COURSE STRUCTURE

B.TECH.

MECHANICAL ENGINEERING

Under

Choice Based Credit System (CBCS)

S.No.	Department	Program Offered	Credits		Total Credits
1	ME	B.Tech. Mechanical Engg. Engineering	HSS	25	184-190
			BS	24	
			ES	28-34*	
			PC	48	
			PE	26	
			OE	16	
			Proj	17	
			MNG	8 U	
(*) 34 credits of ES are offered to branch change (They are offered additional 4 credit of ES as Applied Mechanics (3-0-1-0) and Applied Mechanics Lab (0-0-2)					

First Semester

S. NO.	CODE	SUBJECT	TEACHING SCHEME			CREDITS	CONTACTS HRS/WK
			L	T	P		
THEORY							
1.	BMAS 0101	Engineering Mathematics – I	3	1	0	4	4
2.	BELH 0001	English Language Skills for Communication I	1	2	0	2	3
3.	BPHS 0002	Engineering Physics - I	3	1	0	4	4
4.	BMEG 0001	Basic Mechanical Engineering	3	1	0	4	4
5.	BEEG1001	Basic Electrical Engineering	3	1	0	4	4
PRACTICALS							
6.	BEEG 0800	Electrical Engineering Lab	0	0	2	1	2
7.	BMEG 0801	Engineering Drawing	0	0	2	1	2
8.	BELH0801	English Language Lab I	0	0	2	1	2
9.	BMEG0800	Engineering Workshop Practice Lab	0	0	2	1	2
10.	BPHS 0801	Engineering Physics Lab	0	0	2	1	2
11.	BEGP 0001	General Proficiency	1	0	0	1	0
		Total	15	6	14	24	33

Second Semester

S. NO.	CODE	SUBJECT	TEACHING SCHEME			CREDITS	CONTACTS HRS/WK
			L	T	P		
THEORY							
1.	BMAS 1102	Engineering Mathematics – II	3	1	0	4	2
2.	BELH 0002	English Language Skills for Communication – II	1	2	0	2	3
3.	BCHS 0101	Engineering Chemistry	3	1	0	4	3
4.	BCSG 0002	Computer Programming	3	0	0	3	4
5.	BECG 0001	Electronics Engineering	3	1	0	4	4
6.	BMEG 0002	Applied Mechanics	3	1	0	4	4
7.	APFJ 0001	Field Project				1	
PRACTICALS							
7.	BMEG 0802	Applied Mechanics Lab	0	0	2	1	2
8.	BECG 0800	Electronics Lab – I	0	0	2	1	2
9.	BCSG 0801	Computer Programming lab	0	0	2	1	4
10.	BELH 0802	English Language Lab – II	0	0	2	1	2

11.	BCHS 0801	Engineering Chemistry Lab	0	0	2	1	2
12.	BME G0803	CAD Lab	0	0	2	1	2

Program Core

S. NO.	CODE	SUBJECT	TEACHING SCHEME				CREDITS	CONTACTS HR/WK	PRE- REQUISITES
			L	T	P	J			
THEORY									
1	BME C0001	Material Science	2	0	0	0	2	2	
2	BME C0002	Applied Thermodynamics	3	1	0	0	4	4	Basic Mechanical
3	BME C0003	Measurement & Metrology	2	0	0	0	2	2	-
4	BME C0004	Heat & Mass Transfer	3	0	0	0	3	3	Applied Thermodynamics
5	BME C0005	Fluid Mechanics	3	0	0	0	3	3	Thermal Engineering
6	BMEC 0006	Manufacturing Science I	3	0	0	0	3	3	Material Science
7	BME C0007	Strength of Material	3	0	0	0	3	3	Applied Mechanics
8	BMEC 0008	Kinematics of Machines	3	0	0	0	3	3	Applied Mechanics
9	BMEC 0009	Dynamics of Machine	3	0	0	0	3	3	Kinematics of Machines
10	BME C0010	Machine Design I	3	0	0	0	3	3	Strength of Material
11	BMEC 0011	Machine Design II	3	0	0	0	3	3	Machine Design I
12	BMEC 0012	Fluid Machinery	3	0	0	0	3	3	Fluid Mechanics
13	BME C0013	Manufacturing Science II	3	0	0	0	3	3	Manufacturing Science I
14	BME C0014	Modern Vehicle Technology	3	1	0	0	4	4	
15	BME C0015	Advance Material Science	3	0	0	0	3	3	
PRACTICALS									
1	BME C0800	Material Science & Testing Lab	0	0	2	0	1	2	
2	BME C0801	Measurement & Metrology Lab	0	0	2	0	1	2	
3	BME C0802	Heat & Mass Transfer Lab	0	0	2	0	1	2	
4	BME C0803	Fluid Mechanics Lab	0	0	2	0	1	2	
5	BMEC 0804	Manufacturing Science I Lab	0	0	2	0	1	2	
6	BMEC 0805	Theory of Machine Lab	0	0	2	0	1	2	
7	BME C0806	Machine Design I Lab	0	0	2	0	1	2	
8	BME C0807	Machine Design II Lab	0	0	2	0	1	2	
9	BMEC 0808	Fluid Machinery Lab	0	0	2	0	1	2	
10	BME C0809	Manufacturing Science II Lab	0	0	2	0	1	2	
Total			41	2	20	0	29	61	

Program Elective

S. NO.	CODE	SUBJECT	TEACHING SCHEME				CREDITS	CONTACTS	PRE- REQUISITES
			L	T	P	J			
Bouquet: Thermal Engineering									
THEORY									
1	BMEE 0001	Refrigeration & Air-Conditioning	3	0	0	0	3	3	Applied Thermodynamics
2	BMEE 0002	Internal Combustion Engine	3	0	0	0	3	3	Applied Thermodynamics
3	BMEE 0003	Automobile Engineering	3	0	0	0	3	3	Internal Combustion Engine
4	BME E0004	Power Plant Engineering	3	0	0	0	3	3	Applied Thermodynamics
5	BME E0005	Gas Dynamics	3	1	0	0	4	4	Applied Thermodynamics
6	BME E0006	Gas Turbine and Jet Propulsion	3	1	0	0	4	4	Applied Thermodynamics
7	BME E0007	Advanced Heat Transfer	3	0	0	0	3	3	Heat Transfer
8	BME E0008	Solar Energy	3	0	0	0	3	3	Applied Thermodynamics
9	BME E0009	Introduction to Vehicle Dynamics	3	0	0	0	3	4	Automobile Engineering
PRACTICALS									
1	BMEE 0170	Refrigeration & Air-Conditioning Lab	0	0	2	0	1	2	
2	BMEE 0171	Automobile Engineering Lab	0	0	2	0	1	2	
3	BME E0172	Solar Energy Lab	0	0	2	0	1	2	
4	BME E0173	Vehicle Dynamics Lab	0	0	2	0	1	2	
PROJECTS									
1	BME E0186	Project based Solar Energy Lab	0	0	0	8	2	8	

Bouquet: Fluids Engineering									
THEORY									
1	BMEE 0101	Advanced Fluid Mechanics	3	1	0	0	4	4	Fluid Mechanics
2	BMEE 0102	Compressible Fluid Flow	3	1	0	0	4	4	AdvancedFluid Mechanics
3	BMEE 0103	Aerodynamics	3	0	0	0	3	3	AdvancedFluid Mechanics
4	BMEE 0104	Turbulent Flow	3	1	0		4	4	Advanced Fluid Mechanics
5	BMEE 0105	Computational Fluid Dynamics	3	0	0	0	3	3	Numerical Methods & Turbulent Flow
PRACTICALS									
1	BMEE 0189	Project Based CFD Lab	0	0	0	8	2	8	
	BMEE 0175	CFD Lab	0	0	2	0	1	2	

Bouquet: Design Engineering									
THEORY									
1	BMEE 0184	Machine Drawing Lab	0	0	2	0	1	2	
2	BMEE 0201	Computer Aided Design	3	0	0	0	3	3	Machine Design II
3	BMEE 0176	Advanced Software Lab	0	0	2	0	1	2	
4	BMEE 0202	Continuum Mechanics	3	1	0	0	4	4	Strength of Material
5	BMEE 0203	Finite Element Methods	3	1	0	0	4	4	Continuum Mechanics
6	BMEE 0204	Vibration and Noise	3	1	0	0	4	4	Dynamics of Machine
7	BMEE 0205	Machine Tool Design	3	0	0	0	3	3	Machine Design II & Manufacturing Sc.
8	BMEE 0206	Fundamentals of Computer Aided Design	3	1	0	0	4	4	
PRACTICALS									
1	BMEE 0184	Machine Drawing Lab	0	0	2	0	1	2	
2	BMEE 0176	Advanced Software Lab	0	0	2	0	1	2	

Bouquet: Manufacturing Engineering									
THEORY									
1	BMEE 0301	Computer Aided Manufacturing	3	0	0	0	3	3	Manufacturing ScienceII
2	BMEE 0302	Welding Science & Technology	3	0	0	0	3	3	Manufacturing ScienceI
3	BMEE 0303	Composite Materials	3	0	0	0	3	3	Material Science
4	BMEE 0304	Modern Manufacturing Process	3	0	0	0	3	3	Manufacturing ScienceII
5	BMEE 0305	Metal Forming Analysis	3	0	0	0	3	3	Manufacturing ScienceI
6	BMEE 0306	CNC & Robotics	3	0	0	0	3	3	
PRACTICALS									
1	BMEE 0178	CAD/CAM Lab	0	0	2	0	1	2	
2	BMEE 0185	Welding Science & Technology Lab	0	0	2	0	1	2	
3	BMEE 0179	Modern Manufacturing Process Lab	0	0	2	0	1	2	
PROJECTS									
1	BMEE 0193	Project based Modern Manufacturing Process Lab	0	0	0	8	2	8	
2	BMEE 0192	Project based CAD/CAM Lab	0	0	0	8	2	8	
Bouquet: Industrial Engineering									
THEORY									
1	BMEE 0401	Industrial Engineering	3	0	0	0	3	3	
2	BMEE 0402	Product Development & Design	3	0	0	0	3	3	Machine Design II
3	BMEE 0403	Operations Research	3	0	0	0	3	3	Industrial Engineering
4	BMEE 0404	Value Engineering	3	0	0	0	3	3	Industrial Engineering
5	BMEE 0405	Operations Research for Technocrats	4	0	0	0	4	4	
6	BMEE 0406	Applied Ergonomics	3	0	0	0	3	3	Product Development & Design

7	BMEE XXXX	Supply Chain Management	3	0	0	0	3	3	Industrial Engineering

Robotics & Automation									
THEORY									
1	BMEE 0501	Robotics & FMS	3	0	0	0	3	3	Industrial Engineering
2	BME E0502	Industrial Automation &Control System	3	0	0	0	3	3	Industrial Engineering
3	BME E0503	Engineering System Modeling & Simulation	3	0	0	0	3	3	Industrial Engineering
PRACTICALS									
1	BMEE 0182	Robotics & FMS Lab	0	0	2	0	1	2	
PROJECTS									
1	BMEE 0196	Project based Robotics & FMS Lab	0	0	0	8	2	4	-

Open Elective (Offer to other Departments)

S. NO.	CODE	SUBJECT	TEACHING SCHEME				CREDITS	CONTACTS HR/WK	PRE- REQUISITES
			L	T	P	J			
THEORY									
1.	BMEO 0002	Energy Conservation & Management	3	1	0	0	4	4	
2.	BMEO 0003	Smart Materials	3	1	0	0	4	4	
3.	BMEO 0004	Project Management	3	1	0	0	4	4	
4.	BMEO 0005	Reliability and Maintenance Engineering	3	1	0	0	4	4	
5.	BMEO 0006	Mechatronics	3	1	0	0	4	4	
6.	BMEO 0007	Six Sigma & Applications	3	1	0	0	4	4	

Projects (J)

S. NO.	CODE	SUBJECT	TEACHING SCHEME				CREDITS	CONTACTS	PRE- REQUISITES
			L	T	P	J			
1.	BMEJ 0950	Mini Project I	0	0	0	4	2	4	
2.	BMEJ 0951	Mini Project II	0	0	0	12	2	4	Mini Project I
3.	BMEJ 0961	Industrial Training I	0	0	2	0	1	2	
4.	BMEJ 0962	Industrial Training II	0	0	2	0	1	2	
5.	BMEJ 0971	Minor Project	0	0	0	12	3	6	
6.	BMEJ 0972	Major Project	0	0	0	32	8	16	Minor Project
		TOTAL	**0**	**0**	**4**	**60**	**17**		

Mandatory Non Graded Course (M)

S. NO.	CODE	SUBJECT	TEACHING SCHEME				CREDITS	CONTACTS HR/WK	PRE- REQUISITES
			L	T	P	J			
THEORY									
1.	BCSM 0001	Introduction to Cyber Security	2	0	0	0	0	2	
2.	BCHM 0101	Disaster Management	2	0	0	0	0	2	
3.	MBAM 0001	Basic Course in Entrepreneurship	2	0	0	0	0	2	
4.	MBAM 0002	Leadership And Organizational Behavior	2	0	0	0	0	2	
		TOTAL	**8**	**0**	**0**	**0**	**0**	**8**	

Humanities and Social Sciences (H)

S. NO.	CODE	SUBJECT	TEACHING SCHEME				CREDITS	CONTACTS HR/WK	PRE-REQUISITES
			L	T	P	J			
THEORY									
1.	BELH 0001	English Language Skills for Communication – I	2	0	0	0	2	2	
2.	BELH 0002	English Language Skills for Communication – II	2	0	0	0	2	2	
3.	BELH 0003	English for Professional Purpose – I	2	0	0	0	2	2	
4.	BELH 0004	English for Professional Purpose – II	2	0	0	0	2	2	
5.	BELH 0006	Ethics & Values	2	0	0	0	2	2	
6.	MBAC 0005	Industrial Management	3	0	0	0	3	3	
PRACTICALS									
7.	BELH 0801	English Language Lab – I	0	0	2	0	1	2	
8.	BELH 0802	English Language Lab – II	0	0	2	0	1	2	
9.	BTDH 0301	Soft Skills – I	0	0	2	0	1	2	
10.	BTDH 0302	Soft Skills – II	0	0	2	0	1	2	
11.	BTDH 0303	Soft Skills – III	0	0	8	0	4	4	
12.	BTDH 0304	Soft Skills – IV	0	0	8	0	4	4	
TOTAL			**13**	**0**	**24**	**0**	**25**	**37**	

