SYLLABUS

For

B.Tech. PROGRAMME

in

MECHANICAL ENGINEERING

UNIVERSITY OF KASHMIR
SRINAGAR

JULY – 2026

(Applicable to Batch 2025 & Onwards)

Coordinator (DOME)
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COURSE STRUCTURE, B.Tech MECHANICAL ENGINEERING

THIRD SEMESTER TO EIGHTH SEMESTER

Indicator Alphabit			
E	Engineering Science Courses	L	Experiential Learning Course/ Lab Course
B	Basic Science Courses	H	Humanities and Social Sciences including
C	Professional Core Course	Y	Seminar
D	Professional Elective Course	P	Project work/Internship
O	Open Elective Course	A	Audit Course

ISE	Internal Semester Evaluation (*50 Marks*)	
	MSE	Mid Semester Evaluation (*35 Marks*)
	CA	Continous Assessment (*Assignment + Quiz/ Viva Voce (10 Marks) + Attendence (5 Marks)*)
ESA	End Semester Evaluation	

Semester - 3 (*Three*)

Course Code	Course Title	L	T	P	Credits	ISE (*Theory*) MSE	ISE (*Theory*) CA	ISE (*Theory*) Total	ISE (*Practical*) MSE	ISE (*Practical*) CA	ISE (*Practical*) Total	Internal (*Total*)	ESE (*Theory*)	ESE (*Practical*)	External (*Total*)	Total
BMECCDR325	Dynamics of Rigid Bodies	2	1	0	3	35	15	50	0	0	0	50	50	0	50	100
BMECCCM325	Computer Aided Drawing and Modelling	0	0	4	2	0	0	0	35	15	50	50	0	50	50	100
BMECCME325	Materials Engineering	2	1	2	4	35	15	50	35	15	50	100	50	50	100	200
BMECCET325	Engineering Thermoynamics	2	1	0	3	35	15	50	0	0	0	50	50	0	50	100
BMECCFM325	Fluid Mechanics	2	1	2	4	35	15	50	35	15	50	100	50	50	100	200
BMECCMP325	Metal Cutting and Machining Processes	2	1	2	4	35	15	50	35	15	50	100	50	50	100	200
		10	5	10	20											900
	Total Hours		25													

Semester - 4 (*Four*)

Course Code	Course Title	L	T	P	Credits	ISE (*Theory*) MSE	ISE (*Theory*) CA	ISE (*Theory*) Tota	ISE (*Practical*) MSE	ISE (*Practical*) CA	ISE (*Practical*) Total	Internal (*Total*)	ESE (*Theory*)	ESE (*Practical*)	External (*Total*)	Total
BMECBPD425	Partial Differential Equations, Laplace and Z-transform	2	1	0	3	35	15	50	0	0	0	50	50	0	50	100
BMECCMS425	Mechanics of Solids	2	1	2	4	35	15	50	35	15	50	100	50	50	100	200
BMECD**425	Professional Elective-I	1	0	2	2	35	15	50	35	15	50	100	50	50	100	200
BMECCTM425	Theory of Machines	2	1	2	4	35	15	50	35	15	50	100	50	50	100	200
BMECLFM425	Fluid Machinery	0	2	2	3	0	0	0	35	15	50	50	0	50	50	100
BMECCMC425	Metal Casting and Forming Processes	2	1	2	4	35	15	50	35	15	50	100	50	50	100	200
		9	6	10	20											1000
	Total Hours		25													

Semester - 5 (*Five*)

Course Code	Course Title	L	T	P	Credits	ISE (*Theory*) MSE	ISE (*Theory*) CA	ISE (*Theory*) Total	ISE (*Practical*) MSE	ISE (*Practical*) CA	ISE (*Practical*) Total	Internal (*Total*)	ESE (*Theory*)	ESE (*Practical*)	External (*Total*)	Total
BMECBCA525	Complex Analysis and Special Functions	2	1	0	3	35	15	50	0	0	0	50	50	0	50	100
BMECCAC525	Automatic Control	2	0	2	3	15	35	50	35	15	50	100	0	50	50	150
BMECCHT525	Heat Transfer	2	1	2	4	35	15	50	35	15	50	100	50	50	100	200
BMECCAT525	Applied Thermodynamics	2	1	2	4	35	15	50	35	15	50	100	50	50	100	200
BMECCSM525	Structural Mechanics	2	1	0	3	35	15	50	0	0	0	50	50	50	100	150
BMECLMI525	Metrology & Instrumentation	0	2	2	3	0	0	0	35	15	50	50	0	50	50	100
		10	6	8	20											900
	Total Hours		24													

Semester - 6 (*Six*)

Course Code	Course Title	L	T	P	Credits	ISE (*Theory*) MSE	ISE (*Theory*) CA	ISE (*Theory*) Total	ISE (*Practical*) MSE	ISE (*Practical*) CA	ISE (*Practical*) Total	Internal (*Total*)	ESE (*Theory*)	ESE (*Practical*)	External (*Total*)	Total
BMECHIE625	Industrial Engineering	2	0	2	3	35	15	50	35	15	50	100	50	50	100	200
BMECCMV625	Mechanical Vibrations	2	1	2	4	35	15	50	35	15	50	100	50	50	100	200
BMECLIC625	Internal Combustion Engines	0	2	2	3	0	0	0	35	15	50	50	0	50	50	100
BMECO**625	Open Elective-I	2	0	2	3	35	15	50	35	15	50	100	50	50	100	200
BMECCDM625	Design of Machine Elements	2	1	0	3	35	15	50	0	0	0	50	50	0	50	100
BMECCCL625	Compressible Fluid Flow	2	1	2	4	35	15	50	35	15	50	100	50	50	100	200
		10	5	10	20											1000
	Total Hours		25													

Semester - 7 (*Seven*)						Examination Scheme (*Distribution of Marks*)										
Course Code	Course Title	L	T	P	Credits	ISE (Theory)			ISE (Practical)			Internal (Total)	ESE (Theory)	ESE (Practical)	External (Total)	Total
						MSE	CA	Total	MSE	CA	Total					
BMECLCM725	Computer Aided Manufacturing	0	0	6	3	0	0	0	35	15	50	50	0	50	50	100
BMECLWT725	Welding Technology	0	0	4	2	0	0	0	35	15	50	50	0	50	50	100
BMECD**725	Professional Elective II	2	0	2	3	35	15	50	35	15	50	100	50	50	100	200
BMECLOD725	Operation and Diagnostics of Machines	0	2	2	3	0	0	0	35	15	50	50	0	50	50	100
BMECCMD725	Machine Design	2	1	0	3	35	15	50	0	0	0	50	50	0	50	100
BMECHOR725	Operations Research	2	1	0	3	35	15	50	0	0	0	50	50	0	50	100
BMECPPP725	Final Year Pre-Project	0	0	6	3	0	0	0	35	15	50	50	0	50	50	100
		6	4	20	20											800
	Total Hours	30														

Semester - 8 (*Eight*)						Examination Scheme (*Distribution of Marks*)										
Course Code	Course Title	L	T	P	Credits	ISE (Theory)			ISE (Practical)			Internal (Total)	ESE (Theory)	ESE (Practical)	External (Total)	Total
						MSE	CA	Total	MSE	CA	Total					
BMECHPM825	Introduction to Project Management	2	1	0	3	35	15	50	35	15	50	100	50	50	100	200
BMECO**825	Open Elective-II	2	0	2	3	35	15	50	0	0	0	50	50	0	50	100
BMECD**725	Professional Elective-III	2	0	2	3	35	15	50	35	15	50	100	50	50	100	200
BMECD**825	Professional Elective-IV	2	1	0	3	35	15	50	0	0	0	50	50	0	50	100
BMECPFP825	Final Year Project	0	0	14	7	0	0	0	35	15	50	50	0	50	50	100
BMECPIN825	Internship	0	0	0	1	0	0	0	35	15	50	50	0	50	50	100
		8	2	18	20											1000
	Total Hours	28														

Professional Elective Courses					
Course Code	Course Title	L	T	P	Credits
	Professional Elective I				
BMECDPE425	Programming for Engineers	1	0	2	2
BMECDRE425	Renewable Energy Systems	2	0	0	2
BMECDMC425	Material Characterization Method	1	0	2	2
	Professional Elective II				
BMECDFT725	Fundamentals of Tribology	2	0	2	3
BMECDMC725	Microprocessors and Processor-Based Systems	2	0	2	3
BMECDRF725	Refrigeration	2	0	2	3
	Professional Elective III				
BMECDCE825	Cryogenic Engineering	2	0	2	3
BMECDHV825	Heating Ventilation and Air Conditioning	2	0	2	3
BMECDCM825	Composite Materials	2	0	2	3
	Professional Elective IV				
BMECDPP825	Power Plant Engineering	2	1	0	3
BMECDIC825	Introduction to Computational Mechanics	2	0	2	3
BMECDSP825	Solar PV Installation & Design	2	1	0	3

Open Elective Courses					
Course Code	Course Title	L	T	P	Credits
	Open Elective I				
BMECOAM625	Additive Manufacturing	2	0	2	3
BMECODE625	Design of Experiment	2	1	0	3
BMECONM625	Numerical Methods for Engineers	2	0	2	3
	Open Elective II				
BMECONT825	Non-Destructive Testing	2	0	2	3
BMECOMS825	Mechatronic Systems	2	0	2	3
BMECOME825	Micro-Electro-Mechanical Systems	2	0	2	3
BMECORB825	Robotics	2	0	2	3

Note: Students can also choose Professional Electives courses from Swayam (Moocs) plateform. The list of MOOCs courses will be notified at the start of each semester.

Course Code	BMECCDR325				
Category	Professional Core courses				
Course Title	Dynamics of Rigid Bodies				
Scheme and Credits	L	T	P	Credits	Semester- **3** (*Three*)
	2	1	0	3	
Pre requisites	Engineering Mechanics				

Course Learning Outcomes (CLOs)

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

i) **CLO1:** ***Understand*** the planar motion of rigid bodies by determining displacement, velocity, acceleration, relative motion, and instantaneous center of rotation for bodies undergoing translation, rotation, and general plane motion *(L2)*

ii) **CLO2:** ***Compare*** the principles of three-dimensional rigid body kinematics to determine orientation, angular velocity, and angular acceleration using translating and rotating reference frames and Euler angles. *(L2)*

iii) **CLO3:** ***Interpret*** the motion of planar rigid bodies by applying Newton–Euler equations, D'Alembert's principle, and inertia properties to solve force and acceleration problems involving translation, rotation, and general plane motion. *(L5)*

iv) **CLO4:** ***Draw*** work–energy and impulse–momentum principles to analyze planar rigid body motion and solve engineering problems involving conservation of energy and momentum. *(L3)*

v) **CLO5:** ***Assemble*** the three-dimensional dynamic behavior of rigid bodies using angular momentum, inertia tensor, Euler's equations of motion, and gyroscopic principles for engineering applications. *(L6)*

Theory Module(Internal and External Evaluation)

M.No:	Topic
Module 1.	Kinematics of rigid bodies, translation and rotation about a fixed axis, Relative velocity and acceleration (rotating axes), Instantaneous center of rotation.
Module 2.	Translating and rotating reference frames, Euler angles, angular velocity, and acceleration.
Module 3.	Introduction to Kinetics of rigid bodies, force and acceleration, Moments and products of inertia, D'Alembert's principle, equations of motion, translation, fixed-axis rotation, and general plane motion.
Module 4.	Energy and Momentum Methods, Work and kinetic energy for a rigid body, Impulse and momentum for a rigid body, Conservation of momentum and energy.
Module 5.	Angular momentum, kinetic energy, and inertia tensor, Euler's equations of motion, Gyroscope motion and torque-free motion.

