester**		**Total Course Credit: 4**		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term	Class Assessment	End-Term		

ONLINE COURSE

<table>
<tr><td rowspan="3">Subject: Major Project – Stage II
(Code: MEP463)</td><td colspan="2" rowspan="3">Year & Semester: B. Tech Mechanical Engineering
4rd Year & 8th Semester</td><td colspan="3">Total Course Credit: 9</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
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<tr><td>20 Marks</td><td>40 Marks</td><td colspan="3">40 Marks</td></tr>
</table>

CO1 Identify methods and materials to carry out experiments/develop code.

CO2 Reorganize the procedures with a concern for society, environment and ethics.

CO3 Analyze and discuss the results to draw valid conclusions.

CO4 Prepare a report as per recommended format and defend the work.

CO5 Explore the possibility of publishing papers in peer-reviewed journals/conference proceedings.