BMEG 0001: BASIC MECHANICAL ENGINEERING

Objective: *Precise thermodynamics education is a requirement to discuss issues that one faces in thermodynamics and resulting studies in global warming, energy conversion and other energy related topics that affect sustainability of the environment in the global sense. Also introduce the students to various basic manufacturing processes carried out in various industries very commonly.*

Credits: 03 **Semester I/II** **L–T–P: 3–1–0**

Module No.	Content	Teaching Hours
I	**Fundamentals of Thermal Engineering:** Thermodynamic systems, State & properties, Thermodynamic equilibrium & processes, Heat & work, Work done for different polytrophic processes, Zeroth law of thermodynamics andits applications, First law of thermodynamics, Steady flow energy equation, Application of first law to various thermodynamic systems and its limitations. **Second Law of Thermodynamics:** Concept of heat engine, heat pump & refrigerator, Second Law of Thermodynamics, Carnot Cycle, Carnot theorem.	20
II	**Concept of Entropy:** Clausius Inequality, Concept of entropy, Entropy changeduring various processes. **Introduction to Manufacturing Processes**: Mechanical properties of materials, Engineering Materials: Plain carbon steel and its applications **Casting Process:** Patterns and types of patterns and their allowances, Moulding sand and its properties, Elements of gating system. **Fabrication processes:** Introduction and classification of welding, principleand applications of Shielded Metal Arc Welding and Gas Welding.	20

Text Books:

- Yadav R.: "*Thermodynamics and Heat Engines*" :Vol I & II (Sl Edition) Central Publishing House Allahabad, 2010.
- Kumar D.S: "Thermal Science and Engineering" :S.K Kataria and Sons, Delhi,2004.
- Nag P. K.: "*Engineering Thermodynamics*": TMH, 2017.
- Yadav R.: "*Thermodynamics and Heat Engines*" : Vol I & II (Sl Edition) Central Publishing House Allahabad, 2010.
- Hajra Chowdhary SK and Hajra Chowdhary AK. "*Workshop Technology*": Media Promotors & Publishers, 2010.
- Raghuwanshi RS, "*Workshop Technology*": Dhanpat Rai and Sons, New Delhi, 2012.
- Wark Wenneth: "*Thermodynamics*": McGraw Hill book Co. NY,2015.

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: *At the end of the course the student will be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Understand the basic laws of thermodynamics and their applications in real world	PO1, PO7, PO6/ PSO1	Understand	Factual and Conceptual	10
2	Calculate heat and energy transfer occur in	PO1, PO6, PO7/	Apply	Procedural	10

	atmosphere and in components under thermalengineering applications	PSO1			
3	Interpret the behavior of steam and its applications in thermal engineering.	PO1, PO7/ PSO1	Analyze	Metacogniti ve	6
4	Acknowledge the application of thermal engineering associated with human body	PO1/ PSO1	Apply	Procedural	4
5	Understand the basic industrial processes of metal joining, fabrication & casting with applications in real world.	PO1, PO5/ PSO2	Understand	Conceptual	6
6	Develop basic know how and awareness of various manufacturing processes.	PO1, PO5/ PSO2	Understand	Conceptual	4

BMEG 0002 APPLIED MECHANICS

Objective: *The aim of the applied mechanics is to teach the basic analytical methods that is the fundamental concepts and techniques of engineering mechanics.*

- *To give students practice in applying their knowledge of mathematics, science, and engineering and to expand this knowledge into the vast area of Applied Mechanics.*
- *To enhance students' ability to design by requiring the solution of open-ended problems.*
- *To prepare the students for higher level courses such as courses in Mechanics of Solids, Mechanical Design and Structural Analysis.*

Credits: 04 **Semester I/II** **L–T–P: 3–1–0**

Module No.	Content	Teaching Hours
I	**Introduction: -** Mechanics: Idealization of Bodies, concept of Rigid Bodies, External Forces, Moment and Couple, Laws of Mechanics. **Force Systems And Equilibrium: -** Fundamental Concepts and principles of Mechanics. Reduction of a system of forces to a force couple system**,** Concurrent forces in a plane, Free Body Diagrams, Equations of equilibrium and their applications to various systems of forces. **Friction: - Friction forces and laws of dry friction,** Types of friction and their applications to ladder and belt-pulley systems **Distributed Forces and Moment Of Inertia:** Basic concepts of Centroid, Area Moment of Inertia, Polar Moment of Inertia, Product of inertia, Principal axes, Parallel axis theorem, Perpendicular axis theorem and their applications inComposite figures.	22
II	**Beams: -** Introduction of a Beam and its types**,** Concept of bending moment and shear forces in beams, Shear Force and Bending Moment Diagrams for different loading conditions (point load, uniformly distributed load, uniformly varying load and couple). **Analysis of Plane Trusses: -** Engineering structures, Perfect Truss, Determination of axial forces in the members, Method of Joints, Method of Sections. **Kinematics and Kinetics of Rigid Bodies: -** Plain motion of rigid bodies, Velocity and acceleration under translation and rotation, Work, Power and Energy, Impulse and Momentum, D' Alembert's Principle and Law of conservation of energy.	23

Text Books:

- Tayal, A.K. Engineering Mechanics: Statics & Dynamics, 14th Edition (2011), Umesh Publications, Delhi
- V.S. Mokashi, Engineering Mechanics: Statics Vol. I & Dynamics Vol-II, (Tata McGraw- Hill), New Delhi

Reference Books:

- Shames, I.H(1996), Engineering Mechanics, Statics and Dynamics 4thedition, Prentice Hall of India Pvt. Ltd., New Delhi (EEE)
- F.P. Beer& E.R. Johnston et. al., Vector Mechanics for Engineers: Statics and Dynamics, 12th Edition (2019) TMH New Delhi

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: *At the end of the course the student will be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Understand the representation and analysis of forces, moments, and equilibrium of particles and rigid bodies, Concept and principles of work and energy.	PO1, PO2/ PSO1	U, A	F, C, P	10
2	The effect of friction and its role in engineering applications. Develop basic know how and awareness to deal with real life applications in various fields of engineering.	PO1, PO2/ PSO1	U, A	F, C, P	12
3	Determine internal actions in statically determinate structures and draw internal action diagrams	PO1, PO2/ PSO1	U, A	C, P	6
4	Shear Force (SFD) and Bending Moment Diagrams (BMD) for these structures.	PO1, PO2/ PSO1	U, A	C, P	6
5	Identify an appropriate structural system to study a given problem and isolate it from its environment.	PO1, PO2/ PSO1	U, A	C, P	4
6	Develop concepts of rigid body kinematics and dynamics with an emphasis on the modelling, analysis, and simulation of how forces produce motion of rigid body systems.	PO1, PO2/ PSO1	U, A	F, C, P	7

BMEG 0800: ENGINEERING WORKSHOP PRACTICE LAB

Objective: *The purpose of this lab is to enable the students to have the practical skills for basic manufacturing processes and to study the various tools & equipment used e.g. Machining, Surface finishing, Welding, Casting, Drawings (Developments), Measuring instruments. The student will also have practical exposure with various safety precautions in different sections of the shops.*

Credits: 01 **L–T–P-J: 0–0–2**

Module No.	Contents	Teaching Hours
I	**List of Experiments** **Machine Shop:** **(1)** To study the working of basic machine tools like Lathe m/c, and Drilling m/c. **(2)** To perform the following operations on Centre Lathe: **(i)** Centering, Facing, Turning, Step turning, Taper turning. **(ii)** Knurling, Grooving, Chamfering, and Threading. **Welding Shop:** **(1)** To prepare Lap joint, Butt joint, T-joint by using an Electric Arc welding. **(2)** To prepare Lap joint, Butt joint, T-joint by using an Oxy-Acetylene gaswelding. **Carpentry Shop:** **(1)** To perform different operations in Carpentry shop such as cutting,planning and chiseling on the given wooden piece. **(2)** To prepare a joint Lap joint, T-Joint, Dovetail joint by using woodenspecimen/piece. **Foundry Shop:** **(1)** To prepare a Sand mould for solid casting with the help single piece pattern& split pattern. **(2)** To prepare the mould for hollow casting with the help of pattern and core. **Sheet Metal Shop:** **(1)** To develop the blank dimensions for the given product using developmentprocess. **(2)** To prepare a Funnel of required dimensions using joining processes. **Fitting Shop:** **(1)** To perform the operations of Marking, Filing and Sawing on the givenmetallic work-piece (M.S.) as per given dimensions. **(2)** To perform the operations of drilling of making the holes on the givenmetallic work-piece (M.S.) by use of Drilling machine. **(3)** To perform the operations of making internal threads by use of tapes anddies.	30

Text/Reference Books:

- *John K. C., "Mechanical Workshop Practice": PHI Learning Pvt. Ltd., New Delhi, 2010.*
- *Choudhary Hajra, "Elements of Workshop Technology": Media Promoters & Publishers Pvt. Ltd., Mumbai, 2010*
- *Chapman W.A.J., "Workshop Technology", CBS Publishers & Distributors, New Delhi, 2007*

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: *On successful completion of this lab, the students will be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	CO1: Demonstrate an understanding of and comply with workshop safety regulations.	PO1	R, U	F	3
2	CO2: Select and perform a range of machining operations like: turning, facing, knurling drilling, grinding etc. to produce a given job.	PO1, PO3/PSO1	U, C, E	F, Pc	5
3	CO3: Acquire basic knowledge of welding, joint design such as Lap joint, Lap T-joint, Edge joint, Buttjoint and Corner joint and the application of welding.	PO1, PO3/PSO1	R, U, Ap	F, Pc	4
4	CO4: Ability to design and model different prototypes in the carpentry trade such as Cross lap joint, Dovetail joint.	PO3/PSO1	R, An, E	F, D, Pc	5
5	CO5: Ability to design and model various basic prototypes in the trade of fitting such as Straight fit, V-fit.	PO3/PSO1	R, An, E	F, D, Pc	5
6	CO6: Ability to make various basic prototypes in the trade of Tin smithy such as rectangular tray, and open Cylinder.	PO3/PSO1	R, E, C	F, Pc	4
7	CO7: Student will able to design mould with the help of green sand mould.	PO3/PSO1	R, U, C	F, Pc	4

BMEG 0801 ENGINEERING DRAWING

Objective: *Technical drawing is the language of engineering. The objective of this course is to learn initially the basic principles involved in the projection of points, lines, lamina and solids. As well this course is focused towards the interpenetration of solids, development of surfaces, isometric drawings and some basics of computer aided drafting software. It is expected that a student should learn this subject in a very systematic way to develop the skill to express effectively his/her idea about an object to others through drawings.*

Credits: 01 **Semester I/II** **L–T–P: 0–0–2**

Module No.	Content	Teaching Hours
I	**Introduction** Drawing instruments and their uses, BIS conventions, lettering dimensioning and free hand practicing (2 Drawing sheets) **Geometric construction & engineering Scales** Basic geometric construction -Dividing a given straight line into any number of equal parts, drawing a regular polygon given one side, conic sections – ellipse – parabola. Concepts of scales –Plain, Diagonal & scale of chord. (2 Drawing sheets) **Orthographic projection** Introduction to projection &orthographic Projections *Projections of points* lying in four quadrants *Projection of lines*- parallel and inclined to one or both planes *Projection of planes*- inclined to one or both planes. *Projections of solids* - axis perpendicular to HP, axis perpendicular to VP and axis inclined to one or both planes. (4 Drawing sheets) **Sectioning of solids-** Section planes perpendicular to one plane and parallel or inclined to other plane. (1Drawing sheets) **Development of surfaces-** Development of prisms, pyramids and cylindrical & conical surfaces (1Drawing sheets) **Isometric projection -**Isometric projection and isometric views of different planes and simple solids (1Drawing sheets) **Computer aided drafting** Introduction to computer aided drafting package to make 2-D drawings.	**24**

Text Books:

- Venugopal, K. and Prabhu Raja, V.: 'Engineering Drawing and Graphics + AutoCAD': New Age International,2017.
- Agrawal & Agrawal, C.: 'Engineering Drawing': Tata McGraw Hill,2014.

Reference Books:

- Bhatt, N. D. and Panchal, V.M., 'Engineering Drawing': Charotar Publishing House,2010.
- Natarajan, K. V., 'A text book of Engineering Graphics': Dhanalakshmi Publishers, Chennai,2014.
- Venugopal, K. and Prabhu Raja, V., 'Engineering Drawing and Graphics + AutoCAD': New Age International, 2017.
- Jolhe, D. A., 'Engineering drawing': Tata McGraw Hill,2010.
- Trymbaka Murthy, S., 'Computer Aided Engineering Drawing': I.K. International Publishing House,2008.

- Agrawal & Agrawal, C., 'Engineering Drawing': Tata McGraw Hill, 2014.