Activity Module (Internal Evaluation Only-10 Marks)

Activity	Example Task
Using the tools learned on Module 1, design a variety of items, including:	Identify examples of translational and rotational motion from everyday engineering systems like connecting rod of IC engine etc. using MATLAB
Using the tools learned on Module 2, design a variety of items, including:	Develop free-body diagrams for rigid bodies undergoing plane motion.
Using the tools learned on Module 3, design a variety of items, including:	Develop a MATLAB code to compute instantaneous center of rotation for mechanisms such as rolling wheels and connecting rods.
Using the tools learned on Module 4, design a variety of items, including:	Develop MATLAB code to compute angular velocity and acceleration from Euler angles and compare numerical and analytical results.
Using the tools learned on Module 5, design a variety of items, including:	Demonstrate gyroscopic precession using a bicycle wheel.

CLO-PLO Mapping Matrix

CLO \ PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	3	3	2	2	2	0	0	0	1	1	0	1
CLO2	3	3	2	2	3	0	0	0	1	1	0	1

CLO3	3	3	3	2	3	1	1	0	1	1	1	1
CLO4	3	3	2	2	2	1	1	0	1	1	1	1
CLO5	3	3	3	3	3	1	1	0	1	1	0	2

S.No:	Text Books	Author	Publisher
	Engineering Mechanics: Dynamics	Anthony Bedford and Wallace Fowler	Pearson
2	Text book of Dynamics	F Chorlton	CBS Publishers
	References		
	Engineering Mechanics: Statics and Dynamics	R.C Hibbeler	Pearson
	Engineering Mechanics: Dynamics	J.L Meriam and L.G Kraige	Wiley
	Fundamentals of Dynamics & Analysis of Motion	R.M. Marcelo, Crespo Da Silva	Dover Publications Inc.

Course Code	**BMECCDR325**				
Category	**Professional Core courses**				
Course Title	**Dynamics of Rigid Bodies**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester- 3 (*Three*)**
	2	1	0	3	
Pre requisites	**Engineering Mechanics**				

Course Learning Outcomes (CLOs)

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

i) **CLO1:** ***Understand*** the planar motion of rigid bodies by determining displacement, velocity, acceleration, relative motion, and instantaneous center of rotation for bodies undergoing translation, rotation, and general plane motion. ***(L2)***

ii) **CLO2:** ***Compare*** the principles of three-dimensional rigid body kinematics to determine orientation, angular velocity, and angular acceleration using translating and rotating reference frames and Euler angles. ***(L2)***

iii) **CLO3:** ***Interpret*** the motion of planar rigid bodies by applying Newton–Euler equations, D'Alembert's principle, and inertia properties to solve force and acceleration problems involving translation, rotation, and general plane motion . ***(L5)***

iv) **CLO4:** ***Draw*** work–energy and impulse–momentum principles to analyze planar rigid body motion and solve engineering problems involving conservation of energy and momentum. ***(L3)***

v) **CLO5:** ***Assemble*** the three-dimensional dynamic behavior of rigid bodies using angular momentum, inertia tensor, Euler's equations of motion, and gyroscopic principles for engineering applications. ***(L6)***

Theory Module (Internal and External Evaluation)

M.No:	Topic
Module 1.	kinematics of rigid bodies, translation and rotation about a fixed axis, Relative velocity and acceleration (rotating axes), Instantaneous center of rotation.
Module 2.	Translating and rotating reference frames, Euler angles, angular velocity, and acceleration.
Module 3.	Introduction to Kinetics of rigid bodies, force and acceleration, Moments and products of inertia, D'Alembert's principle, equations of motion, translation, fixed-axis rotation, and general plane motion.
Module 4.	Energy and Momentum Methods, Work and kinetic energy for a rigid body, Impulse and momentum for a rigid body, Conservation of momentum and energy.
Module 5.	Angular momentum, kinetic energy, and inertia tensor, Euler's equations of motion, Gyroscope motion and torque-free motion.

Activity Module (Internal Evaluation Only-10 Marks)

Activity	Example Task
Using the tools learned on Module 1, design a variety of items, including:	Identify examples of translational and rotational motion from everyday engineering systems like connecting rod of IC engine etc. using MATLAB
Using the tools learned on Module 2, design a variety of items, including:	Develop free-body diagrams for rigid bodies undergoing plane motion.
Using the tools learned on Module 3, design a variety of items, including:	Develop a MATLAB code to compute instantaneous center of rotation for mechanisms such as rolling wheels and connecting rods.
Using the tools learned on Module 4, design a variety of items, including:	Develop MATLAB code to compute angular velocity and acceleration from Euler angles and compare numerical and analytical results.
Using the tools learned on Module 5, design a variety of items, including:	Demonstrate gyroscopic precession using a bicycle wheel.

CLO-PLO Mapping Matrix

CLO \ PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	3	3	2	2	2	0	0	0	1	1	0	1
CLO2	3	3	2	2	3	0	0	0	1	1	0	1
CLO3	3	3	3	2	3	1	1	0	1	1	1	1
CLO4	3	3	2	2	2	1	1	0	1	1	1	1
CLO5	3	3	3	3	3	1	1	0	1	1	0	2

S.No:	Text Books	Author	Publisher
1.	Engineering Mechanics: Dynamics	Anthony Bedford and Wallace Fowler	Pearson
2.	Text book of Dynamics	F Chorlton	CBS Publishers
	References	**Author**	**Publisher**
3.	Engineering Mechanics: Statics and Dynamics	R.C Hibbeler	Pearson
4.	Engineering Mechanics: Dynamics	J.L Meriam and L.G Kraige	Wiley
5.	Fundamentals of Dynamics & Analysis of Motion	R.M. Marcelo, Crespo Da Silva	Dover Publications Inc.

Course Code	**BMECCCM325**					
Category	**Professional Core courses**					
Course Title	**Computer Aided Drawing and Modelling**					
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester- 3 (*Three*)**	
	0	0	4	2		
Pre requisites	**Engineering Drawing, Computer Aided Drawing**					

Course Learning Outcomes (CLOs)

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

i) **CLO1:** ***Understand*** the principles of parametric CAD modelling and apply basic sketching techniques, geometric and dimensional constraints, reference geometry, and elementary solid modelling features such as Extrude, Cut, Fillet, Chamfer, and Hole to create simple three-dimensional engineering components. ***(L2)***

ii) **CLO2:** ***Develop*** engineering models by applying advanced sketching techniques, including spline-based modelling and image-based sketching, and create complex part geometries using appropriate modelling strategies. ***(L3)***

iii) **CLO3:** ***Construct*** engineering components using reference geometry, revolve, mirror, and pattern features, and apply advanced modelling operations such as Loft, Sweep, Boundary, Shell, and Draft to develop complex parametric models. ***(L3)***

iv) **CLO4:** ***Evaluate*** different CAD modelling approaches and select the most appropriate feature-based modelling strategy for engineering components based on geometry, design intent, manufacturability, and modelling efficiency. *(L5)*

v) **CLO5:** ***Assemble*** a multi-part CAD model by defining mates and constraints between components, generating exploded views, and producing a detailed assembly drawing complete with a bill of materials, and part callouts. *(L5)*

Theory Module(Internal and External Evaluation)

M.No:	Topic
Module 1.	Introduction to the CAD environment, creating sketches using basic geometric entities, construction lines, geometric and dimensional constraints, reference planes, and sketch editing. Creation of basic solid models using extrude, cut, fillet, chamfer, and hole features, editing models, modifying features, and assigning material and appearance properties.
Module 2.	Creation of complex sketches using spline tools, importing and scaling reference images, tracing geometry, sketch repair, and preparing sketches for three-dimensional modeling.
Module 3.	Creation of reference planes, axes, and coordinate systems. Development of axisymmetric models using revolve features, application of mirror, linear pattern, circular pattern, and sketch pattern tools to create symmetric and repetitive features.
Module 4.	Creation of complex models using loft, sweep, boundary, and revolve features, use of guide curves, multiple profiles, shell, draft, thin features, and advanced reference geometry for developing engineering components.
Module 5.	Fundamentals of 3D scanning, point cloud acquisition, mesh generation (STL), mesh editing, noise filtering, hole filling, surface reconstruction, and importing scanned data as reference geometry for reverse engineering and model reconstruction.

Activity Module (Internal Evaluation only-10 Marks)

Activity	Example Task
Create parametric 3D models of basic mechanical components by applying the tools learned in Module 1.	Washer, spacer, bush, shaft, flange, L-bracket, base plate, pulley, and simple support bracket in SolidWorks/Fusion 360.
Develop engineering models by applying the advanced sketching and image-based modelling techniques learned in Module 2.	Cam profile, gasket, handwheel, airfoil profile, fan blade, and institute logo converted into a 3D model in SolidWorks/Fusion 360.
Develop engineering components by applying the reference geometry and pattern features learned in Module 3.	Bolt flange, chain sprocket, wheel hub, perforated plate, cooling fin, and simple gear blank in SolidWorks/Fusion 360.
Perform reverse engineering by applying the concepts learned in Module 5.	Pipe elbow, nozzle, hopper, bottle, funnel, impeller (basic), and screwdriver handle.
Using the tools learned on Module 5, design a variety of items, including:	Scan and reconstruct a spanner, machine knob, pipe fitting, valve handle, bearing housing, or simple bracket using a 3D scanner or photogrammetry.