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: *On successful completion of this lab, the students will be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration (Hours)
1	Know and understand the conventions and the methods of engineering drawing	PO1/ PSO1	Understand	Factual & Conceptual	6
2	Interpret engineering drawings using fundamental technical mathematics	PO1/ PSO1	Analyze	Procedural	6
3	Improve their visualization skills so that they can apply these skills in developing new products	PO3/ PSO1	Apply	Metacognitive	4
4	Improve their technical communication skill in the form of communicative drawings	PO3/ PSO1	Analyze	Procedural	4
5	Comprehend the theory of projection, Interpret views and sectional views and projections	PO3/ PSO1	Create	Criteria and Specifications& Practical Constraints	4

BMEG 0802 APPLIED MECHANICS LAB

Objective: *This course introduces the fundamentals of statics in engineering, which are prerequisites for further study of advanced mechanics. The main objective of the course is to learn basic principles ofstatic in mechanics analyses, such as rigid bodies, friction between two surfaces, centroid, reaction of beam, Newton's laws of motion and analysis of truss. It also includes a range of essential steps for solvingproblems in statics.*

Credits: 01 **Semester VI** **L–T –P: 0–0–2**

Module No.	Content	Teaching Hours
1	**List of Experiments:** • Study of functioning of gear trains. • To find the mechanical advantages, velocity ratio and efficiency ofworm and worm wheel. • To find the coefficient of friction between the surface of a given wood slide bar and an inclined plane. • To find centre of gravity of different geometrical objects. • Deflection of simply supported beam and verification of theoretical values. • To find reaction at the supports of a simply supported beam with different types of loading. • To determine the modulus of rigidity of rod with the help oftorsion testing machine. • To study functioning of belt pulley systems. • To find moment of inertia of a fly wheel about the axis of rotation using electronic counter machine. • To find forces in members of a truss for different load conditions.	24

Outcome: At the end of the course the student will be able

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

CO	CO Statement	PO/PSO	CL	KC	Duration
1					
2					
3					
4					
5					
6					
7					

BMEG 0803 COMPUTER AIDED DRAFTING LAB

Objective: *The objective of this course is to teach users the basic commands and tools necessary for professional 2D drawing, design and drafting using AutoCAD.*

Credits: 01 **Semester I/II** **L–T–P: 0–0–2**

Module No.	Content	Teaching Hours
I	**Getting Start –** Starting with autocad, open and save files, tool bars, screenlayouts. **Basic Drawing & Editing Commands-** Drawing Lines, rectangles, Circles, viewing Drawing, Undo & Redocommands, Erasing objects etc. **Drawing Precision-** Using Object snap, O snap overrides, Polar tracking settings,Drawing with SNAP & GRID, function keys. **Changes in Drawings-** Selecting object for editing, Moving objects, copying, Rotatingobject, Scaling, mirroring editing with Grips. **Drawing Organization & InformationLayers** Templates, Layers, Layer State, changing object layers, etc. **Advance Editing Commands-** Trimming & extending, Stretching, Creating Fillets and Chamfers,Offset, creating arrays of objects. **Blocks-** Insertion of Block from tool Palettes, using insert, with design centre. **Annotation-** Text, Hatching, Dimensions **3 D Modeling-** Introduction, basic tools, 3D navigation tools, UCS. Formation of simple solids, solid primitives, mesh model. **Creating solid** from 2D – Extrude, Swept, revolve solid, loftedsolid. **Editing Solid**- Editing faces of solid, Fillet and chamfer on solids2d view from 3d. Multiple viewports	**24**

Text Books:-

- Trymbaka Murthy, S., 'Computer Aided Engineering Drawing', Pub- I.K. International PublishingHouse.
- Venugopal, K. and Prabhu Raja, V., 'Engineering Drawing and Graphics + AutoCAD', Pub- NewAge International.

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: After completing this course the student will be able to:

CO	CO Statement	PO/PSO	CL	KC	Duration

1	Use AutoCAD for daily processes requiring designing and drafting.	PO1, PO3, PO5, PO9/ PSO1	R, U	F, C, P	3
2	Navigate throughout AutoCAD using major navigating tools.	PO3, PO4, PO5/ PSO3	U, Ap	C, P	4
3	Understand the concept and techniques to draw typical geometries.	PO1, PO2, PO3/ PSO3	R, U, Ap	C, P, FDP	5
4	Create multiple designs using several tools.	PO1, PO2, PO5/PSO1	U, C	PC, DI	4
5	Create layers to control the objects' visibility.	PO1, PO3, PO10/ PSO3	U, Ap	DI	4
6	Explain drawing using annotations.	PO1, PO5, PO10/PSO3	R, U	P, MC	4

BMEC 0011 MATERIAL SCIENCE

Objective: *To introduce the fundamentals of biomaterials, nanomaterials, ceramics, metals, polymers, electronic materials and composites, smart materials, green and sustainable materials emphasizing the relationships between atomic structure and microstructure as well as the properties, processing and performance of the material in a cohesive and self-contained way within the course.*

Credits: 02 **L–T–P: 2–0–0**

Module No.	Content	Teaching Hours
I	**Crystallography and Imperfections:** Concept of Unit Cell Space Lattice, Bravais-Lattices, Atomic Packing Factor and Density calculations, Miller indices, Imperfections and Dislocations in Solids. **Introduction to Non-Destructive Testing:** Liquid penetrant Testing, Magnetic Particle Testing, Ultrasonic Testing, Eddy current Testing, Radiography, X-Ray Crystallography. **Fatigue**: Stress cycles, Factors affecting fatigue, application of fracture mechanics to fatigue crack propagation, **Creep:** Creep curve, stages in creep curve and explanation, creep mechanisms, metallurgical factors affecting creep. **Strengthening Mechanism:** Concept of Grain and Grain Boundary, Hall-Petch strengthening, Solid solution strengthening, precipitation strengthening and dispersion strengthening.	22
II	**Equilibrium Diagrams:** Types of Equilibrium-Diagrams: Solid-Solution Type, Eutectic Type and Combination Type. Iron-Carbon Equilibrium- Diagram and Its Importance. **Heat Treatment:** Various Types of Heat Treatment Such As Annealing, Normalizing, Quenching, Tempering and Case Hardening. Time Temperature Transformation (TTT) Diagrams. **Corrosion Science:** Definition and importance, Electrochemical reactions, Polarization, Passivity, Environmental effects, Eight forms of corrosion, **Prevention and control of corrosion:** Cathodic protection, Coatings and inhibitors. **Properties and Application:** Concept of Magnetism and Magnetic materials, Ceramics, Superconductors and its types and phenomenon of Superconductivity, Metallic foams, Polymers, Composites, Carbon fibre, Graphene, Nano Materials, Smart Materials.	22

Text Books:

- Gupta K.M., "*Materials Science*", Umesh Publication.
- Raghvan V., "*Material Science*", Prentice Hall.
- Narula, "*Material Science*", TMH.
- Fontana, M.G., "*Corrosion Engineering"*, Tata McGraw-Hill.

Reference Books:

- Callister W.D., JR, "*Material Science & Engineering*", Addition-Wesley Publication.
- Vlack Van, "*Elements of Material Science & Engineering*", John Wiley & Sons.
- Avner "Introduction to Physical Metallurgy" TMH Pub

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: After completing this course the student will be able to:

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Understanding of the correlation between the internal structure of materials, theirmechanical properties.	PO1/PSO2/PSO3	U, E	F, C, Pc	9
2	Understanding of various methods to quantify their mechanical integrity and failure criteria	PO1/PO2/PO12/PSO3	U, An	F, C	8
3	Understanding of detailed interpretation of equilibrium phase diagrams.	PO1/PSO2/PSO3	U, Ap	F, C	9
4	Basic Understanding of different phases and heat treatment methods to tailor the properties of Fe- C alloys	PO1/PO2/PO12/PSO3	F, E	F, C, Pc	9
5	Knowledge of various alloying elements, their properties and applications.	PO1/PO3/PSO2/PSO3	F, U	F, C, Pc	9

BMEC 0800: MATERIAL SCIENCE AND TESTING LAB

Objective: *To introduce the microstructure of solids in reference to solids viewed at the subatomic (electronic) and atomic levels, and the nature of the defects at these levels. The microstructure of solidsat various levels profoundly influences the mechanical, electronic, chemical, and biological properties of solids. The phenomenological and mechanistic relationships between microstructure and the macroscopic properties of solids are, in essence, what materials science is all about.*

Credits: 01 **L–T–P: 0–0–2**

Module No.	Content	Teaching Hours
I	**List of Experiments** • To Prepare Specimen for Micro Structural Examination-Cutting, Grinding, Polishing, Etching. • To Study Crystal Structures and Crystals Imperfections Using Ball Models. • To Study Bravais Lattice with Help of Models. • To Determine the Grain Size of A Given Specimen. • Make A Comparative Study of Microstructures of Different Given Specimens after Micro Structural Examination (Mild Steel, Gray C.I., Brass, Copper Etc.) • Heat Treatment Experiments Such As Annealing, Normalizing, Quenching, Case Hardening and Comparison of Hardness beforeand After. • To Determine the Strength By Testing of A Given Mild Steel Specimen onUTM With Full Details and Plot on the Machine.	12
II	• To Conduct Shear and Bend Tests on UTM. • To Conduct Impact Testing on Impact Testing Machine Like Charpy,Izod or Both. • To Conduct Hardness Testing of Given Specimen Using Rockwelland Vickers/Brinell Testing Machines. • To Calculate the Deflection of Beam and Young's Modulus of Elasticity of a Material of a Beam Simply Supported at the Ends. • To Conduct Torsion Testing of A Rod on Torsion Testing Machine. • To Determine the Spring Index Testing on Spring Testing Machine. • To Plot A Curve Between Strain Vs Time (E-T) for Creep Testing on Creep Testing Machine. • Study the Microstructure of Welded Component and HAZ (Heat Affected Zone) Macro and Micro Examination.	12

Text Books:

- *W. D. Callister, 2006, "Materials Science and Engineering-An Introduction", 6thEdition Wiley India.*
- *Kenneth G. Budinski and Michael K. Budinski, "Engineering Materials", Prentice Hallof India Private Limited, 4th Indian Reprint, 2002.*

Reference Books:

- *Raghavan, "Material Science and Engineering', Prentice Hall of India PrivateLimited,1999.*
- *Mechanics of materials by James M. Gere.*
- *Introduction to engineering materials by B.K. Agarwal.*
- *Physical metallurgy and advanced materials by R.E. Small man.*
- *Engineering mechanics of composite materials by Isaac M. Daniel.*
- *U. C. Jindal, "Engineering Materials and Metallurgy", Pearson, 2011.*

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: *After completion of course, the student will be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	CO1: Understand the various crystal structure using ball and stick models.	PO1/ PSO3	U, R	F, C, PC	5
2	CO2: To demonstrate, Analyse and predict the mechanical behavior present in different engineeringmaterials such as CI, MS etc	PO1/ PSO3	An, R	F, C, PC	4
3	CO3: To understand the working of hardness testing machines like Rockwell, Brinell's hardnessmachines and instruments like dial gauge, Vernier Calipers etc.	PO1/ PSO3	U, E	F, C, PC	5
4	CO4: Understand the various heat-treatment methods and their effect on microstructure andmechanical properties	PO1/ PSO3	U, E	F, C, PC	5
5	CO5: Understand the properties of materials using destructive testing.	PO1/ PSO3	U, E	F, C, PC	5

BMEC 0002 APPLIED THERMODYNAMICS

Pre-requisite: *Basic Mechanical Engineering*
Objective: *To apply basics of thermodynamics and physics in design of thermodynamic systems.*

Credits: 04 **L–T–P: 3–1–0**

Module No.	Content	Teaching Hours
I	**Basics of thermodynamics:** Learning Objective, Definition, First law, Second law, concept of entropy, differential entropy relations. **Thermodynamics Relation:** Learning Objective, Introduction, Helmholtz and Gibbs Function, Maxwell Relation, Chaperon Equation, Joule Thompson Coefficient and Inversion Curve, Coefficient of Volume Expansion, Adiabatic and Isothermal Compressibility. **Availability and Irreversibility:** Learning Objective, Introduction, Available and Unavailable Energy, Availability and Irreversibility,Second Law Efficiency. **Steam Generator:** Learning Objective, Introduction, Steam properties, Function of Boilers, Classification of Boilers, Modern Boilers, Working of Fire Tube and Water Tube Boiler, Mountings and Accessories, Draught and Its Calculation, Performance ofBoilers. Heat balance sheet of boiler. **Condensers and Cooling Towers:** Learning Objective, Introduction, Function of Condenser, Condensing System, Surface and Jet Condensers, Mass of Circulating Water, Condenser and Vacuum Efficiency, Cooling Tower: Construction Details and Analysis.	22
II	**Vapour Power Cycle:** Learning Objective, Introduction, Review of Carnot and Rankine Cycle, Effect of Operating Conditions on Thermal Efficiency of Rankine Cycle, Principle Methods of Increasing Thermal Efficiency, Deviation of Actual Cycle From Theoretical Cycle, Regenerative Feed Heating Cycles, Reheating and Regenerative Cycles ,Binary Vapour Cycle. Case study of design and installation of thermal power plant of 500 MW to fulfill requirement of small medium city . **Flow Through Nozzles and Diffusers:** Learning Objective, Introduction, Classification of Nozzles and Diffusers. Steady Flow Energy Equation Through Nozzles, Momentum Equation. Nozzle and Diffuser Efficiencies, Mass Flow Rate Through Nozzle Under Isentropic Flow Condition, General Relationship, Between Area, Velocity and Pressure in Nozzles and Diffuser, Supersaturated Flow Through Nozzles, Effect of Variation of Back Pressure in Nozzle. **Steam Turbines:** Learning Objective, Introduction, Principles of Working of Steam Turbines, Classification & Comparison, Velocity Diagram For Impulse and Reaction Turbines. Staging, Stage and Overall Efficiency, Reheat Factor, Bleeding.	23

Text Books:

- Domkundawar S, Kothandaraman C.P, Domkundawar A.V "Thermal Engineering" Dhanpat Rai & Sons.
- Yadav R., "Steam & Gas turbines and Power Plant Engineering", VII ed., 2004, Central Publishing House Allahabad.
- Rajput R.K., "Thermal Engg." Dhanpat Rai & Sons.
- Nag P.K., "Basic and Applied Thermodynamics", TMH Publication New Delhi.
- Kearton W.J., "Theory of Steam Turbine", Dhanpat Rai and Sons

Reference Books:

- Yunus A. Cengel. And Michael A. Boles., "Thermodynamics: An Engineering Approach", Mcgraw HillEducation
- Ennis W. D., "Applied Thermodynamics For Engineers", D. Van Nostrand Company.
- Davies D., Jeremy., "Concise Thermodynamics: Principles and Applications", Horwood Publishing
- McConkey A. and Eastop T., "Applied Thermodynamics for Engineering Technologists" Pearson India

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: *After completing this subject student will be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Determine the availability and irreversibility of open and closed system thermodynamic cycles.	PSO1/PO1/PO2 /PO5/PO6	A	F, C	5
2	Understand Maxwell's and thermodynamic relations of gas mixtures.	PSO1/PO1/PO2	U	F, C	6
3	Understand the working of boilers and evaluate the boiler performance.	PSO1/PO1/PO2 /PO6	U	C	7
4	Analyze the performance of condenser and cooling tower	PSO1/PO1/PO5 /PO6	An	C	4
5	Determine the thermal efficiency of Rankine cycle, regenerative cycle and reheat cycle.	PSO1/PO1/PO5 /PO6	An	C, P	5
6	Understand basic concepts, energy equations and working of nozzle and diffuser.	PSO1/PO1/PO5 /PO6/PO7	U	C, P	5
7	Analyze performance of nozzle and diffuser	PSO1/PO1/PO3 /PO5/PO6/PO7	An	C, P	5
8	Analyze impulse and reaction steam turbo machines for energy transfer.	PSO1/PO1/PO3 /PO5/PO6/PO7	An	F, C, P	8

BMEC 0003 MEASUREMENT AND METROLOGY

Objective:

To develop in students the knowledge of basics of Measurements, Metrology and Measuring devices.

Credits: 02 **Semester IV** **L–T–P: 2–0–0**

Module No.	Content	Teaching Hours
I	**Introduction to measurement:** Generalized measuring system and its functional element, units of measurement, static characteristics of measuring instruments, Systematic and Random errors, Statistical analysis of errors, Calibration. **Measurement of geometric forms:** Measurement of roundness, flatness and straightness. **Sensors and Transducers:** Introduction to sensors and transducers. **Limits, fits and Tolerances:** Interchangeability, selective assembly, limits, fit and tolerances, limit gauging, design of limit gauges.	15
II	**Strain Measurement:** Types of Strain Gauges and Their Working, Strain Gauge Circuits, Temperature Compensation. **Measurements of Force and Torque:** Introduction to Devices used for Measuring Force and Torque. **Linear Meaurement and Angular Measurement:** Steel rule, vernier caliper, vernier height gauge, vernier micrometers, Angle gauges, sine bar, slip gauges, vernier bevel protractor. **Surface Texture:** Surface Roughness, Quantitative Evaluation of Surface Roughness and Its Measurement. **Comparators:** Sigma comparator, Johansson's Microkrator.	17

Text Books:

- Kumar D.S., "*Mechanical Measurements and Control*", Metropolitan, N. Delhi.
- Tayal A.K., "*Instrumentation and Mechanical Measurement*", Galgotia Publishers.
- Jain R.K., "*Measurement & Metrology*", Khanna Publications.

Reference Books:

- Dobilin Ernest, "Measurement Systems Application and Design", TMH.
- Bewoor., "Metrology & Measurement", TMH publication new Delhi.
- Kenneth John Hume., "Engineering metrology", Macdonald.

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: *At the end of this course students will be able to*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Understand the measurement systems, units and dimensions and characteristics ofmeasuring instruments	PSO1/PSO2/PSO 3/PO1/PO6	U	F	5
2	Explain the various form measurements like straightness, flatness, roundness	PSO2/PSO3/PO1 /PO2/PO6	U	F	3
3	Understand concepts of limits, fits and tolerances in	PSO2/PSO3/PO1	U	C, F, P	5

	industrial application.	/PO5			
4	Design of limit gauges.	PSO3/PO1/PO3/ PO5	C	P	4
5	Understand working of suitable instruments for typical measurements like strain, force and torque	PSO2/PSO3/PO1 /PO2/PO6	U	F, C	5
6	Compute length and angle using concept of measuring instruments	PSO2/PSO3/PO1 /PO2/PO3/PO6	A	F, C	5
7	Determine and measure of surface roughness	PSO2/PSO3/PO1 /PO3/PO5	A	P	7

BMEC 0801 MEASUREMENT AND METROLOGY LAB

Objective: *To educate students on different measurement instruments and on common types of errors.*

Credits: 01 **L–T–P: 0–0–2**

Module No.	Content	Teaching Hours
I	**List of Experiments:** • To Find Out the Error in the measurement of the given specimen Using Vernier Caliper. • To Analyzed the Deviation in Diameter of A Given Specimen Using Micrometer. • To Measure the Angle of A Given Specimen (Wooden Block) Using Sine Bar and Slip Gauges. • To Study the Limit Gauge For Better Understanding of Limits,Fits and Tolerances. • To Observe the Angular Measurements of A Given Specimen Using Vernier Bevel Protector. • To Perform Strain Measurement in Cantilever Beam Using Strain Gauge By Applying the Different Loads. • To Find Out the Circularity of A Cylindrical Rod Using Dial Gauge Indicator and V-Block. • To Find Out the Speed of Any Rotating Part (I.E., Ceiling Fan) Using Stroboscope (Non-Contact Device). • To Measure the Height of A Given Specimen Using Height Gauge. • To Determine the Temperature of A Heat Bath Using Resistance Type Detector (RTD) and Thermocouple. • To Measure the Linear Displacement Using Linear Variable Differential Transformer (LVDT). • To Measure the Pressure Using Bourdon Gauge and Strain Gauge. • To Determine the Torque of A Rotating Shaft Using Strain Gauge Coupled With Torque Sensor. • To Find Out the Flatness of A Surface Plate Using Spirit Level. • To determine the various elements of a threaded specimen withthe help of profile projector.	24

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: *At the end of this course students will be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Determine error in the measurement using Vernier calliper and Micrometer.	PSO2/PSO3/PO1/PO3/PO5/PO6	A	F, P	4
2	Determine angle using sine bar and Vernier bevel protractor.	PSO2/PO1/PO3/PO6/PO5	A	C, P	4
3	Understand limits, fits and tolerances using limit gauges.	PSO2/PSO3/PO1/PO5	U	F	2

4	Understand the concept of circularity using circularity test on V block and dial gauge.	PSO2/PSO3/PO1/PO3/PO5/PO6	U	F, C	2
5	Determine the elements of a threaded specimen with the help of profile projector.	PSO2/PSO3/PO1/PO3/PO5	A	F, C, P	4
6	Determine speed of rotating part using non-contactable device.	PSO1/PSO2/PSO3/PO1/PO5	A	C	2
7	Understand working of LVDT, RDT, Thermocouples, strain gauge and bourdon gauge.	PSO1/PSO2/PSO3/PO1/PO3/PO5/PO6	U	F	2
8	Determine height using Vernier height gauge.	PSO2/PSO3/PO1/PO5	A	C, P	2

BMEC 0004 HEAT & MASS TRANSFER

Pre-requisite: *Applied Thermodynamics*

Objective: *To develop the understanding of basic of heat transfer mechanism and their application in industry.*

Credits: 03 **L–T–P: 3–0–0**

Module No.	Content	Teaching Hours
I	**Introduction to Heat Transfer:** Basic concepts of heat transfer, Effect of Temperature on Thermal Conductivity of Materials; Introduction to Combined Heat Transfer Mechanism, Engineering Applications of Heat Transfer. **Conduction:** Fourier's law of heat conduction for homogeneous, isotropic media, One-Dimensional General Differential Heat Conduction Equation in the Rectangular, Cylindrical and Spherical Coordinate Systems (Case of constant thermal conductivity); Significance of thermal diffusivity, Initial and Boundary Conditions. **Steady State One-Dimensional Heat Conduction:** Composite Systems inRectangular, Cylindrical and Spherical Coordinates With and Without Energy Generation; Thermal Resistance Concept; Analogy Between Heat and ElectricityFlow; Thermal Contact Resistance; Critical Thickness of Insulation. **Extended Surfaces (Fins):** Introduction, types, General equations, Fin efficiency and effectiveness, Fins of Uniform Cross-Sectional Area, Fin applications. **Transient Conduction:** Transient Heat Conduction; Lumped Capacitance Method; Non-dimensional numbers in conduction – Significance of Biot and Fourier numbers, Time Constant; Unsteady State Heat Conduction in One Dimension Only, Heisler Charts. **Natural Convection:** Physical Mechanism of Natural Convection; Characteristic Length, Non-dimensional numbers with their significance Empirical Heat Transfer Relations for Natural Convection Over Vertical Planes and Cylinders, Horizontal Plates and Cylinders.	20
II	**Forced Convection:** Basic Concepts; Hydrodynamic Boundary Layer; Thermal Boundary Layer; energy equation, Concentration Boundary Layer Non-dimensional numbers with their significance Local and average heat transfer coefficients, Flow Over a Flat Plate; Empirical Heat Transfer Relations; **Radiation:** Gray Body; Shape Factor; Black-Body Radiation; Radiation Exchange Between Diffuse Non Black Bodies in An Enclosure; Radiation Shields; Radiation from cavities, Electrical Analogy of Radiation Heat Transfer; Solar Radiation. **Heat Exchanger:** Introduction, Types of Heat Exchangers; Fouling Factors; Overall Heat Transfer Coefficient; Analysis of heat exchangers: Logarithmic Mean Temperature Difference (LMTD) Method; Correction factor charts, Effectiveness-NTU Method; Heat Pipes **Condensation and Boiling:** Introduction to Condensation Phenomena; Drop wise Condensation; Boiling Modes, Pool Boiling;	20

Text Books:

- Yadav R., "*Heat Transfer*", Central Publishing House, Allahabad, 2018
- Rajpoot,R.K. "Heat and Mass Transfer", S. Chand Publications, 2018
- D.S.Kumar, "Heat and Mass Transfer" S.K Kataria & sons, 2008

Reference Books:

- Bayazitouglu & Ozisik, "*Elements of Heat transfer*", T.M.H., 2015
- Holman J.P., "*Heat Transfer*", McGraw-Hill International edition. 2016
- Pitts & Sisson, "*Schaum's outline of Heat Transfer*", McGraw-Hill International edition, 2018
- Frank Kreith, "*Principles of Heat Transfer*", McGraw-Hill Book co., 2019

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2.*

Outcome: *After completion of course, the students will be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Determine the overall thermal conductivity of composite wall of a Furnace	PO1, PO2/PSO1	Evaluate	P	6
2	Determine the critical thickness of insulation of steam pipes of thermal power plant.	PO1, PO3/PSO1, PSO2	Evaluate	P	6
3	Evaluate the effectiveness and efficiency of heat transfer of Fins of motorbike engine.	PO1, PO2/PSO1	Apply	P	6
4	Determine the heat transfer effectiveness of shell and tube heat exchangers.	PO1, PO2, PO3/PSO1	Evaluate	P	6
5	Understand mass diffusion rate in case of evaporative cooling in cooling towers.	PO1, PO2/PSO1, PSO2	Understand	C	8
6	Understand the effects of fouling in boiler tubes of thermal power plant.	PO1, PO2/PSO1, PSO2	Understand	C	8

BMEC 0802 HEAT AND MASS TRANSFER LAB

Objective: *Heat Transfer is one of the important subjects which is commonly applied in renewable energy, industrial, commercial and domestic systems. The experiments are designed to provide exposure of practical aspects of the various theoretical concepts developed under the course, Heat and Mass Transfer. The laboratory consists of experiments on various conductive, convective, radiative, boiling mechanisms of heat transfer.*

Credits: 01 **Semester V** **L–T–P: 0–0–2**

Module No.	Content	Teaching Hours
	List of Experiments • To Determine the Overall Heat Transfer Coefficient for a Composite Wall • To determine the thermal Conductivity of a Metallic Rod and Draw a Graph Between Variation in Conductivity and Temperature. • To Determine the Heat Transfer Rate Through the Composite Cylinder and the Overall Heat Transfer Coefficient of Composite System • To Determine the thermal Conductivity of Liquid • To Determine the thermal Contact Resistance of a Composite Wall • To Determine the Critical Thickness of insulation of a Lagged Pipe. • To Determine the Heat Transfer Through a Heat Pipe & Draw a Temperature Distribution Profile Under Steady State Condition • To Determine the Heat Transfer & Temperature Distribution Along a Uniform Cross- Section Fin Under Steady State in Free Convection. • To Determine the Heat Transfer & Temperature Distribution Along a Uniform Cross-Section Fin Under Steady State in Forced Convection. • To Determine the Specific Heat of Air under Specified atmospheric Conditions. • To Determine the Critical Heat Flux Through a Given Wire (Nichrome Wire) in a Pool Boiling Process. • To Determine the Heat Transfer & Overall Heat Transfer Coefficient in a Counter Flow & Parallel Flow Heat Exchanger. • To Determine the Stefan Boltzmann Constant Under Given Condition. • To Determine the Emissivity of A Test Plate. • To Determine the View Factor /Shape Factor of A Given Arrangement.	

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcomes: After completion of course, the students will be able to:

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Understand the overall thermal conductivity of the composite wall of a Furnace.	PO1, PO2/PSO1	Evaluate	C	2
2	Determine the critical thickness of insulation of composite cylinder.	PO1, PO3/PSO1, PSO2	Evaluate	C	2
3	Determine the thermal conductivity of fluids.	PO1, PO2/PSO1	Evaluate	C	2
4	Determine the heat transfer through tube in tube heat exchangers.	PO1, PO2, PO3/PSO1	Understand	C	2
5	Understand the working of heat pipe.	PO1, PO2/PSO1, PSO2	Understand	C	2
6	Understand the concept Stefan Boltzmann Constant in radiation heat transfer.	PO1, PO2/PSO1, PSO2	Understand	C	2

BMEC 0005 FLUID MECHANICS

Objective: *It is major branch of mechanics. It introduces students about fluid and its difference with solids. Geometry of fluid flow can be visualized. Its importance lies in its wide-ranging applications in fluid power engineering and mechanics of fluid flow. It also discusses various empirical relations which are helpful in boundary layer applications. It provides basis for computational fluid dynamics.*

Credits: 03 **L–T–P: 3–0–0**

Module No.	Content	Teaching Hours
I	**Introduction:** Fluid and Continuum, Physical Properties of Fluids, Rheology of Fluids. **Dimensional Analysis and Hydraulic Similitude:** Dimensional Analysis, Buckingham's Pi Theorem, Important Dimensionless Numbers and Their Significance, Geometric, Kinematic and Dynamic Similarity, Model Studies. **Fluid Statics:** Pressure-Density-Height Relationship, Manometers, Pressure Transducers, Pressure on Plane and Curved Surfaces, Centre of Pressure, Buoyancy, Stability of Immersed and Floating Bodies. **Kinematics of Fluid Flow:** Types of Fluid Flows: Continuum & Free Molecular Flows. Steady and Unsteady, Uniform and Non-Uniform, Laminar and Turbulent Flows, Rotational and Irrotational Flows, Compressible and Incompressible Flows, Subsonic, Sonic and Supersonic Flows, Sub-Critical, Critical and Supercritical Flows, One, Two- and Three-Dimensional Flows, Streamlines, Continuity Equation For 3D and 1D Flows, Circulation, Stream Function and Velocity Potential.	20
II	**Dynamics of Fluid Flow:** Euler's Equation of Motion Along A Streamline and Its Integration, Bernoulli's Equation and Its Applications- Pitot Tube, Orifice Meter, Venturi Meter and Bend Meter, Notches and Weirs, Momentum Equation and Its Application to Pipe Bends. **Laminar and Turbulent Flow:** Equation of Motion For Laminar Flow Through Pipes, Stoke's Law, Transition From Laminar to Turbulent Flow, Types of Turbulent Flow, Mixing Length Concept and Velocity Distribution in Turbulent Flow Over Smooth and Rough Surfaces, Resistance to Flow, Minor Losses, Pipe in Series and Parallel, Power Transmission Through APipe, Siphon, Water Hammer. **Boundary Layer Analysis:** Boundary Layer Thickness, Boundary Layer Over A Flat Plate, Laminar Boundary Layer, Application of Momentum Equation, Turbulent Boundary Layer, Laminar Sublayer, Separation and Its Control, Drag and Lift, Drag on A Sphere, A Two-Dimensional Cylinder, and An Aerofoil, Magnus Effect, Kutta-Jonkowski Theorem.	20

Text Books:

- Bansal R.K., "*Fluid Mechanics*", Laxmi Publications.2016.
- Modi, P.N., and Seth, S.H., "*Hydrualics and Fluid Machines*", Standard Book House,2010.
- Agarwal S.K. "*Fluid Mechanics & Machinery*", TMH,2010.
- Gupta Vijay and Gupta S.K., "*Fluid Mechanics and its Applications*", Wiley Eastern Ltd, 1984.