CLO-PLO Mapping Matrix

CLO \ PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	3	2	2	0	3	0	0	0	1	1	0	1
CLO2	3	3	3	0	3	1	0	0	1	1	0	2
CLO3	3	3	2	3	3	1	1	0	1	1	1	2
CLO4	3	3	3	3	3	1	1	1	1	2	2	3
CLO5	3	3	3	3	3	1	1	1	1	2	2	3

S.No:	Text Books	Author	Publisher
1.	SolidWorks 2024: A Power Guide for Beginners and Intermediate Users	Sandeep Dogra	CADArtifex, 2024

2.	Autodesk Fusion 360: A Power Guide for Beginners and Intermediate Users	Sandeep Dogra & John Willis	CADArtifex, 2024
	References		
1.	Reverse Engineering: An Industrial Perspective	Vinesh Raja & Kiran J. Fernandes	Springer, 2008
2.	Engineering Design Graphics with SolidWorks 2022	James D. Bethune	Pearson, 2022
3.	3D Scanning and Printing for the Engineering Classroom (MIT OCW RES.16-002 Course Notes)	Andy G. Eskenazi	MIT OpenCourseWare, 2024

Course Code	**BMECCME325**				
Category	**Professional Core courses**				
Course Title	**Materials Engineering**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester- 3 (Three)**
	2	1	2	4	
Pre-requisites	-				

Course Learning Outcomes (CLOs)

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

i) **CLO1:** Understand the classification, crystal structures, properties, imperfections, diffusion mechanisms, deformation behaviour, phase transformations, and heat treatment of engineering materials. ***(L2)***

ii) **CLO2:** Compare the structure, properties, processing methods, and applications of metals, ceramics, polymers, composites, and advanced engineering materials. ***(L4)***

iii) **CLO3:** Interpret crystallographic directions and planes, X-ray diffraction data, diffusion behaviour, stress–strain curves, phase diagrams, and microstructural evolution in engineering materials. ***(L4)***

iv) **CLO4:** Draw unit cells, crystal structures, crystallographic planes and directions, stress–strain curves, phase diagrams, iron–carbon equilibrium diagram, and representative microstructures of engineering materials. ***(L3)***

v) **CLO5:** Assemble the knowledge of crystal structure, defects, diffusion, deformation, strengthening mechanisms, phase transformations, and heat treatment to select suitable engineering materials for mechanical engineering applications. ***(L5)***

Theory Module(Internal and External Evaluation)

M.No:	Topic
Module 1.	Historical perspective, classification of engineering materials, advanced engineering materials (smart materials, nanomaterials, biomaterials and shape memory alloys), atomic structure and bonding in solids, crystal structures of metals, unit cells, face-centered cubic (FCC), body-centered cubic (BCC) and hexagonal close-packed (HCP) crystal structures, density calculations for metals, ceramic crystal structures, density calculations for ceramics, polymorphism, allotropy, crystal systems, lattice parameters. .
Module 2.	Crystallographic directions, crystallographic planes, Miller indices, linear atomic density, planar atomic density, close-packed crystal structures, single crystals, polycrystalline materials, anisotropy, principles of X-ray diffraction, Bragg's law, determination of crystal structures, non-crystalline solids, amorphous materials, imperfections in solids, point defects, line defects, surface defects, volume defects, grain size, grain size determination, diffusion mechanisms, diffusion in solids, Fick's first and second laws, steady-state diffusion, non-steady-state diffusion, factors influencing diffusion.
Module 3.	Stress-strain behaviour, elastic deformation, plastic deformation, mechanical properties, hardness, deformation mechanisms, slip systems, plastic deformation of single and polycrystalline metals, deformation by twinning, strengthening mechanisms, grain size strengthening, solid solution strengthening, strain hardening, recovery, recrystallization, grain growth, fracture, ductile and brittle fracture, fatigue, creep and wear.
Module 4.	Phase concepts, solubility limits, phase equilibria, unary phase diagrams, binary phase diagrams, interpretation of phase diagrams, lever rule, iron-carbon phase diagram, microstructure of iron-carbon alloys, development of microstructure in iron-carbon alloys, heat treatment of steels, annealing, normalizing, hardening and tempering. .

Module 5.	Classification of polymers, thermoplastic polymers, thermosetting polymers, polymer crystallinity, polymer crystal structures, engineering ceramics, glasses, material selection for engineering applications, sustainability and recycling of engineering materials.

Activity Module (Internal Evaluation Only-10 Marks)

Activity	Example Task
Using the tools learned on Module 1, design a variety of items, including:	Construct BCC, FCC, and HCP crystal models using model kits or CAD software, identify unit cell parameters, and calculate the theoretical density of metallic and ceramic materials using MATLAB, Python, or Excel.
Using the tools learned on Module 2, design a variety of items, including:	Determine crystallographic directions and planes, calculate linear and planar atomic densities, simulate X-ray diffraction patterns using crystallographic software, and compare experimental and theoretical results.
Using the tools learned on Module 3, design a variety of items, including:	Solve steady-state and non-steady-state diffusion problems using MATLAB, Python, or Excel based on Fick's laws, and analyze the influence of temperature and time on diffusion behaviour
Using the tools learned on Module 4, design a variety of items, including:	Analyze experimental stress–strain data to determine elastic modulus, yield strength, and toughness, compare strengthening mechanisms, and evaluate the effect of heat treatment on mechanical properties using spreadsheet or computational tools.
Using the tools learned on Module 5, design a variety of items, including:	Use computational tools to interpret binary and iron–carbon phase diagrams, apply the lever rule to calculate phase fractions, predict microstructures under different cooling conditions, and correlate phase composition with mechanical properties.

Practical Module (Internal and External Evaluation)

M.No:	Experiments
Module 1.	To study 2D & 3D lattices.
Module 2.	To study crystal structures using appropriate models.
Module 3.	To study Bravais Lattices using appropriate models.
Module 4.	To study crystal imperfections using appropriate models.
Module 5.	To study three dimensional close packing using appropriate models.
Module 6.	Specimen preparation for micro structural examination.
Module 7.	To study microstructure of metals/alloys.
Module 8.	To study Heat Treatment Processes of steel.
Module 9.	To study creep behaviour of a given specimen(e.g. lead, zinc, solder wire).

CLO-PLO Mapping Matrix

CLO \ PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	3	2	1	0	0	0	0	0	0	0	3	2
CLO2	3	2	2	1	0	1	2	0	0	0	3	2
CLO3	2	3	2	3	2	0	0	0	0	1	2	3
CLO4	2	2	3	2	2	0	0	0	0	1	2	2
CLO5	3	3	3	2	2	1	2	1	1	1	3	3

S.No:	Text Books	Author	Publisher
1.	Fundamentals of Materials Science and Engineering	W.DJohn Wiley & Sons, 2011	John Wiley & Sons
	References	**Author**	**Publisher**
2.	Mechanical Metallurgy	George E. Dieter	McGraw Hill
3.	Physical Metallurgy	Cahn. R.W., Haasen. P	North-Holland

Course Code	BMECCET325				
Category	Professional Core courses				
Course Title	Engineering Thermodynamics				
Scheme and Credits	L	T	P	Credits	Semester- 3 (*Three*)
	2	1	0	3	
Pre requisites	Mathematics, Physics and Chemistry				

Course Learning Outcomes (CLOs)

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

i) **CLO1:** Explain the fundamental concepts of thermodynamics, thermodynamic properties, equations of state, and behaviour of pure substances and gas mixtures. *(L2)*

ii) **CLO2:** Apply the first law of thermodynamics to analyze energy interactions in closed and open systems *(L3)*

iii) **CLO3:** Analyze thermodynamic systems using the second law, entropy, and availability concepts. *(L4)*

iv) **CLO4:** Analyze entropy changes, exergy, and second-law efficiency using thermodynamic property diagrams. *(L4)*

v) **CLO5:**Apply thermodynamic property relations, Maxwell's relations, Clausius–Clapeyron equation, and Joule–Thomson coefficient to solve engineering thermodynamics *(L3)*

Theory Module(Internal and External Evaluation)

M.No:	Topic
Module 1.	Review of basic concepts of thermodynamics, thermodynamic systems and surroundings, properties and state of a system, thermodynamic equilibrium, Zeroth law of thermodynamics, concept of temperature and heat, thermometry and temperature scales, thermodynamic properties of pure substances, phase rule, P–V, P–T, T–V and PVT surfaces, ideal and real gases, equations of state, Avogadro's law, Van der Waals equation of state, compressibility factor, generalized compressibility charts.
Module 2.	Thermodynamic cycles, closed and open systems, first law of thermodynamics, internal energy, enthalpy, specific heats, energy balance for closed systems, control volume analysis, steady-flow energy equation, engineering applications.
Module 3.	Second law of thermodynamics, Kelvin–Planck and Clausius statements, heat engines, Carnot theorem, Carnot cycle, refrigerators and heat pumps, Clausius inequality, entropy, principle of increase of entropy, reversible and irreversible processes, entropy generation, second law analysis, availability, irreversibility, Gibbs free energy.
Module 4.	Entropy change of pure substances, entropy change of ideal gases, property diagrams, T–S diagram, h–s (Mollier) diagram, reversible steady-flow work, exergy, exergy balance for closed and open systems, exergy destruction, second law efficiency, engineering applications of exergy analysis.
Module 5.	Exact differentials, thermodynamic property relations, Maxwell's relations, Tds equations, Clausius–Clapeyron equation, Joule–Thomson coefficient, Joule–Thomson expansion.

Activity Module (Internal Evaluation Only-10 Marks)

Activity	Example Task
Using the tools learned on Module 1, design a variety of items, including:	Determine the properties of pure substances and gas mixtures, generate P–V and P–T plots, compare ideal and real gas behaviour using equations of state, and compute compressibility factors using Python, MATLAB, or Excel.
Using the tools learned on Module 2, design a variety of items, including:	Perform energy balance calculations for closed systems and steady-flow devices such as nozzles, turbines, compressors, pumps, and heat exchangers using analytical or computational methods, and compare the results.
Using the tools learned on Module 3, design a variety of items, including:	Evaluate the performance of heat engines, refrigerators, and heat pumps by calculating entropy generation, irreversibility, thermal efficiency, and second-law efficiency using Python, MATLAB, or Excel.
Using the tools learned on Module 4, design a variety of items, including:	Plot T–S and h–s diagrams, perform exergy analysis of engineering systems, determine exergy destruction and availability, and interpret the results using computational tools.
Using the tools learned on Module 5, design a variety of items, including:	Solve engineering problems involving Maxwell's relations, Clausius–Clapeyron equation, Joule–Thomson coefficient, and thermodynamic property relations using analytical methods or computational tools such as Python, MATLAB, or Excel. .

CLO-PLO Mapping Matrix

CLO \ PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	3	2	2	0	3	0	0	0	0	0	0	2
CLO2	2	3	3	0	3	0	0	0	0	0	0	2
CLO3	2	3	2	3	3	0	2	0	0	2	0	3
CLO4	3	2	3	0	3	2	0	2	0	3	0	0
CLO5	3	3	3	2	3	2	2	0	3	3	2	3

S.No:	Text Books	Author	Publisher
1.	Engineering Thermodynamics	Nag.P.K.	Tata McGraw-Hill
2.	Fundamentals of Thermodynamics	R. E. Sonntag, C. Borgnakke, & G. J. V Wylen.	John Wiley & Sons.
	References	**Author**	**Publisher**
1.	Thermodynamics, An Engineering Approach	Cengel,	Tata McGraw-Hill
2.	Fundamentals of Engineering Thermodynamics	Moran, J. Shapiro, H. N., Boe□ ner, D. D., & M. Bailey	John Wiley & Sons.

Course Code	**BMECCFM325**				
Category	**Professional Core courses**				
Course Title	**Fluid Mechanics**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	Semester- **3** (*Three*)
	2	1	2	4	
Pre requisites	**Engineering Mechanics**				

Course Learning Outcomes (CLOs)

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

i) **CLO1:** ***Understand*** the fundamental concepts of fluid mechanics, including fluid properties, fluid statics, and fluid kinematics. *(L2)*

ii) **CLO2:** ***Compare*** different fluid flow phenomena, pressure measurement techniques, and methods of fluid flow analysis for engineering applications. *(L2)*

iii) **CLO3:** ***Interpret*** fluid flow behavior using conservation laws, Bernoulli's equation, momentum principles, and Navier–Stokes concepts to evaluate engineering systems *(L5)*.

iv) **CLO4:** ***Draw*** streamlines, flow nets, velocity profiles, and boundary layer representations for different fluid flow conditions. *(L3)*

v) **CLO5:** ***Assemble*** the principles of dimensional analysis, similarity, internal and external flows to develop solutions for practical fluid engineering problems. *(L6)*

Theory Module(Internal and External Evaluation)

M.No:	Topic
Module 1	Scope and applications of fluid mechanics, fluid as a continuum, fluid properties (density, specific gravity, specific weight, viscosity, compressibility, vapor pressure, surface tension), Newtonian and non-Newtonian fluids, methods of analysis (system and control volume), pressure measurement and manometry.
Module 2.	Pressure variation in static fluids, hydrostatic forces on plane and curved surfaces, buoyancy and stability of floating and submerged bodies, metacentric height, Eulerian and Lagrangian descriptions, velocity and acceleration fields, streamlines, pathlines, streaklines, continuity equation, rotation and vorticity, stream function and velocity potential, flow nets.

Module 3.	Reynolds Transport Theorem, conservation of mass, momentum and energy, Bernoulli equation and its applications, flow measurement devices, limitations of Bernoulli's equation.
Module 4.	Differential continuity equation, Euler's equation of motion, Navier–Stokes equations, exact solutions for Couette and Poiseuille flows, Darcy–Weisbach equation, major and minor losses in pipe flow, pipe systems in series and parallel.
Module 5.	Dimensional homogeneity, Buckingham π theorem, geometric, kinematic and dynamic similarity, model and prototype studies, boundary layer theory, laminar and turbulent boundary layers, flow over flat plates, cylinders and airfoils, lift and drag.

Activity Module (Internal Evaluation Only-10 Marks)

Activity	Example Task
Using the tools learned on Module 1, design a variety of items, including:	Develop a simple MATLAB/Python program to calculate hydrostatic pressure at different depths and plot pressure variation with depth for water, oil, and mercury.
Using the tools learned on Module 2, design a variety of items, including:	Use MATLAB/Python to generate streamlines and velocity vectors for a given 2D velocity field and interpret the flow pattern.
Using the tools learned on Module 3, design a variety of items, including:	Create a program in MATLAB/Python to determine flow rate through a Venturimeter using Bernoulli's equation and study the effect of pressure difference on discharge.
Using the tools learned on Module 4, design a variety of items, including:	Develop a MATLAB/Python program to calculate Reynolds number and classify the flow as laminar, transitional, or turbulent for different pipe diameters and flow rates.
Using the tools learned on Module 5, design a variety of items, including:	Develop a MATLAB/Python/Excel-based program to evaluate Reynolds, Froude, Weber, and Mach numbers for engineering applications such as pipe flow *etc.* determine the appropriate similarity criterion for model testing.

Practical Module (Internal and External Evaluation)

M.No:	Experiments
Module 1.	Measurement of viscosity
Module 2.	Study of pressure measuring devices
Module 3.	Determination of metacentric height
Module 4.	Hydrostatics force on flat surfaces/ curved surfaces
Module 5.	Verification of Bernoulli's theorem
Module 6.	Determination of friction factor as a function of Reynolds number in pipe flow
Module 7.	Determination of coefficient of discharge of Venturimeter/ Orifice meter
Module 8.	Studying laminar-turbulent transition for flow in a tube
Module 9.	Determination of friction factor as a function of Reynolds number in pipe flow
Module 10.	Flow Visualisation around a body/ over surface
Module 11	Boundary layer flow over a flat plate

CLO-PLO Mapping Matrix

CLO \ PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	3	2	2	0	3	0	0	0	0	0	0	2
CLO2	2	3	3	0	3	0	0	0	0	0	0	2
CLO3	2	3	2	3	3	0	2	0	0	2	0	3
CLO4	3	2	3	0	3	2	0	2	0	3	0	0
CLO5	3	3	3	2	3	2	2	0	3	3	2	3

S.No:	Text Books	Author	Publisher
1.	Introduction to Fluid Mechanics	Fox, R. W., McDonald, A. T., & Pritchard, P. J.	Wiley
2.	Introduction to Fluid Mechanics and Fluid Machines	S K Som, Gautam Biswas, S Chakraborty	McGraw Hill
	References		
3.	Fluid Mechanics	Munson | Okiishi | Huebsch | Roth Mayer	Wiley

4.	Fluid Mechanics	Dr. Bansal, R.K	Lakshmi Publications
5.	Fluid Mechanics and hydraulics	Dr. Jagadishlal	Metropolitan Book Co-Ltd., 1997
6.	Fluid Mechanics: Fundamentals and Applications.	Yunus A. Cingel John M.Oimbala.	McGraw Hill
7.	Fluid Mechanics	John F. Douglas, Janul and M.Gasiosek and john A.Swaffield	Pearson Education Asia,

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Course Code	**BMECCMP325**				
Category	**Professional Core courses**				
Course Title	**Metal Cutting and Machining Processes**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester- 3 (*Three*)**
	2	1	2	4	
Pre requisites	**Engineering Workshop, Materials Engineering**				

Course Learning Outcomes (CLOs)

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

i*) CLO1:** ***Understand machining processes, chip formation, tool materials, grinding, etc. ***(L2)***

ii)* CLO2:** ***Compare orthogonal *vs.* oblique cutting, EDM vs. ECM, honing vs. lapping, polishing vs. buffing, conventional vs. non-conventional machining. ***(L2)***

iii)* CLO3: Interpret** Merchant Force Circle, tool life equations, grinding forces, machining economics, and process performance. ***(L5)

iv)* CLO4: Draw** single-point cutting tool geometry, Merchant Force Circle, chip formation, grinding wheel, EDM, ECM, LBM, honing, lapping, etc. ***(L3)

v)* CLO5: Assemble** machining operations by selecting suitable tools, machining processes, cutting parameters, and finishing methods for a given component. ***(L6)

Theory Module(Internal and External Evaluation)

M.No:	Topic
Module 1.	Machining Processes: Mechanics of Cutting; Geometry of Single-point Cutting Tool, Mechanism in Chip Formation, Types of Chips, Orthogonal and Oblique Cutting, Cutting Forces and Merchant Force Circle Diagram, Shear and Friction angle, Shear and Chip Velocity, Energy in Shear and Friction Plane,
Module 2.	Materials and Life of Cutting Tool; Composition and Properties of Tool Materials, Tool Life; Various Failures in Cutting Tool, Calculation of Tool life (Taylor's Tool Life Equation), Description of Practical Machining Processes; Process Geometry, Process Parameters for Turning and related machining operations, Economics of Cutting.
Module 3.	Abrasive Machining Processes: Need and Classifications; Abrasive Grinding: Wheel Specification, Wheel Life, Balancing, Truing and Dressing of Wheels, Classifications of Abrasive Grinding Processes, Chipping action in grinding, Calculation of Material Removal Rate, Forces and Power, Heat and Temperature in Abrasive Grinding, Working Principle and Applications of Grinding Processes for Prismatic and Rotational Parts.
Module 4.	Abrasive Finishing Processes: Conventional Abrasive Finishing: Honing, Lapping, Polishing and Buffing, Modern Abrasive Finishing: Abrasive Flow Finishing, Magnetic Abrasive Finishing and Magnetic Float Finishing.
Module 5.	Non-conventional Machining Processes: Need and Classification of Mechanical Machining Processes,, Electrochemical Processes, Electro-Thermal & Optical Processes, Process Principle, Equipments and Applications

Activity Module (Internal Evaluation Only-10 Marks)

Activity	Example Task

Using the tools learned on Module 1, design a variety of items, including:	Simulation of Orthogonal Cutting to Determine Cutting Forces and Merchant Circle Parameters (Using MATLAB/Excel)
Using the tools learned on Module 2, design a variety of items, including:	Simulation of Tool Life Prediction Using Taylor's Tool Life Equation *(Using MATLAB/Excel)*
Using the tools learned on Module 3, design a variety of items, including:	Computational Analysis of Grinding Wheel Speed and Depth of Cut on Surface Finish (Using MATLAB/Excel)
Using the tools learned on Module 4, design a variety of items, including:	Simulation of Material Removal during Honing and Lapping Processes (Using MATLAB/Excel)
Using the tools learned on Module 5, design a variety of items, including:	Computational Analysis of Electrochemical Machining (ECM) Material Removal Rate Using Faraday's Law (Using MATLAB/Excel)

Practical Module (Internal and External Evaluation)

M.No:	Experiments
Module 1.	To study the geometry of a single-point cutting tool.
Module 2.	To investigate the effect of machining process parameters on the surface roughness of machined components.
Module 3.	To compare the theoretical and experimental machining time in the turning operation.
Module 4.	To make a job as per drawing using a surface grinding machine. Write the process sheet and draw the sketches of the machine tool and tools used.
Module 5.	To study the Abrasive Flow Finishing process and evaluate material removal
Module 6.	To produce a cavity on a conductive workpiece using EDM.
Module 7.	To study the effect of discharge current on MRR during EDM.
Module 8.	To determine electrode wear during EDM.
Module 9.	To compare machining performance using copper and graphite electrodes using EDM.
Module 10.	To identify machining parameters for maximum MRR and minimum tool wear.

CLO-PLO Mapping Matrix

CLO \ PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	3	2	1	1	1	0	1	0	0	1	0	1
CLO2	3	3	1	1	1	0	1	0	0	1	0	1
CLO3	3	3	2	3	2	0	1	0	0	1	0	1
CLO4	2	2	3	1	3	0	0	0	0	2	0	1
CLO5	3	3	3	2	2	0	2	0	1	2	2	2

S.No:	Text Books	Author	Publisher
1.	Fundamentals of Modern Manufacturing: Materials Processes and Systems	M. P. Groover	John Wiley and Sons
2.	Manufacturing Technology: Volume 2	P N Rao	Tata McGraw Hill
3.	Manufacturing Science	Ghosh and Mallik	East West Press.
	References		
1.	Introduction to Machining Science	G. K. Lal	New Age International
2.	Fundamentals of Machining Processes	Hassan El-Hofy	Taylor and Francis.
3.	Rapid Prototyping: Principles and Applications	Rafiq Noorani	Wiley International.