Reference Books:

- Narasimhan S., "First Course in Fluid Mechanics", University Press,2012.
- Som, S.K. & Biswas G., "Introduction of fluid mechanics & Fluid Machines", TMH, 2000.
- Das M. M., "Fluid Mechanics & Turbomachines", Oxford University Press,2013.
- Garde, R.J., "Fluid Mechanics through Problems", New Age International Pvt. Ltd, New Delhi,2015.

- Shames, I.H., "Mechanics of Fluids", McGraw Hill, Int. Student, Education,2017.

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: *On learning this subject student will be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Identify and obtain the values of fluid properties and relationship between them.	PO1, PO2, PO3/PS1	Understand	conceptual	
2	Understand the principles of continuity, momentum, and energy as applied to fluid motions.	PO1, PO2, PO3/PS1	Understand	conceptual	
3	Calculate hydrostatic force on submerged surface in a static fluid.	PO1, PO2, PO3/PS1	Apply	Fundamental design principle	
4	Calculate buoyancy force to understand the stability concept of the floating body.	PO1, PO2, PO3/PS1	Apply	Fundamental design principle	
5	Apply dimensional analysis to predict physical parameters that influence the flow in fluidmechanics in engineering applications.	PO1, PO2, PO3/PS1	Apply	Criteria and specification	
6	Relate fundamentals of fluid mechanics to the wide spectrum of real life problems.	PO1, PO2, PO12/PS1	Analyze	Practical constraint	
7	Tackle real life problems related to supply and distribution of fluid in domestic and industrial sector.	PO1, PO2, PO12/PS1	Evaluate	Practical constraint	

BMEC 0803 FLUID MECHANICS LAB

Objective: *This lab is run in conjunction with the theory course. It is an introductory course where flow behavior, fluid forces and analysis tools are introduced. It covers measuring devices and techniques, error analysis in experimental works and analysis of assumptions in the theory of fluid mechanics. The laboratory provides training to undergraduate and graduate students in flow measurements.*

Credits: 01 **L–T–P: 0–0–2**

Module No.	Content	Teaching Hours
I	**List of Experiments:** • To Determine Coefficient of Discharge of Given Shape of Orifice. • To Determine Coefficient of Discharge of Given Shape of Venturimeter. • To Demonstrate the Transition From Laminar to Turbulent Flow and to Determine Lower Critical Reynolds Number. • To Determine the Loss of Heads for Pipe Fittings. • To Determine Coefficient of Discharge of Given Shape of Mouth Piece. • To Determine the Meta Centric Height of the Given Ship Model Experimentally. • To Determine Coefficient of Discharge of A Given Shape of V-Notch. • To Verify Bernoulli's Theorem Experimentally. • To Study the Boundary Layer Velocity Profile Over A Flat Plate and to Determine the Boundary Layer Thickness. • To Verify Momentum Theorem Using Momentum Theorem Apparatus. • To Determine Coefficient of Discharge for Flow Over A Rectangular Weir. • To Determine the Friction Factor for Flow Through Pipes • Virtual Demonstration of Velocity, Viscosity and Pressure Measuring Devices.	24

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: *On successful completion of the course, the student will be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Enhance their knowledge of basic principles of fluid mechanics	PO1, PO2/PS1	Apply	Fundamental design principle	
2	Analyze fluid flow problems with the application of the momentum and energy equations.	PO1, PO2, PO3/PS1	Analyze	Practical Constraint	
3	Understand basic working principles of various flows and pressure measuring equipments like	PO1, PO2, PO3/PS1	Understand	Fundamental design	

	mouthpiece, orifice notches and weirs.			principle	
4	Use the techniques, skills and modern engineering tools necessary for fluid engineering practice.	PO1, PO2, PO5/PS1	Create	Fundamental design principle	
5	Evaluate the Meta centric height of submerged bodies to understand the stability concept.	PO1, PO2, PO3/PS1	Analyze	Criteria and specification	
6	Estimate the minor and major frictional losses in pipe flow.	PO1, PO2/PS1	Evaluate	Fundamental design principle	
7	Verify the concept of Bernoulli's equation in pipe flow experimentally.	PO1, PO2/PS1	Understand	Fundamental design principle	

BMEC 0006 MANUFACTURING SCIENCE – I

Pre-requisite: *Material Science*

Objective: *To impart the comprehensive insight into various manufacturing processes such as metalcasting, sheet metal, welding and advanced welding processes.*

Credits: 03 **L–T–P: 3–0–0**

Module No.	Content	Teaching hours
I	**Introduction:** Importance of Manufacturing, Classification of Manufacturing Processes and Its Applications. **Casting:** Pattern Design & Allowances. Gating, Riser, Runners, Molding Parameters and Design, Solidification of Casting, Gating System Design, Sand Testing Methods, Casting Defects and Remedies. Die Casting, Centrifugal Casting, Investment Casting, Carbon Di-Oxide Casting, **Sheet metal Processing:** Types of Press Die, Simple, Progressive, Compound and Combination. Punch & Die Clearance. Blanking & Piercing, Cutting and Punching Mechanism. Method of Reducing Cutting Forces. Bending of Strip & Spring Back. **Welding:** Introduction and Concept of various Welding Processes, Electric Arc Welding Resistance Welding, Atomic Hydrogen Welding, Gas Welding.	21
II	**Advanced Welding Processes:** Electron Beam Welding and Plasma arc Welding Process. Laser beam welding and diffusion Welding, Heat Affected Zone (HAZ) Metallurgical Aspects of Weld Joint, Welding Defects and Remedies, Solid State Welding Processes, Friction Welding Process, Explosive Welding. **Metal Forming:** Metal Deformation, Yield Criteria. Concept of Inter-Facial Friction and Lubrication Mechanism in Manufacturing. Determination and Calculation of Pressure Distribution With Sliding Friction for Drawing and Extrusion of Wire/Strip, Conditions for Rolling, Force and Power in Rolling, Limiting Thickness and Reduction. **Advanced Metal Forming Processes:** Unconventional Metal Forming Processes- Explosive Forming, Electromagnetic Forming, Electro-Hydraulic Forming, Hydro-Static Extrusion, Hydro-Dynamic Wire Drawing, Concept and Applications of Powder Metallurgy.	21

Reference Books:

- Sharma P.C., "Manfacturing Engineering", S. Chand New Delhi
- Groover M.P., "Manufacturing Process: Materials of Systems", John Wiley & Sons, Inc.
- Serope **Kalpakjian,** "Manufacturing Process" ,Addison Wesley Publishing Co.
- Ghosh and Malik, "Manufacturing science", East West Pvt. Ltd.
- Boothroyd, "Fundamental of Metal Cutting and Machine Tools", John Wiley & Sons, Inc.
- Ostwald Phillip F., "Manufacturing Process", John Wiley & Sons, Inc.
- DeGarmo, "Materials & Manufacturing", Wiley Publications.

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcomes: *On completion of this course, the students would be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Develop the skill of selecting suitable manufacturing process to manufacture the product.	PO1, PSO2	A	P	3 Hours
2	Analyze the gating system and riser design in metal casting process.	PO3, PSO2	An	P	9 Hours
3	Understand the concept of sheet metal operations in automobile industry.	PO3, PSO2	U	C	9 Hours
4	Implementation of conventional and advanced welding techniques as per material properties.	PO1, PSO2	A	C	10 Hours
5	Understand the concept of metal forming process.	PO1, PSO2, PSO3	U	C	11 Hours

BMEC 0804: MANUFACTURING SCIENCE - I LAB

Objective: *The purpose of this lab is to enable the students to have the practical skills for basic manufacturing operations e.g. Preparation of Sand, Making Pattern with allowances, Preparation of different types of moulds with cores for various castings. The student will also have practical exposure to Press work and die assembly and machining processes on various machine tools such as Spur gear on milling machine, knurling Bush on Capstan Lathe and preparation of Single point cutting tool on Tool Grinding machine.*

Credits: 01 **L–T–P: 0–0–2**

Module No.	Content	Teaching Hours
I	**List of Experiments -** • To Study and Analyze Different Types of Patterns Considering: (A) Shape (B) Size (C) Parting Line • To Design and Fabricate the Pattern for A Given Component Considering Different Allowances and Surfaces Which Require Machining. • To Make A Casting for Half Bush Gland By Self Hanging Core Mould as Per Given Dimensions. • To Make A Casting for Hollow Step Pulley With the Help of GreenSand Mould. • To Prepare the Bush Gland From Metal By Use of Dies Casting Method. • To Prepare A Bar of Circular Cross Section From Square Bar Keeping Length Constant. • To Prepare the Ring By Using the Bending and Forge Welding Operation. • To Make a Washer by Using Combination Die and to Study How Progressive Die is Different from Combination Die. • To Analyze the Flow Pattern During Tube Bending Process. • To Analyze the Flow Pattern and Die Load During Direct Extension Process By Using Dies of Different Shapes and Cross Section During: (A) Different Reduction Ratio (B) Different Shapes • To Make A 10 T.P.I. (R.H.) Thread on M.S. Bar for Hexagonal Bolt With the Help of Centre Lathe Machine as Per Given Figure. • To Make A Cast Iron Block and Make A Key Way on Its Surface With the Help of Shaper Machine as Per Given Figure. • To Make A Plain (Spur) Gear of 10 Teeth on Milling Machine asPer Given Figure. • To Make A Knurling Bush on Capstan Lathe as Per Given Dimensions and Sketch. • To Make A Single Point Cutting Tool Angles With the Help of Tool Grinding Machine A Per Given Dimensions and Sketch.	24

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: *On successful completion of this lab, the students will be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Able to use tools for mould preparation, cores for manufacturing the casting objects	PO1, PO3, PSO3	A	P	5 Hours
2	Able to gain the knowledge of basic operation of Hand Forging	PO1	U	C	5 Hours
3	Able to perform the basic operations of Hand press machine	PO1, PO3	A	C	4 Hours
4	Able to perform the operations on Lathe Machine Tool	PO1	A	P	5 Hours
5	Able to gain the operational knowledge of Shaper and Milling Machine Tool	PO1, PO3, PSO3	A	P	5 Hours

BMEC 0007 STRENGTH OF MATERIALS

Pre-requisite: *Applied Mechanics*

Credits: 03 **L–T–P:3–0–0**

Module No.	Content	Teaching Hours
I	**Stress and Strain:** Simple stress, types of stresses and strains, hook's law, principle of superposition, Elastic constants, bars of varying section, uniformly tapered bars, elongation of bar due to self-weight, compound bars, Indeterminate structures, Thermal stresses in uniform bars. Strain energy, impact loading. **Simple Bending of Beams:** Theory and assumptions of Pure Bending, Stresses in Beams Under Different Types of Loads, Beam of uniform strength, Direct shear stresses in beams. **Torsion:** Torsion of Circular shafts, design of shaft, stress and strain in pure shear, Statically indeterminate torsional member, strain energy in torsion. **Slope and Deflection of Beams:** Slope and Deflection of Statically Determinate Beams Using Macaulay's Method, Area-Moment and Castigliano's Theorem.	22
II	**Compound stress and strain:** Introduction, plane stress, principle planes, principle stresses and maximum shear stresses, Mohr's circle for plane stress, hook's law for plane stress, tri-axial stress, transformation equations for plane stress, plane strain. **Theories of Elastic failures:** Rankine's theory, St. Venent theory, Guest's theory, Haigh's theory, Maximum distortion energy theory, graphical representation and their comparison. **Columns:** Euler's Theory of Buckling of A Column, Middle-Third and Middle-Quarter Rules, End Conditions For Columns, Different Empirical Formulae For Columns. **Pressure Vessels:** Stresses and Strains in Thin and Thick Cylinders and Spheres Subjected to Internal and External Pressures. **Springs:** Deflection of Helical Springs (open coil and closed coil) Under Different Types of Loads, Springs in Series and Parallel, Leaf Springs.	24

Text Book:

- L. S. Shrinath, "Mechanics of Solids": Tata McGraw-Hill Publication, 2009.
- B. J. Goodno and J. M. Gere, "Mechanics of materials, 9e": Cenage Learning, 2018.
- B.C. Punamia, A. K. Jain and A. K. Jain, "Mechanics of materials": Laxmi Publication, 2017.
- R. K. Rajput, "A Textbook of Strength of Materials (Mechanics of Solids) in SI Units 7e": S Chand, 2018.

Reference Books:

- G. H. Ryder, "Strength of Materials": Macmillan Publishers India Limited, 2002.
- S. P. Timoshenko and D. H. Young, "Elements of Strength of Materials": Affiliated East-West Press,2003.
- F. P. Beer and E. R. Johnston, "Mechanics of Materials (SIE) 7e": McGraw Hill Education India Private
- Limited, 2017.