Course Code	BMECBPD425				
Category	Basic Science Course				
Course Title	Partial Differential Equations, Laplace and Z-transform.				
Scheme and Credits	L	T	P	Credits	Semester- 4 (*Four*)
	2	1	0	3	
Pre requisites	-				

Course Learning Outcomes (CLOs)

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

i) **CLO1:** ***Classify*** and distinguish between linear and non-linear partial differential equations. ***(L2)***

ii) **CLO2:** ***Explain*** the fundamental concepts of Laplace transforms, vector spaces, and multivariate calculus structures. ***(L2)***

iii) **CLO3:** ***Evaluate*** the consistency of systems of linear equations and analyze the physical and geometric meaning of mathematical models, such as wave equations, periodic functions, and optimization boundaries. ***(L4)***

iv) **CLO4:** ***Synthesize*** concepts from linear algebra, integral calculus, and differential equations to model, solve, and analyze complex engineering systems. ***(L6)***

v) **CLO5:** ***Construct, formulate,*** and ***sketch*** geometric transformations, coordinate changes (Jacobians), and change of limits in multiple integrals to solve engineering boundary-value problems. ***(L6)***

Theory Module (Internal and External Evaluation)

M.No:	Topic
Module 1.	Formation of partial differential equations, first-order partial differential equations, linear and non-linear first-order PDEs, Lagrange's linear equations, standard forms, Charpit's method.
Module 2.	Homogeneous and non-homogeneous linear partial differential equations with constant coefficients, complementary function (CF), particular integral (PI), methods for solving higher-order linear PDEs and applications.
Module 3.	Laplace transform, condition for the existence of Laplace transform, Laplace transform of some elementary functions, differentiation and integration of laplace transform, laplace transform of periodic functions, shifting theorem, Laplace transforms of different functions. Heavisides unit function, dirac delta function, its Laplace transform, Heaviside's expansion theorem.
Module 4.	Initial and final value theorems, convolution theorem and its applications, inverse Laplace transforms, solution of ordinary differential equations using Laplace transforms, applications to engineering problems.
Module 5.	Finite Fourier transform, Fourier integral formula, properties of Fourier transform, Fourier sine and cosine transforms, convolution theorem, Parseval's identity, applications of Fourier transforms to the solution of boundary value problems.

Activity Module (Internal Evaluation Only-10 Marks)

Activity	Example Task
Using the tools learned on Module 1, design a variety of items, including:	Solve first-order partial differential equations using MATLAB/Python and compare analytical and numerical solutions.
Using the tools learned on Module 2, design a variety of items, including:	Simulate one-dimensional heat conduction, wave propagation, and string vibration using MATLAB.
Using the tools learned on Module 3, design a variety of items, including:	Develop MATLAB/Python programs to compute Laplace transforms and inverse Laplace transforms of engineering functions.
Using the tools learned on Module 4, design a variety of items, including:	Laplace transforms using MATLAB Symbolic Toolbox/Python (SymPy) to solve linear differential equations arising in engineering systems.
Using the tools learned on Module 5, design a variety of items, including:	Implement MATLAB/Python codes to compute Fourier transforms and solve boundary value problems through graphical visualization and interpretation.

CLO-PLO Mapping Matrix

CLO \ PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	3	2	1	1	2	0	0	0	0	0	0	1
CLO2	3	3	2	2	2	0	0	0	0	1	0	1

CLO3	2	3	2	3	3	0	0	0	0	1	0	2
CLO4	3	3	2	3	2	0	0	0	0	1	0	2
CLO5	2	2	2	2	3	0	0	0	1	2	1	3

S.No:	Text Books	Author	Publisher
1.	Advanced Engineering Mathematics	Erwin Kreyszig	Wiley India
2.	Advanced Engineering Mathematics,	H. K. Dass,	S. Chand Publishing.
3.	Higher Engineering Mathematics	B. S. Grewal,	Khanna Publishers.
	References		
1.	Laplace Transforms (Schaum's Outline Series)	Murray R. Spiegel,	McGraw-Hill Education.
2.	Advanced Engineering Mathematics,	Michael D. Greenberg	Pearson Education.
3.	Elements of Partial Differential Equations	Ian N. Sneddon	McGraw-Hill Education.

Course Code	**BMECCMS425**				
Category	**Professional Core courses**				
Course Title	**Mechanics of Solids**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester- 4 (*Four*)**
	2	1	2	4	
Pre-requisites	**Statics and Dynamics**				

Course Learning Outcomes (CLOs)

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

i) **CLO1:** ***Analyze*** stress, strain, deformation, and thermal effects in axially loaded members by applying elasticity principles, generalized Hooke's law, compatibility conditions, and equilibrium equations to solve determinate and indeterminate problems. ***(L2)***

ii) **CLO2:** ***Analyze*** two-dimensional stress and strain states using stress transformation equations, Mohr's circle, and strain rosette techniques to determine principal stresses, principal strains, and maximum shear stresses. ***(L2)***

iii) **CLO3:** ***Apply*** torsion theory to determine shear stresses, angle of twist, torsional deformation, and spring deflection in circular shafts and helical springs under various loading conditions. ***(L3)***

iv) **CLO4:** ***Analyze*** the structural behavior of beams by determining shear forces, bending moments, bending stresses, shear stresses, beam deflection, and shear center for beams subjected to different loading conditions. ***(L3)***

v) **CLO5:** ***Analyze*** stress distributions in thin- and thick-walled pressure vessels using pressure vessel theory, Lamé's equations, and shrink-fit principles to evaluate the structural integrity of cylindrical and spherical vessels. ***(L6)***

Theory Module(Internal and External Evaluation)

M.No:	Topic
Module 1.	Introduction to stress and strain, stress-strain diagram, Poisson's ratio, multiaxial loading- generalized Hooke's law, dilatation and bulk modulus, shearing strain, deformations under axial loading, stress concentrations, plastic deformations, residual stresses, elastic constants and their relations, statically indeterminate problems, problems involving temperature change.
Module 2.	State of stress at a point, Stress tensor, general state of stress, introduction to three dimensional analysis of stress, Plane Stress, complimentary property of shear stress, transformation of plane stress, transformation equations, principal stresses and maximum shearing stress, Mohr's Circle for plane stress, transformation of plane strain, transformation equations, Mohr's circle for plane strain, , measurement of strain and strain rosette.
Module 3.	Torsion, stresses and deformation in circular and hollow shafts, stepped shafts, Power transmission for solid and hollow circular shafts.

Module 4.	Theory of bending of beams, bending stress distribution and neutral axis, shear stress distribution, shear stresses in beams of rectangular and circular cross section, shear stresses in the webs of beams with flanges, shear centre concept and its determination for thin walled members.
Module 5.	Thin walled pressure vessels, stresses in thin cylindrical and spherical pressure vessels subjected to internal pressure, deformation of and thin cylinders, deformation in spherical shells subjected to internal pressure. Introduction to Hertz contact stresses.

Activity Module (Internal Evaluation Only-10 Marks)

Activity	Example Task
Using the tools learned on Module 1, design a variety of items, including:	Develop a MATLAB/Python program to compute normal stress, strain, elongation, and thermal stresses in prismatic and non-prismatic bars under axial loading.
Using the tools learned on Module 2, design a variety of items, including:	Develop MATLAB/ Python program to calculate and plot Mohr's Circle for plane stress and plane strain.
Using the tools learned on Module 3, design a variety of items, including:	Develop MATLAB/ Python code to generate Shear Force Diagrams (SFD) and Bending Moment Diagrams (BMD) for various loading conditions.
Using the tools learned on Module 4, design a variety of items, including:	Develop a MATLAB/ Python program to analyze the torsional behavior of solid, hollow, and stepped circular shafts,
Using the tools learned on Module 5, design a variety of items, including:	Plot radial and hoop stress distributions using Lamé's equations for thick cylinders.

Practical Module (Internal and External Evaluation)

M.No:	Experiments
Module 1.	Tensile test of mild steel and Aluminum Bars
Module 2.	Shear test on specimens of two different materials.
Module 3.	Charpy and Izod Impact test on a metallic specimen.
Module 4.	Brinnell and Rockwell hardness tests on metallic specimens.
Module 5.	Bending deflect on test on beams.
Module 6.	Strain measurement using rosette strain gauge.
Module 7.	Torsion test on specimens of different metals for determining the angle of twist for a given torque.
Module 8.	Compressive test of a specimen.
Module 9.	Shear test on specimens of two different metals.

CLO-PLO Mapping Matrix

CLO \ PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	3	3	2	2	2	1	1	0	1	1	0	1
CLO2	3	3	2	3	2	1	0	0	1	1	0	1
CLO3	3	3	3	2	2	1	1	0	1	1	1	1
CLO4	3	3	3	2	3	1	1	0	1	1	0	1
CLO5	3	3	3	2	2	2	1	0	1	1	0	2

Recommended Books

S.No:	Text Books	Author	Publisher
1.	Mechanics of Materials	R. C. Hibbeler	Pearson
2.	Mechanics of Materials	Barry J Goodno, James M. Gere	Cengage Learning
	References		
1.	Mechanics of Materials	J.M. Gere and S.P. Timoshenko	Cengage Learning, 1997
2.	Introduction to Solid Mechanics	I.H. Shames and J.M. Pitarresi	Pren ce Hall of India,1999
3.	Mechanics of Materials	Andrew Pytel & JAAN Kiulaas	Cengage Learning

Course Code	BMECDPE425				
Category	Professional Elective Course				
Course Title	Programming for Engineers				
Scheme and Credits	L	T	P	Credits	Semester- 4 (*Four*)
	1	0	2	2	
Pre-requisites	Basic Mathematics				

Course Learning Outcomes (CLOs)

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

i) **CLO1:** ***Understand*** the fundamentals of algorithms, flowcharts, pseudocode, computing software, and object-oriented programming concepts. ***(L2)***

ii) **CLO2:** ***Compare*** programming constructs, software types, functions, and object-oriented programming features for solving computational problems. ***(L2)***

iii) **CLO3:** ***Interpret*** computational results obtained from vector and matrix operations, numerical methods, program execution, and graphical visualizations. ***(L5)***

iv) **CLO4:** ***Develop*** algorithms, flowcharts, and 2D/3D graphical representations using programming constructs, functions, and visualization tools. ***(L3)***

v) **CLO5:** ***Design*** and implement modular object-oriented programs by integrating data structures, functions, file handling, numerical techniques, and visualization to solve engineering problems. ***(L6)***

Theory Module(Internal and External Evaluation)

M.No:	Topic
Module 1.	Role of computation in engineering analysis, engineering problem-solving methodology, algorithms, flowcharts, pseudocode, introduction to computational platforms (MATLAB, Python, GNU Octave, or equivalent), variables, constants, data types, operators, expressions, basic input/output operations.
Module 2.	Scalars, vectors, and matrices, mathematical operations on vectors and matrices, matrix manipulation, solution of linear algebraic equations, engineering data representation, file input/output operations.
Module 3.	Decision-making statements, logical operators, loops and iterations, implementation of engineering algorithms, debugging techniques, program testing and verification, computational problem-solving using iterative methods.
Module 4.	User-defined functions, built-in libraries, script and function files, modular programming concepts, two-dimensional plotting, graph customization, annotations, engineering data visualization and interpretation.
Module 5.	Numerical solution of engineering problems, introduction to root-finding methods, numerical differentiation, numerical integration, simple finite difference formulation for one-dimensional heat conduction, engineering case studies using computational platforms.