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: *After completion of course, the student will be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Understand the concepts of stress and strain at a point as well as the stress-strain relationships for homogenous, isotropic materials and classify the theories of failure for static loading.	PO2, PO4/PSO3	C	U	
2	Understand the concepts of stress and strain at a point as well as the stress-strain relationships for homogenous, isotropic materials and classify the theories of failure for static loading.	PO2, PO3/PSO3	C	U	
3	Draw Shear Force and Bending Moment diagrams of various types of beams subjected to different loads.	PO2, PO3/PSO3	P	A	
4	Determine the slope and deflections produced by the three fundamental types of loads: axial, torsional, and flexural.	PO2, PO3, PO4/PSO3	P	A	
5	Compute and illustrate the principal stresses, maximum shearing stress, and the stresses acting on a structural member.	PO2, PO3/PSO3	P	A	
6	Calculate the stresses and strains associated with thin-wall spherical and cylindrical pressure vessels.	PO2, PO3, PO4/PSO3	M	AN	
7	Understand the phenomenon of buckling of columns and calculate the critical load for slender, long columns subjected to axial loads.	PO2, PO3/PSO3	F	U	

BMEC 0008 KINEMATICS OF MACHINES

Pre-requisite: *Applied Mechanics*

Objective: *To explain various governing laws to understand mechanism, to develop machines based on simple mechanism and understand forces involved. To understand different types of gears based on link mechanisms*

Credits: 03 **L–T–P: 3–0–0**

Module No.	Content	Teaching Hours
I	**Introduction:** Definitions: Link, kinematic pairs, kinematic chain, mechanism, structure, degrees of freedom, Classification links, Classifiction of pairs based on type of relative motion, Grubler\'s criterion, mobility of mechanism, Groshoff's criteria, inversionsof Four Bar, Single Slider and Double Slider Crank. **SPECIAL MECHANISMS:** Exact Straight-Line Motion Mechanisms - Peaucellier's, Hart andScott Russell Mechanisms, Approximate Straight-Line Motion Mechanisms – Grass- Hopper, Watt and Tchebicheff Mechanisms, Pantograph, Condition for correct steering, Davis and Ackerman steering gear mechanism. **Velocity and Acceleration Analysis of Mechanisms:** Velocity and acceleration analysis of Four Bar mechanism, slider crank mechanism and Simple Mechanisms by vector polygons: Relative velocity and acceleration of particles .in a common link, relative velocity and accelerations on separate links- Coriolis component of acceleration. Angular velocity and angular acceleration of links, velocity of rubbing.	22
II	**Velocity Analysis by Instantaneous Center Method Klein's Construction:** Velocity Analysis by Instantaneous Center Method: Definition, Kennedy's Theorem, Determination of linear and angular velocity using instantaneous center method Klein's Construction: Analysis of velocity and acceleration of single slider crank mechanism. **Spur Gears**: Gear terminology, law of gearing, path of contact, arc of contact, contact ratio of spur gear. Interference in involute gears, methods of avoiding interference, for minimum number of teeth to avoid interference, Simple gear trains, compound gear trains.Epicyclic gear trains: Algebraic and tabular methods of finding velocity ratio of epicyclic gear trains, torque calculation in epicyclic gear trains. **Cams:** Types of cams, types of followers. displacement, velocity and acceleration curves velocity, Simple Harmonic Motion, Uniform Acceleration Retardation, Cycloidal motion. Cam profiles: disccam with reciprocating / oscillating follower having, roller and flat- face follower inline.	18

Text Books:

- S. S. Ratan, "Theory of Machines 5e": Tata McGraw-Hill Publication, 2019.
- J. K. Gupta and R. S. Khurmi, "Theory of Machines 14e": S Chand & Co Ltd, 2005.
- R. K. Bansal and J. S. Brar, "A Textbook of Theory of Machines 5e": Laxmi Publishers, 2016.

Reference Books:

- J. J. Uicker, G. R. Pennock and J. E. Shigley, "Theory of Machines and Mechanisms": Oxford University Press, 2014.
- Ghosh and A. K. Mallik, "Theory of Machines and Mechanisms": East west press, 2008.

- P. L. Ballaney, "Theory of machines & Mechanism": John Wiley Publishers, 2005.

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: *After studying this subject student will be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Compute the forces and torques involved in friction drives like screw threads, clutches, belts, ropes and band and block brakes.	PO1/PSO3	U	P	
2	Design a possible gear train and determine the speeds of simple, compound and epicyclic gear trains.	PO3/PSO3	U	P	
3	Sketch slow speed and high-speed cam profile for the required predefined motion of follower.	PO1, PO2/PSO3	U	P	
4	Analyze velocity and acceleration of mechanisms.	PO1, PO2/PSO3	R	C	
5	Calculate kinematic properties of simple planar mechanisms using graphical approach, instantaneous center method and synthesis them at elementary level.	PO2, PO3/PSO3	R	F	
6	Model planar mechanisms which will have defined required motion.	PO2, PO3/PSO3	AN	M	

BMEC 0009: DYNAMICS OF MACHINES

Pre-requisite: *Kinematics of Machine*
Objective: *The objective of this course is to provide the details of the concepts of generalized forces and Static and dynamic force analysis, concepts of static and dynamic mass balancing. To introduce the approaches and mathematical models used dynamical analysis of machinery. To teach students concepts of free Vibration of Single Degree of Freedom Systems, Vibration Measurement and Applications, Modal Analysis.*

Credits: 03 **L–T–P: 3–0–0**

Module No.	Content	Teaching Hours
I	**Static and Dynamic Force Analysis:** Static equilibrium. Equilibrium of two and three force members. Members with two forces and torque. Free body diagrams. Static force analysis of four bar mechanism. Dynamic force analysis of Slider Crank mechanism. **Turning Moment & Flywheel:** Turning Moment on Crankshaft, Turning Moment Diagrams- Four Stroke IC Engine and Multi-Cylinder Steam Engine, Fluctuation of Energy, Flywheel. **Balancing of Rotating and Reciprocating Masses:** Static and Dynamic Balancing, Balancing of Several Masses in the Same Plane and Different Planes, Balancing of Reciprocating Masses, Balancing of Primary Force in Reciprocating Engine, Partial Balancing of Two Cylinder Locomotives, Variation of Tractive Force, Swaying Couple, Hammer Blow. **Governors:** Terminology, Centrifugal Governors-Watt Governor, Dead Weight Governors-Porter & Proell Governor, Spring Controlled Governor-Hartnell Governor, Sensitivity, Stability, Hunting, Isochronism, Effort and Power of Governor, Controlling Force Diagrams for Porter Governor and Spring Controlled Governors.	20
II	**Friction:** Pivots and Collar Friction-Uniform Pressure and Uniform Wear, Frictional, Centrifugal Clutches, Belt and Pulley Drive, Length of Open and Cross Belt Drive, Ratio of Driving Tensions for Flat Belt Drive, Centrifugal Tension, Condition for Maximum Power Transmission, V Belt Drive. **Gyroscopic Motion:** Gyroscopic Torque, Effect of Gyroscopic Couple on the Stability of Two Wheeler and Four Wheeler, Ships and Aero-Planes. **Mechanical Vibrations:** Types of Vibrations, Degrees of Freedom, Single Degree Free & Damped Vibrations, Forced Vibration of Single Degree System Under Harmonic Excitation, Critical Speeds of Shaft.	20

Text Books:

- Rattan S.S., "Theory of Machines", TMH.
- Ballaney P.L., "Theory of Machines", Khanna Publication.
- Khurmi & Gupta, "Theory of Machines", S.Chand and Company Ltd.,. New Delhi.
- Bansal R.K., "Theory of Machines", Laxmi Publishers.

- Singh V. P. & Chand S., "Theory of Machines", Dhanpat Rai & Sons.

Reference Books:

- Bevan Thomas, "Theory of Machines", CBS Publishers and Distributors.
- Shingle, "Theory of Machines and Mechanisms", McGraw – Hill International Editions.
- Ghosh & Mallik, "Theory of Machines and Mechanisms", East west press.
- Rao & Dukkipati, "Theory of Machines and Mechanisms", East west press.

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: *After completing this course the student will be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Notice of importance of the balancing and learn procedures of the static and dynamic balancing.	PO1, PO2, PO4, PO12/ PSO1	R, U	F, C	6
2	Understand the implications of computed results in dynamics to improve the design of a mechanism.	PO1, PO2, PO3, PO4/PSO1, PSO3	U, Ap	F, C, P	7
3	Understand the concept of whirling of shaft, effect of gyroscopic couple on aeroplane.	PO1, PO2, PO4/ PSO3	U, Ap, An	F, C, M	7
4	Practically know how the governor apparatus works.	PO1, PO6, PO8/ PSO3	R, U	C, P, M	6
5	Determine the natural frequencies of continuous systems starting from the general Equation of displacement.	PO1, PO2, Po3, PO9/ PSO1	Ap, An, E	C, P, PC	5
6	Understand the various types of vibratory motions.	PO1, PO2,PO4, PO12/ PSO1	R, U	F, C,P	9

BMEC 0805: THEORY OF MACHINE LAB

Objective: *Objectives of this Theory of Machines lab are to impart practical knowledge on design and analysis of mechanisms for the specified type of motion in a machine. With the study of rigid bodies motions and forces forthe transmission systems, machine kinematics and dynamics can be well understood. Demonstration exercises are provided with wide varieties of transmission element models to understand machine kinematics. Various experiments with governors, gyroscopes, balancing machines and universal vibration facilities are available to understand machine dynamics.*

Credits: 01 **L–T–P: 0–0–2**

Module No.	Content	Teaching Hours
	List of Experiments • Study of Simple Linkage Models/Mechanisms and Verification of Grashoff's Criteria of Four Bar Linkages. • Determination of Velocity Ratio and Verification of Holding torque in Epicyclic Gear Trains. • Determination of Natural Frequency in Longitudinal Vibrating System. • Determination of Natural Frequency in Transverse Vibration System. • Experimental investigation of the Characteristics of Dead Weight Mechanical Governor. • Experimental investigation of the Characteristics of Spring Controlled Governor. • Determination of Critical Speed in Whirling of Shafts. • Study of the Principles of Gyroscope and Verification of the Equation of Gyroscopic Couple. • Study of the Concept of Statics & Dynamic Balancing of Rotating Masses in Single and Multi Planes and Verification of Balancing Principles. • Measurement of Slip in Flat Belt under Different Belt Tensions and Varying Load Conditions.	

Text Books:

- S. S. Ratan, "Theory of Machines", TMH
- Khurmi & Gupta, "Theory of Machines", S.Chand and Company Ltd.,. New Delhi.
- Bansal R.K., "Theory of Machines", Laxmi Publishers.
- Singh V. P. & Chand S., "Theory of Machines", Dhanpat Rai & Sons.

Reference Books:

- Shingle, "Theory of Machines and Mechanisms", McGraw – Hill International Editions.
- Ghosh & Mallik, "Theory of Machines and Mechanisms", East west press.
- Rao & Dukkipati, "Theory of Machines and Mechanisms", East west press.
- Balani, "Theory of machines & Mechanism", John Wiley Publishers.

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: *After completing this course the student will be able to*:

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Understand the concept of whirling of shaft, effect of gyroscopic couple on aeroplane.	PO1, PO2, PO4/ PSO3	R, U	C.P	
2	Analyze the different types of mechanism involved in the machines.	PO1, PO2, PO9/ PSO3	U, An	C, M	
3	Gather knowledge about the slip and creep phenomena occurring in belt drives.	PO1, PO2/ PSO3	R, U	F, C, CS	
4	Practically Know how the governor apparatus works.	PO1, PO6, PO8/PSO1	R, U	C, P, M	
5	Know the condition of Static and dynamic balancing.	PO1, PO2/PSO1	U, R	F, C, M	
6	Understand the various types of vibratory motions.	PO1, PO2, PO12/ PSO3	U, Ap	P, M	

BMEC 0010: MACHINE DESIGN – I

Pre-requisite: *Strength of Materials*

Objective: *The objective of this course is to introduce design concepts and procedures necessary to design and select a machine component in terms of geometry and materials, subjected to static and/or dynamic load.*

Credits: 03 **L–T–P: 3–0–0**

Module No.	Content	Teaching Hours
I	**Introduction:** Mechanical Engineering Design, Design considerations, Standards in Design, Material Selection. **Design Against Static Load:** Modes of Failure, Factor of Safety, Theories of Failure. **Design Against Fluctuating Loads:** Cyclic Stresses, Fatigue and Endurance Limit, Stress Concentration Factor, Design for Finite and Infinite Life, Soderberg, Goodman Criteria. **Shafts:** Cause of Failure in Shafts, Materials for Shaft, Design of Shafts, Shafts Subjected to Fatigue Loads. **Keys and Couplings:** Types of Keys, Splines, Design of Square & Flat Keys, Couplings- Design of Rigid and Flexible Couplings.	20
II	**Design of Riveted Joints:** Types of Riveted Joints, Failure of Riveted Joint, Efficiency of Riveted Joint, Design of Boiler Joints, Eccentric Loaded Riveted Joint. **Design of Threaded Joint:** Design of Bolted Joint, Eccentrically Loaded Bolted Joint. **Design of Welded Joints-** Stresses in Butt and Fillet Welds, Eccentrically LoadedJoint. **Mechanical Springs:** Material for Helical Springs, Design of Helical Springs Subjectedto Static and Fatigue Loading, Design of Leaf Spring. **Power Screws:** Forms of Threads, Multiple Threads, Efficiency of Square Threads,Trapezoidal Threads, Stresses in Screws, Design of Screw Jack. **Note: Design Data Book Is Allowed in the Examination**	20

Text Books:

- Sharma and Agrawal, "*Machine Design*", S.K. Katara & Sons.
- Bhandari V.B., "*Design of Machine Elements*", Tata McGraw Hill Co.
- Shigely Joseph E., "*Mechanical Engineering Design*", McGraw Hill Publications.

Reference Books:

- Valance Alex and Doughtie VI, "*Design of Machine Members*", McGraw Hill Co.
- Spott M.F., "*Machine design*", Prentice Hall India.
- Maleev and Hartman, "*Machine Design*", CBS Publications.
- Black & Adams, "*Machine design*", Mc Graw Hill.