Activity Module (Internal Evaluation Only-10 Marks)

Activity	Example Task
Using the tools learned on Module 1, design a variety of items, including:	Design an algorithm and flowchart to calculate stress, strain, and factor of safety for a mechanical component.
Using the tools learned on Module 2, design a variety of items, including:	Solve the stiffness matrix of a simple spring system or truss using matrix operations using MATLAB, Python, GNU Octave, or any other equivalent computational platform.
Using the tools learned on Module 3, design a variety of items, including:	Develop a program to determine the root of a heat transfer or fluid flow equation using the Bisection or Newton–Raphson method using MATLAB, Python, GNU Octave, or any equivalent computational platform.
Using the tools learned on Module 4, design a variety of items, including:	Create a reusable function to calculate Reynolds number, Nusselt number, pressure drop, or beam deflection for different operating conditions using MATLAB, Python (Matplotlib), GNU Octave, or any equivalent computational platform.
Using the tools learned on Module 4, design a variety of items, including:	Simulate one-dimensional steady-state heat conduction using the Finite Difference Method and visualize the temperature distribution using 2D and

	surface plots using MATLAB, Python (Matplotlib), GNU Octave, or any equivalent computational platform.

Practical Module (Internal and External Evaluation)

M.No:	Experiments
Module 1.	Write the algorithm, draw the flowchart, and prepare pseudocode for simple problems such as finding the largest number, factorial, and checking whether a number is prime.
Module 2.	Create vectors and matrices, and perform addition, subtraction, multiplication, transpose, determinant, and inverse operations.
Module 3.	Write programs to accept scalar, string, vector, and matrix inputs from the user and display formatted outputs. Save and load data using MAT-files.
Module 4.	Implement programs using if, if-else, and switch statements to solve problems such as grading systems, leap year checking, and maximum of three numbers.
Module 5.	Develop programs using for and while loops to generate multiplication tables, Fibonacci series, factorial, and prime numbers.
Module 6.	Solve nonlinear equations using numerical methods such as the Bisection Method, Newton-Raphson Method, and MATLAB's fzero() function.
Module 7.	Create user-defined functions, anonymous functions, subfunctions, and function files. Pass arrays as function arguments and use built-in mathematical functions.
Module 8.	Create user-defined functions, anonymous functions, subfunctions, and function files. Pass arrays as function arguments and use built-in mathematical functions.
Module 9.	Create a simple class with properties and methods. Demonstrate OOP concepts such as encapsulation, inheritance, and polymorphism through basic examples.
Module 10.	Plot mathematical functions (e.g., sine, cosine, exponential), add titles, labels, legends, grids, annotations, and create simple animations using draw now.
Module 11	Generate 3D line plots, mesh plots, surface plots, contour plots, and customize their appearance using MATLAB plotting commands.
Module 12	Create mesh, surf, contour 3, and waterfall plots for mathematical functions and engineering data.

CLO-PLO Mapping Matrix

CLO \ PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	3	2	-	1	2	0	0	0	0	1	0	1
CLO2	2	3	2	3	2	0	0	0	0	1	0	2
CLO3	3	3	2	2	3	0	0	0	0	2	0	1
CLO4	3	3	3	2	3	0	0	0	0	2	1	2
CLO5	3	3	3	2	3	0	0	0	1	2	2	3

Recommended Books

S.No:	Text Books	Author	Publisher
1.	Programming for Engineers	Aaron. R. Bradley	Springer
2.	Introduction to Programming with C++ for Engineers	Boguslaw Cyganek	Wiley
	References	**Author**	**Publisher**
1.	How to Solve It by Computer	R. G. Dromey (algorithms and programming logic)	Prentice Hall
2.	MATLAB: A Practical Introduction to Programming and Problem Solving	Stormy Attaway (primary textbook)	Butterworth-Heinemann

Course Code	**BMECDRE425**

Category	Professional Elective				
Course Title	Renewable Energy Systems				
Scheme and Credits	L	T	P	Credits	Semester- 4 (*Four*)
	2	0	0	2	
Pre-requisites	Engineering Thermodynamics and Environmental Studies				

Course Learning Outcomes (CLOs)

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

i) **CLO1:** The student will understand the fundamental concepts, principles, and significance of renewable energy systems, including solar, wind, biomass, geothermal, and small hydro energy technologies. *(L1)*

ii) **CLO2:** The student will compare different renewable energy technologies based on their working principles, efficiency, environmental impact, economic feasibility, and applications.*(L2)*

iii) **CLO3:** The student will interpret the performance characteristics, resource availability, and operational data of renewable energy systems for various engineering applications. *(L3)*

iv) **CLO4:** The student will draw schematic layouts and design basic renewable energy systems, including solar photovoltaic, solar thermal, wind energy, and hybrid energy systems for specific application. *(L4)*

v) **CLO5:** The student will apply engineering principles and analytical methods to evaluate, size, and select appropriate renewable energy systems for domestic, commercial, and industrial applications. *(L5)*

Theory Module(Internal and External Evaluation)

M.No:	Topic
Module 1.	Global and Indian energy scenario, energy demand and supply, conventional and non-conventional energy resources, classification of renewable energy sources, energy utilization, environmental impacts of energy systems, energy conservation, energy and climate change.
Module 2.	Biomass resources, classification and properties of biomass, proximate and ultimate analysis, calorific value, density and moisture content, biomass pre-treatment, thermochemical and biochemical conversion processes, stoichiometry of biomass combustion, heat and power generation from biomass, biomass-based power generation using internal combustion engines, gas turbines and fuel cells.
Module 3.	Wind characteristics, wind data analysis, energy available in the wind, wind energy extraction principles, Betz limit and its derivation, classification and components of wind turbines, blade profiles, performance analysis of wind turbines, wind resource assessment and wind energy potential in India.
Module 4.	Solar radiation and its measurement, fundamentals of solar thermal energy conversion, photovoltaic effect, semiconductor materials and doping, solar photovoltaic systems, solar energy potential in India. Small hydropower: power equation, classification of small hydropower plants, hydraulic turbines, major components of small hydropower projects. Geothermal energy: geothermal resources, geothermal power generation, global status, advantages and limitations.
Module 5.	Fundamentals of thermal radiation, blackbody radiation, emissive power and surface properties. Hydrogen energy systems: hydrogen production methods, storage technologies, safety considerations, renewable hydrogen applications. Fuel cells: operating principles, types, components, performance characteristics and applications. Hybrid energy systems: need and configuration of hybrid systems, integration of renewable energy sources, integrated gasification combined cycle (IGCC), combined cycle power plants, electric vehicles, hybrid electric vehicles and hydrogen fuel-cell electric vehicles.

Activity Module (Internal Evaluation Only-10 Marks)

Activity	Example Task
Using the tools learned on Module 1, design a variety of items, including:	Conduct a comparative study of conventional and renewable energy resources in India. Prepare an energy scenario report highlighting India's energy mix, renewable energy potential, environmental impacts, and climate change mitigation strategies. Present the findings through a seminar or poster.
Using the tools learned on Module 2, design a variety of items, including:	Determine the moisture content and calorific value of locally available biomass samples (or analyze provided data). Develop a flowchart illustrating biomass conversion technologies and perform simple stoichiometric calculations for biomass combustion. Prepare a case study on a biomass-based power plant.
Using the tools learned on Module 3, design a variety of items, including:	Collect wind speed data from a selected location (or use publicly available data) and estimate the wind power potential. Plot the power curve of a wind turbine and calculate turbine efficiency using Betz limit concepts.
Using the tools learned on Module 4, design a variety of items, including:	Design a basic stand-alone solar PV system for a residential load using given specifications. Draw the layout of a small hydropower plant and identify its

	major components. Prepare a presentation comparing solar PV, small hydropower, and geothermal power generation technologies in terms of efficiency, cost, environmental impact, and applications.

CLO-PLO Mapping Matrix

CLO \ PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	3	3	0	0	0	2	3	0	0	0	0	1
CLO2	2	3	1	2	0	2	3	1	0	1	0	1
CLO3	2	3	1	3	2	1	2	0	0	1	0	1
CLO4	2	2	3	1	3	2	3	0	1	1	2	1
CLO5	3	3	2	2	2	2	3	1	1	1	2	2

Recommended Books

S.No:	Text Books	Author	Publisher
1.	Solar Energy: Fundamental and Application	H. P. Garg and S. Prakash	McGraw Hill
2.	Non-Conventional Energy Resources	B H Khan	McGraw Hill
	References	**Author**	**Publisher**
1.	Solar Photovoltaics: Fundamentals, Technologies and Applications	Solanki C. S.	Prentice Hall India
2.	Applied Energy: An Introduction	Mohammad Omar Abdullah	CRC Press

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Course Code	**BMECDMC425**				
Category	**Professional Elective Course**				
Course Title	**Material Characterization Methods**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester- 4 (*Four*)**
	1	0	2	2	
Pre-requisites	**Material Engineering**				

Course Learning Outcomes (CLOs)

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

i) **CLO1:** ***Understand*** the principles, concepts, and applications of X-ray diffraction techniques for structural characterization of ceramic and crystalline materials. ***(L2)***

ii) **CLO2:** ***Compare*** different microscopy techniques such as optical microscopy, SEM, and TEM based on their principles, capabilities, and applications in material characterization. ***(L2)***

iii) **CLO3:** ***Interpret*** surface morphology, elemental composition, chemical bonding, and structural information obtained from AFM, SEM, EDAX, WDS, and XPS analysis. ***(L5)***

iv) **CLO4:** ***Draw*** and represent the working principles, instrumentation setup, and analysis procedures of spectroscopic techniques such as UV-Visible and FTIR spectroscopy. ***(L3)***

v) **CLO5:** ***Assemble*** suitable characterization techniques including fluorescence, XRF, ESR, NMR, and thermal analysis methods for evaluating glass and ceramic materials. ***(L6)***

Theory Module(Internal and External Evaluation)

M.No:	Topic
Module 1.	X-ray Diffraction, diffraction under non-ideal conditions, atomic scattering and geometrical structure factors, factors influencing the intensities of diffracted beams, powder X-ray diffractometer, EXAFS and XANES, applications of XRD in ceramic materials.

Module 2.	Microscopy, study of the morphology, aggregation, size and microstructure of ceramic materials using. optical microscope, quantitative phase analysis, principle of electron microscopy. Construction and operation of transmission electron microscope and scanning electron microscope, electron diffraction by crystalline solids; selected area diffraction.
Module 3.	AFM, SEM and XPS, atomic force microscope, mechanism of image formation in SEM and its processing. electron microprobe analysis (EDAX and WDS), preparation of samples for electron microscopic studies, electron spectroscopy for chemical analysis (ESCA/XPS).
Module 4.	Spectrophotometric analysis of materials, basic laws of spectrophotometry and its application in micro analysis in UV/ visible range, effect of reflectance factor on optical analysis, construction and working principle of spectrophotometer, importance of additive absorbance in multiple analysis of materials. Infrared spectrophotometry, general aspects of IR spectroscopy and its application in structural analysis of systems, sources of IR radiations, optical systems and operation of Fourier transformed infrared (FTIR) spectrophotometer, samples preparation, IR analysis and structural co-relations.
Module 5.	Fluorescence and phosphorescence spectroscopy, basic principle, geometrical optics, construction, working principle and use of fluorescence spectrometry in materials analysis. X-ray fluorescence, electron spin resonance spectroscopy, nuclear magnetic resonance, thermal characterization, differential thermal analysis, thermogravimetric analysis and differential scanning calorimetry with suitable examples of glass and ceramic materials.

Activity Module (Internal Evaluation Only-10 Marks)

Activity	Example Task
Using the tools learned on Module 1, design a variety of items, including:	Students are shown simple XRD diffraction patterns and asked to identify peak positions, intensity variations, and relate peaks to crystal structure/material identification through group discussion.
Using the tools learned on Module 2, design a variety of items, including:	Image processing and grain size Measurement from SEM/optical microscope Images.
Using the tools learned on Module 3, design a variety of items, including:	Simulation of atomic force microscopy Surface Topography Analysis (using Gwyddion)
Using the tools learned on Module 4, design a variety of items, including:	Simulation of FTIR spectrum acquisition and functional group identification (using spectragryph /Excel)
Using the tools learned on Module 5, design a variety of items, including:	Students participate in a rapid quiz or create a classroom concept map linking characterization techniques (XRF, fluorescence, DSC, TGA, DTA) with their principles and applications.

Practical Module (Internal and External Evaluation)

M.No:	Experiments
Module 1.	Identification of crystalline phases and determination of crystal structure using X-ray Diffraction (XRD) analysis.
Module 2.	Determination of crystallite size and lattice parameters from XRD diffraction patterns.
Module 3.	Study of morphology and microstructure of ceramic materials using Optical Microscope and SEM images.
Module 4.	Analysis of TEM images and Selected Area Electron Diffraction (SAED) patterns for crystalline material characterization.
Module 5.	Surface topography and roughness analysis of materials using Atomic Force Microscopy (AFM).
Module 6.	Elemental and chemical composition analysis of materials using EDAX and XPS techniques.
Module 7.	Determination of optical properties of materials using UV-Visible spectrophotometry.
Module 8.	Identification of functional groups and structural analysis of materials using FTIR spectroscopy.
Module 9.	Elemental composition analysis of ceramic/glass materials using X-ray Fluorescence (XRF) spectroscopy.
Module 10.	Thermal characterization of materials using TGA/DSC/DTA analysis and interpretation of thermal behavior.

CLO-PLO Mapping Matrix

CLO \ PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	3	2	0	2	1	0	1	0	0	0	0	1
CLO2	2	3	0	2	3	0	0	0	1	0	0	1
CLO3	2	3	1	3	3	0	0	0	0	1	0	1

CLO4	2	2	0	2	2	0	0	0	1	2	0	1
CLO5	3	3	2	3	3	1	1	0	2	2	1	3

Recommended Books

S.No:	Text Books	Author	Publisher
1.	Materials Characterization Techniques	Sam Zhang, Lin Li and Ashok Kumar	CRC Press
2.	Materials Characterization: Introduction to Microscopic and Spectroscopic Methods	Yang Leng,	Wiley & Sons.
	References	**Author**	**Publisher**
1.	Characterization of Materials	Elton N. Kaufmann	Wiley & Sons.
2.	Springer Handbook of Crystal Growth	G. Dhanaraj, K. Byrappa, V. Prasad and M. Dudley	Springer-Verlag
3.	Physical Methods of Materials Characterization	Peter E.J. Flewitt and R.K. Wild	Taylor & Francis.

Course Code	**BMECCTM425**				
Category	**Professional Core courses**				
Course Title	**Theory of Machines**				
Scheme and Credits	**L**	**T**	**P**	**Credits**	**Semester- 4 (*Four*)**
	2	1	2	4	
Pre-requisites	**Engineering Mechanics**				

Course Learning Outcomes (CLOs)

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

i) **CLO1:** ***Understand*** the kinematic behavior of planar mechanisms by determining mobility, velocity, acceleration, instantaneous centers, and Coriolis acceleration for common mechanisms such as four-bar and slider-crank chains. ***(L2)***

ii) **CLO2:** ***Compare*** and analyze cam-follower mechanisms by selecting appropriate follower motion laws and evaluating displacement, velocity, acceleration, and pressure angle characteristics for engineering applications. ***(L2)***

iii) **CLO3:** ***Interpret*** the principles of friction to analyze screw threads, screw jacks, and belt drive systems, and determine belt tensions, velocity ratio, slip, efficiency, and power transmission characteristics. ***(L5)***

iv) ***CLO4: Draw*** gear geometry and gear train configurations by applying the law of gearing to determine velocity ratios, contact ratio, interference, and power transmission in simple, compound, reverted, and epicyclic gear trains.***(L3)***

v) **CLO5:** ***Assemble and*** analyze the performance of governors, flywheels, and gyroscopic systems by evaluating speed regulation, stability, controlling force, and gyroscopic effects in engineering applications, ***(L6)***

Theory Module(Internal and External Evaluation)

M.No:	Topic
Module 1.	Mechanism and machine, elements or links, kinematic Joint, kinematic pair, degree of freedom (DOF), Mobility of Mechanism, Gruebler Criterion, four bar chain, inversions of four bar mechanism, Grashoff's law, transmission angle, single slider crank chain and double slider crank chain, velocity and acceleration analysis, Instantaneous centre of velocity, special cases of instantaneous centre of rotation, Coriolis acceleration.
Module 2.	Classification of cams and followers, terminology for cams, types of motion curves and their analytical expressions, graphical construction of cam profile for different types of followers, pressure angle.
Module 3.	Types of friction, laws of friction, force analysis of a single body, screw threads friction, screw jack, types of belt drive, velocity ratio, effect of slip, belt tensions, power transmission of belt drive, conditions for max power transmission.
Module 4.	Gear introduction, classification of gears, gear terminology, law of gearing, velocity of sliding , conjugate teeth, meshing of involute teeth, comparison of cyclodial and involute tooth, length of contact, contact ratio, interference, simple gear train, compound gear train, reverted gear train and epicyclic gear train.
Module 5.	Governors, Watt governor, Porter governor, Proell governor, Hartnell governor, controlling force, sensitivity, stability, hunting, isochronism, effort and power of a governor, working and analysis of flywheel,

	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.

Activity Module (Internal Evaluation Only-10 Marks)

Activity	Example Task
Using the tools learned on Module 1, design a variety of items, including:	Build a wooden four-bar linkage using four wooden bars joined with pivot pins.
Using the tools learned on Module 2, design a variety of items, including:	Profile synthesis and simulation of high speed cam follower systems to evaluate SVAJ curves and contact forcelift off thresholds using MATLAB
Using the tools learned on Module 3, design a variety of items, including:	Model an open belt drive and investigate the effects of pulley diameter and slip on velocity ratio.
Using the tools learned on Module 4, design a variety of items, including:	Modeling, simulation and kinematic analysis of simple, compound and epicyclic gear trains using MATLAB Multibody.
Using the tools learned on Module 5, design a variety of items, including:	Simulation-based dynamic analysis of slider-crank and flywheel systems for turning moment diagrams, fluctuation of energy and flywheel sizing.
Using the tools learned on Module 6 design a variety of items, including	MATLAB-based simulation of gyroscopic torque effects and directional stability of two-wheel and four-wheel vehicles during curved path maneuvers.

Practical Module (Internal and External Evaluation)

M.No:	Experiments
Module 1.	Study of kinematic pairs.
Module 2.	Study slider crank motion and reciprocating engine mechanism.
Module 3.	Study characteristics of various types of cams and followers.
Module 4.	To plot follower displacement vs cam rotation for various Cam Follower systems
Module 5.	To find coefficient of friction between belt and pulley
Module 6.	To study simple and compound screw jack and determine the mechanical advantage, velocity ratio and efficiency
Module 7.	Study the characteristics of a Watt Governor, Proell Governor and Porter Governor
Module 8.	Performance characteristics of a spring loaded governor
Module 9.	To study various types of gears- Spur, Helical, Worm and Bevel Gears
Module 10.	Determine the velocity of precession of a given motorized gyroscope.