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

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

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Analyze the stresses in machine elements and structural members under various loads	PO1, PO2/ PSO1	U	C	5 hours
2	Apply multidimensional failure criteria in the analysis and design of machine components	PO3, PO4/ PSO1	A	FDP, P	6 hours

3	Understand the causes of structural joints failures	PO1, PO2, PO3/ PSO1	U	FDP, P	6 hours
4	Design and selection of structural riveted, bolted and welded joints	PO1, PO2, PO3/PSO1	U	FDP, P	6 hours
5	Design and determine the fatigue life of circular shafts under the combined loadings	PO2, PO3/PSO1	A	FDP, P	5 hours
6	Selection of mechanical keys.	PO1, PO2, PO3/ PSO1	U	FDP, P	6 hours
7	Design of rigid & flexible couplings	PO1, PO2, PO3/PSO1	A	FDP, P	6 hours

BMEC 0806: MACHINE DESIGN – I LAB

Objective: *The primary objective of this course is to demonstrate how engineering design uses the many principles learned in previous engineering science courses and to show how these principles are practically applied Estimate fatigue strengths of steel parts. Apply techniques of combined stress and Mohr's circle in machine design situations.*

Credits: 01 **L–T–P: 0–0–2**

Module No.	Content	Teaching Hours
	List of Experiments **Students are Advised to Use Design Data Book For the Design. Drawing Shall be Made Wherever Necessary (Using CAD-Software Such as AutoCAD).** • Design & Drawing of Cotter Joint. • Design & Drawing of Knuckle Joint. • Design of Machine Components Subjected to Combined Steady and Variable Loads. • Design & Drawing of Eccentrically Loaded Riveted Joint. • Design & Drawing of Boiler Riveted Joint. • Design of Shaft for Combined Constant Twisting and Bending Loads. • Design of Shaft Subjected to Fluctuating Loads. • Design & Drawing of Flanged Type Rigid Coupling. • Design & Drawing of Flexible Coupling. • Design of Helical Spring. • Design of Leaf Spring. • Design of Helical Spring Subjected to Fluctuating Load . • Design of Screw Jack. • Design of Eccentrically Loaded Welded Joint. • Design of Eccentrically Loaded Threaded Joint.	

Text Books:

- Sharma and Agrawal, "*Machine Design*", S.K. Katara & Sons.
- Bhandari V.B., "*Design of Machine Elements*", Tata McGraw Hill Co.
- Shigely Joseph E., "*Mechanical Engineering Design*", McGraw Hill Publications.

Reference Books:

- Valance Alex and Doughtie VI, "*Design of Machine Members*", McGraw Hill Co.
- Spott M.F., "*Machine design*", Prentice Hall India.
- Maleev and Hartman, "*Machine Design*", CBS Publications.
- Black & Adams, "*Machine design*", Mc Graw Hill.

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

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

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Understand the concepts of geometric and solid modelling	PO1, PO5/ PSO1	U	C, P	4 hours
2	Design of Machine Components Subjected to Combined	PO2, PO3/	U, A	FDP, P	6 hours

	Steady and Variable Loads.	PSO1			
3	Model and simulate the mechanical engineering parts and components which include Cotter Joint, Knuckle Joint, structural joints, shaft, spring & screw jack along with their assembly in a CAD package	PO3, PO5/ PSO1	R, A	FDP, P	4 hours
4	Students will be able to identify and analyze practical problems	PO3, PO5/PSO1	U, A	FDP, P	6 hours

BMEC 0011: MACHINE DESIGN II

Pre-requisite: *Machine Design I*
Objective: *The objective of this course is to introduce the guidelines for design of bearings, gears, to know the design process of different IC engine parts like cylinder head, piston, gudgeon pin, connecting rod, crank shaft etc.*

Credits: 03 **L–T–P: 3–0–0**

Module No.	Content	Teaching Hours
I	**Spur Gears:** Tooth Forms, Standard Proportions of Gear Systems, Interference,Selection of Gear Materials, Beam Strength of Gear Tooth, Dynamic Tooth Load,Wear Strength of Gear Tooth, Failure of Gear Tooth, Design of Spur Gears, AGMAand Indian Standards. **Helical Gears:** Beam Strength and Wear Strength of Helical Gears, Design of Helical Gears. **Bevel Gears:** Stresses in Bevel Gears, Design of Bevel Gears. **Worm Gears:** Efficiency of Worm Gears, Heat Dissipation in Worm Gearing, Strength and Wear Tooth Load for Worm Gears, Design of Worm Gearing.	18
II	**Sliding Contact Bearing:** Selection of Bearing, Hydrodynamic Lubrication, Properties and Materials, Lubricants and Lubrication, Hydrodynamic Journal Bearing, Design of Journal Bearing, Thrust Bearing-Pivot and Collar Bearing, Hydrodynamic Thrust Bearing. **Rolling Contact Bearing:** Classification, Bearing Life, Reliability of Bearing, Selection of Rolling Contact Bearing, Lubrication, Mounting of Bearing. **IC Engine Parts:** Selection of IC Engine, Design Considerations, Design of Cylinder and Cylinder Head; Design of Piston, Piston Ring and Gudgeon Pin; Design of Connecting Rod; Design of Crankshafts.	22

Text Books:

- Sharma and Agrawal, "*Machine Design*", S.K. Katara & Sons.
- Bhandari, V.B., "*Design of Machine Elements*", Tata McGraw Hill Co.

Reference Books:

- Shigely, Joseph E., "*Mechanical Engineering Design*", McGraw Hill Publications.
- Valance, Alex and Doughtie, VI, "*Design of Machine Members*", McGraw Hill Co.
- Spott, M.F., "*Machine Design*", Prentice Hall India.
- Maleev and Hartman, "*Machine Design*", CBS Publications.
- Black & Adams, "*Machine Design*", Mc Graw Hill.

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

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

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Understand the gear tooth system as per AGMA standards Spur Gear, Helical gear, Bevel Gear & worm gears	PO1/ PSO1	U, R	C, P	5 hours
2	Analyze the force acting on Spur Gear, Helical gear, Bevel	PO1, PO3/	A	FDP, P	5 hours

	Gear & worm gears used in power transmission applications.	PSO1			
3	Select the material and evaluate of stresses for Spur Gear, Helical gear, Bevel Gear & worm gears used in power transmission applications	PO1, PO3/ PSO1	R, A	FDP, P	5 hours
4	Design and selection of Spur Gear, Helical gear, Bevel Gear & worm gears using AGMA standards and catalogues	PO1, PO6, PO8/PSO1	A	FDP, P	5 hours
5	Understand the causes of bearing failures	PO2, PO3, PO4/PSO1	U	FDP, P	5 hours
6	Understand the selection of hydrodynamic, hydrostatic and rolling element bearings used for power transmission shafts.	PO1, PO3/ PSO1	U, A	FDP, P	5 hours
7	Design of hydrodynamic, hydrostatic and rolling element bearings used for power transmission shafts	PO1, PO2, PO3/PSO1	A	FDP, P	5 hours
8	Design cylinder, piston, connecting-rod and crankshafts used in IC engines.	PO1, PO2, PO3/ PSO1	A	FDP, P	5 hours

BMEC 0807: MACHINE DESIGN - II LAB

Objective: *Develop and evaluate alternatives for mechanical systems. Learn programming of design problems. Apply iterative techniques in design, including making estimate of unknown values for first computation and checking or revising and re-computing. Design Gears, Bearings and IC engine. Learn Modeling and Analysis on Software.*

Credits: 01 **L–T–P: 0–0–2**

Module No.	Content	Teaching Hours
	• Design of Spur Gear • Design of Helical Gear • Design of Bevel Gear • Design of Worm and Worm Gear • Design of Gear Assembly • Design of Project Report Consists of Different Types of Gears • Design of Antifriction Bearing Assembly • Design of Journal Bearing • Design of Project Report Consists of Different Types of Bearings. • Design of Cylinder and Cylinder Head. • Design of Piston, Piston Ring and Gudgeon Pin. • Design of Connecting Rod. • Design of Crankshafts. • The Design Project Consists of Two Imperial Size Sheets Drawn With 3D/2D CAD Software- One Involving Assembly Drawing With A Part List and Overall Dimensions and the Other Sheet Involving Drawings of Individual Components, Manufacturing Tolerances, Surface Finish Symbols and Geometric Tolerances Should be Specified So as to Make It Working Drawing. A Design Report Giving All Necessary Calculations of the Design of Components and Assembly Should Be Submitted. Students Are Required to be Submitted A Design Report Giving All Necessary Calculations of the Design of Components and Assembly. Develop the Programs in 'C' Language for All Design Components.	

Text Books:

- Sharma and Agrawal, "*Machine Design*", S.K. Katara & Sons.
- Bhandari, V.B., "*Design of Machine Elements*", Tata McGraw Hill Co.

Reference Books:

- Shigely, Joseph E., "*Mechanical Engineering Design*", McGraw Hill Publications.
- Valance, Alex and Doughtie, VI, "*Design of Machine Members*", McGraw Hill Co.
- Spott, M.F., "*Machine Design*", Prentice Hall India.
- Maleev and Hartman, "*Machine Design*", CBS Publications.
- Black & Adams, "*Machine Design*", Mc Graw Hill.

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

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

CO	CO Statement	PO/PSO	CL	KC	Duration
1	**:** Develop the Programs in MatLAB Language for the design of machine components which include Gears, Bearings and I.C. engine components.	PO1, PO2, PO5/ PSO1	U, A	FDP, P	4 hours
2	Model and simulate Gears, Bearings and I.C. Engine components used in power transmission applications with their assembly in a CAD package.	PO2, PO5/ PSO1	R, A	C, P	4 hours
3	Design and selection of Spur, Helical, Bevel and Worm Gears.	PO1, PO3/ PSO1	A	FDP, P	4 hours
4	Design of hydrodynamic, hydrostatic and rolling element bearings used for power transmission shafts.	PO1, PO3/PSO1	A	FDP, P	4 hours
5	Design cylinder, piston, connecting-rod and crankshafts used in IC engines.	PO1, PO3/PSO1	A	FDP, P	4 hours

BMEC 0012: FLUID MACHINERY

Pre-requisite: *Fluid Mechanics*
Objective: *To understand basic concept of Hydraulic Turbines, Reciprocating Pumps and Centrifugal Pumps and it's application to hydro power generation.*

Credits: 03 **L–T–P: 3–0–0**

Module No.	Content	Teaching Hours
I	**Introduction:** Classification of Fluid Machines & Devices, Application of Momentum and Momentum, Equation to Flow Through Hydraulic Machinery, Euler's Fundamental Equation. **Impact of Jet:** Introduction to Hydrodynamic Thrust of Jet on A Fixed and Moving Surface (Flat & Curve), Effect of Inclination of Jet With the Surface. **Hydraulic Turbines:** Classification of Turbines, Impulse Turbines, Constructional Details, Velocity Triangles, Power and Efficiency Calculations. **Reaction Turbines:** Francis and Kaplan Turbines, Constructional Details, Velocity Triangles, Power and Efficiency Calculations, Degree of Reaction, Draft Tube, Cavitations in Turbines, Principles of Similarity, Unit and Specific Speed, Performance Characteristics, Selection of Water Turbines, Governing of Turbines.	20
II	**Centrifugal Pumps:** Classifications of Centrifugal Pumps, Vector Diagram, Work Done by Impellor, Efficiencies of Centrifugal Pumps,Specific Speed, Model Testing, Cavitations & Separation and Their Control, Performance Characteristics. **Positive Displacement Pumps:** Reciprocating Pump Theory, Slip and Coefficient of Discharges, Indicator Diagram, Effect and Acceleration, Work Saved by Fitting Air Vessels, Comparison of Centrifugal and Reciprocating Pumps, Positive Rotary Pumps, Gear Pump and Vane Pump, Performance Characteristics. **Hydraulic System:** Hydraulic Accumulator, Special Duty Pumps, Intensifier, Hydraulic Press, Lift and Cranes, Theory of Hydraulic Coupling and Torque Converters, Hydraulic Ram, Jet Pumps, Air Lift Pumps.	20

Text Books:

- Lal, Jagdish, "*Hydraulic Machines*", Metropolitan Book Co. Pvt. Ltd., 2016
- Rajput, R K, "*Hydraulic Machines*", S. Chand & co Ltd., 2016
- Kumar, D. S., "*Hydraulic Machines*", Khanna Publishers, 2010

Reference Books:

- Vasandhani, V.P., "*Hydraulic Machines: Theory & Design*", Khanna Publishers, 2019
- Addison, Thomas, "*Applied Hydraulics*", CBS Publishers, 2003
- Philip, Gerhart and Wright Terry, "Fluid Machinery- application Selection and Design", CRS Publishers, 2009.