CLO-PLO Mapping Matrix

CLO \ PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	3	3	3	2	2	1	1	0	1	1	1	2
CLO2	3	3	3	2	3	1	1	0	1	1	1	2
CLO3	3	3	3	2	2	2	1	1	1	1	2	2
CLO4	3	3	3	2	3	1	1	0	1	1	2	2
CLO5	3	3	3	3	3	2	1	1	1	2	2	2

S.No:	Text Books	Author	Publisher
1.	Theory of Mechanisms and Machines	Amitabha Ghosh and Ashok Kumar Mallik	EWP, 2007
2.	Theory of Machines	SS Ratan	Mc Graw Hill
	References	**Author**	**Publisher**
1.	Theory of Machines	Shigley	McGraw Hill, 1995
2.	Theory of Machines	Bevan	C.B.S Publica on, 1997
3.	Theory of Machines	Sadhu Singh	Pearson

Course Code	BMECDFM425				
Category	Experiential Learning Course				
Course Title	Fluid Machinery				
Scheme and Credits	L	T	P	Credits	Semester- 4 (*Four*)
	0	2	2	3	
Pre-requisites	Fluid Mechanics				

Course Learning Outcomes (CLOs)

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

i) **CLO1:** ***Explain*** the classification, operating principles, energy transfer mechanisms, and performance parameters of fluid machines using the fundamental concepts of turbomachinery. ***(L2)***

ii) **CLO2:** ***Analyze*** the performance of hydraulic turbines by constructing velocity triangles, applying Euler's turbomachinery equation, determining efficiencies, and selecting suitable turbines for specified operating conditions. ***(L4)***

iii) **CLO3:** ***Evaluate*** the performance of rotodynamic pumps by analyzing pump characteristics, system characteristics, pumps in series and parallel, NPSH, cavitation, and pump selection for engineering applications. ***(L4)***

iv) **CLO4:** ***Apply*** the principles of positive displacement pumps to determine discharge, slip, acceleration head, power requirements, and select appropriate pumps for industrial applications. ***(L3)***

v) **CLO5:** ***Analyze*** hydraulic transients, cavitation, and fluid power devices, and recommend suitable engineering measures for improving the reliability and efficiency of fluid systems. ***(L4)***

Theory Module(Internal and External Evaluation)

M.No:	Topic
Module 1.	Introduction to fluid machinery and its engineering applications, classification of fluid machines, positive displacement and rotodynamic machines, energy transfer in turbomachines, Euler's turbomachinery equation, velocity triangles, hydraulic, mechanical, volumetric and overall efficiencies, application of dimensional analysis and model testing for turbomachines, dimensionless groups, specific speed and unit quantities.
Module 2.	Classification and selection of hydraulic turbines, Impulse turbines: Pelton wheel-construction, working principle, velocity triangles, work done, efficiencies and governing, Reaction turbines: Francis, Propeller and Kaplan turbines-construction, inlet and outlet elements of turbine, draft tubes and their performance, characteristic curves of turbines, cavitation in hydraulic turbines.
Module 3.	Classification of pumps, centrifugal pumps, Euler and manometric head, hydraulic, manometric, mechanical, volumetric and overall efficiencies, Hydraulic Grade Line (HGL) and Energy Grade Line (EGL) in pumping systems, pump and system characteristic curves, pumps in series and parallel, axial-flow and mixed-flow pumps, Net Positive Suction Head (NPSH), cavitation in pumps.
Module 4.	Classification of positive displacement pumps, reciprocating pumps, slip and coefficient of discharge, acceleration head, air vessels, double-acting and multicylinder pumps, rotary positive displacement pumps: gear, vane, screw and lobe pumps, performance characteristics and engineering applications.
Module 5.	Head losses in pump and turbine systems, water hammer in pipelines, surge tanks and surge phenomena, cavitation and its prevention, hydraulic accumulator, hydraulic ram, hydraulic lift and hydraulic press, fluid coupling and torque converter.

Activity Module (Internal Evaluation Only-10 Marks)

Activity	Example Task
Using the tools learned on Module 1, design a variety of items, including:	Develop a MATLAB/Python/Excel program to construct velocity triangles and calculate work output using Euler's turbomachinery equation. apply dimensional analysis and similarity laws to predict the performance of a prototype from model test data.
Using the tools learned on Module 2, design a variety of items, including:	Analyze the performance of Pelton, Francis and Kaplan turbines using manufacturer or experimental data, develop a computational model to estimate turbine efficiency under varying head and discharge conditions, and prepare a case study on the hydraulic turbine employed in an existing hydroelectric power station. Conduct a field visit to a hydroelectric power station and prepare a performance evaluation report. Design a micro-hydropower system for a given site.
Using the tools learned on Module 3, design a variety of items, including:	Develop a MATLAB/Python/Excel program to generate pump characteristic curves and determine the operating point using system curves, evaluate the performance of pumps connected in series and parallel, design a pumping

	system for water supply, irrigation, or industrial applications using manufacturer's performance data.
Using the tools learned on Module 4, design a variety of items, including:	Develop a computational model to calculate discharge, slip, acceleration head, and power requirements of reciprocating pumps, compare reciprocating, gear, vane, screw, and lobe pumps for different industrial services and justify the selection based on operating conditions.
Using the tools learned on Module 5, design a variety of items, including:	Prepare a case study on the design and operation of hydraulic accumulators, hydraulic presses, hydraulic lifts, hydraulic rams, fluid couplings, or torque converters.

Practical Module (Internal and External Evaluation)

M.No:	Experiments
Module 1.	Impact of jet of water on vane (To find the coefficient of impact of jet on flat circular and hemispherical vanes).
Module 2.	Study of Pelton turbine (To conduct performance test on the Pelton turbine).
Module 3.	Study of Francis turbine (To conduct performance test on the Francis turbine).
Module 4.	Study of Kaplan turbine (To conduct performance test on the Kaplan turbine).
Module 5.	Study of centrifugal Pump (To analyse the pump and system characteristics).

CLO-PLO Mapping Matrix

CLO \ PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	3	2	1	-	-	-	-	-	-	1	-	1
CLO2	3	3	2	2	1	-	1	-	-	1	-	1
CLO3	3	3	2	2	2	1	2	-	-	1	1	1
CLO4	3	2	2	1	1	-	1	-	-	1	-	1
CLO5	3	3	3	2	2	2	3	1	-	1	1	2

Recommended Books

S.No:	Text Books	Author	Publisher
1.	Turbomachinery	Maneesh Dubey, BVSSS Prasad, Archana Nema	Mc Graw Hill Education
2.	Hydraulic Machines	Jagdish Lal	Metropolitan Book Company Pvt. Ltd., New Delhi
	References	**Author**	**Publisher**
1.	Fluid Machinery: Performance, Analysis, and Design	Terry Wright	New Age
2.	Principles of Turbomachinery	R.K Turton	Chapman and Hall
3.	Turbomachinery Design and Theory	Rama S. R. Gorla, Aijaz A. Khan	Marcel Dekkerinc

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Course Code	BMECCMC425				
Category	Professional Core Courses				
Course Title	Metal Casting and Forming Processes				
Scheme and Credits	L	T	P	Credits	Semester- 4 (*Four*)
	2	1	2	4	
Pre-requisites	Basic knowledge of Material Science, Fluid Mechanics and Engineering Thermodynamics				

Course Learning Outcomes (CLOs)

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

i) **CLO1:** ***Understand*** the principles of metal casting processes, moulding materials, gating and risering systems, casting defects, and special casting techniques used in manufacturing. ***(L2)***

ii) **CLO2:** ***Compare*** various metal forming processes such as rolling, forging, extrusion, wire drawing, and tube drawing based on their working principles, applications, and product characteristics. ***(L2)***

iii) **CLO3:** ***Interpret*** the sequence of operations, tooling requirements, and process parameters involved in sheet metal manufacturing processes and die design. ***(L5)***

iv) **CLO4:** ***Draw*** process flow diagrams, mould layouts, die designs, and schematic representations of advanced plastic moulding processes used in product manufacturing. ***(L3)***

v) **CLO5:** ***Assemble*** the knowledge of powder metallurgy processing, powder production methods, compaction techniques, and sintering operations to develop suitable manufacturing solutions for engineering components. ***(L6)***

Theory Module(Internal and External Evaluation)

M.No:	Topic
Module 1.	Fundamentals of metal casting, pattern design and allowances, moulding materials and mould preparation, gating and risering systems, melting practice, solidification, casting cleaning and inspection, casting defects and remedies, product design considerations for castings. Special casting processes: shell moulding, investment casting, permanent mould casting, pressure die casting, vacuum die casting, low-pressure die casting, centrifugal casting, continuous casting and squeeze casting.
Module 2.	Fundamentals of plastic deformation, stress–strain relationships in metal forming, hot and cold working, rolling, forging, extrusion, wire drawing, rod drawing and tube drawing, process parameters, defects, applications and product design considerations.
Module 3.	Sheet metal characteristics, shearing mechanism, press working operations, blanking, punching, piercing, drawing, drawability, draw die design, bending, stretch forming, spinning, embossing, coining, sheet metal die design, defects and applications.
Module 4.	Classification and properties of engineering polymers, injection moulding, blow moulding, rotational moulding, thermoforming, compression moulding, mould design considerations, process parameters, defects and industrial applications.
Module 5.	Introduction to powder metallurgy, production and characterization of metallic powders, powder blending and compaction, sintering, secondary processing operations, alternative compaction techniques, defects and applications of powder metallurgy.

Activity Module (Internal Evaluation Only-10 Marks)

Activity	Example Task
Using the tools learned on Module 1, design a variety of items, including:	Simulation of Casting Solidification and Shrinkage Defect Prediction (Using ANSYS Student)
Using the tools learned on Module 2, design a variety of items, including:	Computational Analysis of Rolling Load and Power Requirement (Using Excel/MATLAB)
Using the tools learned on Module 3, design a variety of items, including:	Simulation of Deep Drawing Process and Springback Analysis (Using SolidWorks Simulation/ ANSYS Student)
Using the tools learned on Module 4, design a variety of items, including:	Computational Analysis of Blow Moulding Parameters and Wall Thickness Distribution (Using Excel/MATLAB)
Using the tools learned on Module 5, design a variety of items, including:	Computational Analysis of Powder Compaction Pressure and Green Density (Using Excel/MATLAB)

Practical Module (Internal and External Evaluation)

M.No:	Experiments
Module 1.	To prepare a green sand mould and study the properties and constituents of moulding sand used in casting.
Module 2.	To design a pattern and gating system for a given casting component and understand metal flow during casting.
Module 3.	To produce a casting using the sand casting process and examine the quality of the cast product.
Module 4.	To identify common casting defects and analyze their causes and remedial measures.
Module 5.	To perform a forging operation and study the effect of plastic deformation on the shape and dimensions of a workpiece.
Module 6.	To fabricate a simple sheet metal component using marking, cutting, bending, and joining operations.
Module 7.	To perform blanking and piercing operations using a press tool and study the working of sheet metal dies.
Module 8.	To produce a cup-shaped component by deep drawing and study the influence of drawing parameters.

Module 9.	To study and differentiate products manufactured by injection moulding, blow moulding, rotational moulding, thermoforming, and compression moulding processes.
Module 10.	To prepare a powder metallurgy compact using a die and press and evaluate the green density of the compact.

CLO-PLO Mapping Matrix

CLO \ PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	3	2	1	1	1	0	1	0	0	1	0	1
CLO2	3	2	1	0	1	0	1	0	0	1	0	1
CLO3	3	3	2	2	2	0	1	0	0	1	0	1
CLO4	2	2	3	1	3	0	1	0	0	2	0	1
CLO5	3	3	3	2	2	0	2	0	0	1	1	2

Recommended Books

S.No:	Text Books	Author	Publisher
1.	Manufacturing Science	A Ghosh and A K Mallik	Wiley Eastern
2.	Manufacturing Technology: Foundry, Forming And Welding	P N. Rao	Tata McGraw Hill
3.	Introduction to manufacturing technologies Principles and technologies	Prashant P Date	Jaico publications
	References	**Author**	**Publisher**
1.	Manufacturing Processes for Engineering Materials	S Kalpakjian and S R Schmid	Pearson education
2.	Principles Of Manufacturing Materials And Processes	J S Campbell	Tata McGraw Hill 3.
3.	Production Engineering Sciences	P C Pandey and C K Singh	Standard Publishers Ltd.