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: *On learning this subject student will be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Analyze the forces exerted by a jet of fluid on fixed and moving vanes.	PO1, PO2, PO3/PSO1	Analyze	Fundamental design principle	
2	Evaluate the performance of miscellaneous hydraulic machines hydraulic Ram, press, intensifier	PO1, PO2, PO6/ PSO1	Apply	conceptual	
3	Analyze the construction features and working principles of Pelton Turbine, Francis Turbine and Kaplan Turbine.	PO1, PO2, PO3/ PSO1	Analyze	Fundamental design principle	
4	Analyze the construction features and working principles of Centrifugal and Reciprocating pump.	PO1, PO2, PO12/ PSO1	Analyze	Fundamental design principle	
5	Estimation of hydro power potential and efficiency of Francis Turbine and Kaplan Turbine.	PO1, PO2, PO3/ PSO1	Apply	Criteria and specification	
6	Analyze the performance characteristic curves of Francis Turbine and Kaplan Turbine.	PO1, PO2, PO3/ PSO1	Analyze	Practical constraint	
7	Design and analysis of draft tubes used in reaction turbines.	PO1, PO2, PO3/ PSO1	Analyze	Practical constraint	

BMEC 0808 FLUID MACHINERY LAB

Objective: *To understand basic concept of Hydraulic Turbines, Reciprocating Pumps and Centrifugal Pumps and its application to hydro power generation.*

Credits: 01 **Semester VI** **L–T –P: 0–0–2**

Module No.	Content	Teaching Hours
1	**List of Experiments:** • Demonstration of Working Principle of the Runner of Pelton Wheel, Francis Turbine and Kaplan Turbine. • To Find Efficiency and Performance Characteristics Curve of Pelton Turbine. • To Find Efficiency and Performance Characteristics Curve of Francis Turbine. • To Find Efficiency and Performance Characteristics Curve of Kaplan Turbine. • To Find the Performance Characteristics of A Centrifugal Pump and To Find Its Specific Speed and Efficiency. • To Find the Performance Characteristics of A Reciprocating Pump and to Find the Slip. • To Verify Momentum Equation Experimentally Through Impact of Jet Experiment. • To Determine the Efficiency of Hydraulic Ram. • Demonstration of Any Water Pumping Station/Plant Through Detailed Visit. • Demonstration of Working Model of Hydraulic Lift. • Demonstration of Working Model of Hydraulic Brake. • To Design the Impeller of Centrifugal Pump Using Single Arc Method Through Auto Cad. • To Design the Casing of Impeller Pump Through Auto Cad. • To Investigate the Performance of A Gear Pump and to Plot the Characteristics.	24

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: *On learning this subject student will be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Select a hydro turbine (Pelton wheel, Francis turbine, Kaplan turbine) or a pump on the basic of available head and discharge.	PO1, PO2/PSO1	Apply	Fundamental design principle	
2	Determine the force exerted by a jet of fluid on fixed and moving vanes	PO1, PO2/PSO1	Analyze	Fundamental design principle	
3	Calculate various parameters like work done, efficiency, working proportions, specific speed of various turbines.	PO1, PO2, PO3/PSO1	Understand	Fundamental design principle	
4	*Gain knowledge about the design methodologies of various components of hydro turbine and pumps.*	PO1, PO2, PO12/PSO	Create	Fundamental design principle	

		1			
5	Conduct experiments for a given purpose and to analyze experimental data and develop empirical equations.	PO1, PO2, PO12/PSO 1	Analyze	Criteria and specification	
6	Understand the working of hydraulic ram, hydraulic brake, torque converter and hydraulic lift.	PO1, PO2/PSO1	Understand	Fundamental design principle	

BMEC 0013 MANUFACTURING SCIENCE – II

Pre-requisite: *Manufacturing Science I*

Objective: *In this course students acquire the ability to formulate problems in Traditional and advanced metal cutting and evaluate the cutting parameters, establish a complete solution to metal cutting problems using mathematical or graphical techniques.*

Credits: 03 **L–T–P: 3–0–0**

Module No.	Content	Teaching Hours
I	**Machining:** Mechanics of Metal Cutting. Geometry of Tool and Nomenclature, ASA System, Mechanics of Chip Formation, Types of Chips. Merchant's Circle Analysis, Cutting Forces, Power Required, Tool Material, Tool Wear and Tool Life, Machinability, Economics of metal cutting. **Grinding:** Grinding Wheel, Abrasive & Bonds, Grinding Wheel Specifications, Grinding Wheel Wear, Attritions Wear & Fracture Wear, Dressing & Truing, Surface Grinding, Cylindrical Grinding & Center less Grinding **Machine Tools:** Working Principle, Constructions and Operations of Turret and Capstan Lathe, Tool Lay Out Turret and Capstan Lathe, Shaper, Planer, Slotter, Milling, Dividing Head and Indexing, Analysis of maximum chip thickness,	22
II	**Additive Manufacturing:** Introduction to Rapid Prototyping Technology (RPT), Rapid Manufacturing, Rapid Tooling Application and Advancement. Introduction of Solid Based (SB), Liquid Based (LB), Powder Based (PB) Rapid Prototyping. **Advanced Machining:** Working Principle & Applications of Laser Beam Machining (LBM), Electron Beam Machining (EBM), Electro chemical Machining (ECM), Electric Discharge Machining (EDM), abrasive Jet Machining (AJM), Ultrasonic Machining (USM) and Plasma Arc Machining (PAM) Introduction of Hybrid Machining. **Super-Finishing Process**: Honing, Lapping & Buffing, Magnetic Abrasive Finishing (MAF)	18

Text Book:

- P. C. Sharma, "*Manufacturing Technology (Manufacturing Processes)*", S. Chand Publication,2006
- Jain V.K., "*Advance Machining Process*", Prentice Hall, 2007.
- P Pandey, H Shan "Modern Machining Processes" McGraw Hill Education; New edition 2017
- Ghosh and Malik, "*Manufacturing science*", East West Pvt. Ltd, 2010.

Reference Books:

- Boothroyd, "Fundamental of Metal Cutting and Machine Tools", S. Chand, 2017.
- Jeffrey A. Hoffer "Modern Materials and Manufacturing Processes" Pearson Education 2007.
- Serope Kalpakjian, "Manufacturing Engineering and Technology (SI Edition)", 2018
- P. N. Rao, "Manufacturing Technology", Volume 2 | 4th E McGraw Hill Education; Forth edition, 2018.

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: *After completion of course, the student will be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Understand and compare the functions and applications of metal cutting tools, cutting motions and concept of generatrix and directrix.	PO1, PO4/PSO3	U	F, C	6
2	Analyze the cutting forces, shear force and friction force in machining at different feeds, velocities and depth ofcut and able to construct Merchant's circle diagram.	PO1, PO2, PO3/PSO3	An	F, PC	8
3	Understand chip formation mechanism and determination of cutting ratio and shear angle and application of coolant and lubricant in machining.	PO1, PO3/PSO3	U	C, PC	7
4	Understand the working principle of shaping machine, milling machine, Capstan lathe, Turret latheand slotter machine	PO1, PO5/PSO2, PSO3	U	F, C&S	8
5	Apply the different metal removing, finishing and super finishing techniques for component production, understand the concept of rapid prototyping and rapid tooling	PO1/PSO3	A	P, FDP	5
6	Understand the basic concepts and application of nontraditional machining processes for micro machining	PO1/PSO3	U	FDP, C	9

BMEC 0809: MANUFACTURING SCIENCE - II LAB

Objective: *The purpose of this lab is to enable the students to have the practical skills manufacturing operations and design Jig and Fixtures, Cutting Tools, Measuring Tools, Press Tools for washer making, design of a circular form tool, design the gang milling arrangement of cutters , tooth profile & tolerances for arbor, cutter & key , twist drill to machine the holes The student will also have practical exposure to analysis the cutting force components of a tool point with design of various tool angles and machining variables.*

Credits: 01 **L–T–P: 0–0–2**

Module No.	Content	Teaching Hours
	• Design A Process Sheet Showing Machine Tool, Tool Layout, Operation Elements, Jig & Fixtures Used, Cutting Tool, Measuring Tool, Cutting Conditions for the Given Components as Shown in the Figure. • To Design A Layout of Foundry Shop to Produce/Manufacture Given Components. • Design A Drilling Jig for Drilling Four Holes on the Component as Shown in the Figure. • Design a Suitable Milling Fixture for the Component Shown in the Figure. • Design an Indexing Jig/Fixture for the Component Shown in the Figure. • Design & Draw A Press Tool to Produce the Component Shown in theFigure. • Design & Draw A Press Tool Set to Produce A Washer at Each Stroke of the Press. The Washer is Made of Mild Steel 2 Mm Thick and 20 Mm is Outside Diameter, Hole 8 Mm in Diameter. Assume Suitable Value of Shear Strengthof Material. • Design A Twist Drill to Machine A Hole in Cast Iron Gear Housing. The Hole is 20 Mm in Diameter by 20 mm Deep and is A through Hole and the Machine Tool is A Vertical Drill Press. • Design the Gang Milling Arrangement of Cutters That You Would Provide forMachining of Faces Mark in Figure material of the Component is the Cast Iron. Clearly Dimension Tooth Profile & Tolerances for Arbor, Cutter &Key. • Design A Circular Form Tool for the Component Shown in the Figure. Assume Suitable Data Wherever Necessary & Also Find the Tooth Profile. • The Cutting Force Components of a Tool Point While Machining on Mild Steel with a 10^0 Back Rake Angle High Speed Steel Tool is 105 Kg. If Feed is 0.06 Mm/Rev., Depth of Cut 2.2 Mm, Design a Suitable Cross Section of the Tool, Assuming the Shear Strength of the Tool Material to Be 20 Kg. /Mm^2 and A Factor of Safety is Approximately 2.5. The Young Module of the Tool Material is $20x10^3$ Kg. /Mm^2. If the Maximum Permissible Deflection is 0.04Mm, Find the Extent by Which the Tool Can Be Projected Out of the Tool Post. Recommend Suitable Values of Tool Angles. Give A Neat Sketch of the Designed Tool.	

Text Book:

- P. C. Sharma, “Manufacturing Technology (Manufacturing Processes)”, S. Chand Publication, 2006
- P Pandey, H Shan “Modern Machining Processes” McGraw Hill Education; New edition 2017

- Ghosh and Malik, "Manufacturing science", East West Pvt. Ltd, 2010.

Reference Books:

- Boothroyd, "Fundamental of Metal Cutting and Machine Tools", S. Chand, 2017.
- Serope Kalpak Jian, "Manufacturing Engineering and Technology (SI Edition)", 2018
- P. N. Rao, "Manufacturing Technology", Volume 2 | 4th E McGraw Hill Education; Forth edition, 2018.
- Rajender Singh, "Introduction to Basic Manufacturing Process & Workshop Technology", New Age International; Second edition, 2010.

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: *After completion of course, the student will be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Understand of design of various machine tools, cutting tools & measuring tool layout. And consideration ofmachining variables at different cutting conditions.	PO1/ PSO3	U	F	4
2	Demonstrate practical skills in the designing of press tool along with die assembly and the operations performed on them.	PO1/PSO3	A	FDP	4
3	Calculate and optimize the cutting forces components of a tool point by cutting tool dynamometer.	PO1/ PSO3	U	C	4
4	Plan and produce job on shaping machine, job on milling machine, job on planer and slotter machine	PO1/PSO3	R	FDP	6
5	Develop a machining program and processing of electric discharge machining.	PO1/PSO3	An	PC	4

BMEC 0014: MODERN VEHICLE TECHNOLOGY (B. TECH. (AUTOMOBILE ENGG.))

Objective: *The course content should be taught and curriculum should be implemented with the aim to develop different types of skills leading to the achievement of the following competency: Improve efficiency, security, safety & performance of automobile using electronics andtechnology.*

Credits: 04 **Semester III** **L–T–P: 3–1–0**

Module No.	Content	Teaching Hours
I	**Applications of Transducers & Sensors:** Concept of general measurement system& difference between Mechanical and electrical/ electronic instruments; Measurement of Temperature: Working of Thermocouple and Thermister; Measurement of Speed: Contact less electrical tachometer, Inductive, Capacitive type tachometer, Stroboscope; Measurement of Force: Strain gauge load cell; Basic requirement of Sensors, Functions, Applications and Circuitry arrangement of various Sensors such as Mass Air flow rate sensor, Exhaust gas Oxygen concentration, Throttle plate angular position, Crankshaft angular position, Coolanttemperature, Intake air temperature, Manifold absolute pressure (MAP), Vehicle speed Sensor, Rain Sensor & Rain sensing wiper. **Advance Ignition system:** Electrical & electronics ignition system. Modern SparkIgnition system (e.g. D.T.S.I , T.D.S.I., Multi electrode etc. System) Insulated coils. Concept of Non-battery Energy Storage: Ultra capacitors and Flywheels. **Advancement in Engine and related components:** Introduction & types of hybridvehicle. Hybrid drives systems. Compressed air car. Solar Cars. Hydrogen operated Engine. Basic concepts of Blue Motion Technologies like DSG, TSI, TDI, GDI variablevalve timing system.	28
II	**Modernization in Peripheral systems:** Security Systems. Remote keyless entry, Anti-theft system, Alarm system. Entertainment and peripheral systems. Integrated communications, Proximity sensors, Global positioning satellites (GPS). **Advance Safety Equipments:** Seat Belts, Seat Belts pre-tensioners, Smart seatbelt Reminder, Concepts of Crash test, Crash sensors. Air bags Introduction of air bags,Duel stage air bags, Side Airbags. Tire pressure monitoring system Pedestrian Protection & Night vision with pedestrian detection. **Modern Features in Automobile:** Power Sliding doors. Electronic stability / Skid- control system, Traction control system. Telescopic steering wheel / adjustable pedals. Rear mounted Radar & Cameras. Electromagnetic suspension and levitation.Automatic Lift Axle. Regenerative Braking Systems. Continuous Variable Transmission. Intelligent Parking Assist System, Self Parking.	21

Text Books:

- Tom Denton, 'Automobile Electrical and electronic systems', Arnold ISBN-0750662190, third edition,2004.
- Thareja BL, 'Fundamentals of Electrical and Electronics Engineering', Nirja Construction &Development Co Ltd, New Delhi, 1984.
- P L Kohli , 'Automotive Electrical Equipments', Tata Mc- Graw Hill, New Delhi, 1983.
- A. K. Sawhney and Puneet Sawhney, 'A Course in Electrical and Electronic Measurements'

Reference Books:

- John Turner, 'Automotive Sensors', Momentum press, LLC NEW YORK ISBN-

9781606500095, ISBN-1606500090, 2009.
- Barbara J. Peters, George A. Peters, 'Automotive Vehicle Safety', SAE International and Taylor & Francis ISBN - 978-0-7680-1096-1, London, 2002.
- J. Marek, H.-P. Trah Sensors, 'Automotive Technology', Y.Suzuki, I. Yokomor / ISBN – 3527295534Wiley-vch , weinheim, 2003.
- Jeff Daniels, 'Modern Car Technology', J Haynes & Co. Ltd., 2009

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

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

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Describe construction, functions and applications of various sensors and actuators used in modern vehicle	PO1, PO3, PO6, PO12/ PSO1	U & Ap	F	8
2	Explain modern Ignition systems of S.I. and C.I. Engines.	PO1, PO3, PO4, PO6, PO10/ PSO1	U	C	7
3	Describe latest advancement in Engine technology.	PO2, PO3, PO4, PO6/ PSO1	R&U	C	8
4	Identify and describe various advanced peripheral system used in automobile.	PO2, PO3, PO4, PO6/ PSO1	R&U	P	8
5	Demonstrate various safety features and equipment used in modern vehicle.	PO3, PO6, PO9/ PSO1	Ap	C&S	10
6	Describe various modern features like EBD, ABS, Regenerative Braking System etc for better functioning ofvehicle	PO1, PO3, PO6, PO9/ PSO1	U	C	8

BMEC 0015 ADVANCE MATERIAL SCIENCE

Objective: *Materials Science is focused on the fundamentals of biomaterials, nanomaterials, ceramics, metals, polymers, electronic materials and composites, smart materials, green and sustainable materials emphasizing the relationships between atomic structure and microstructure as well as the properties, processing and performance of the material in a cohesive and self-contained way within the course.*

Credits: 03 **L–T–P: 3–0–0**

Module No.	Content	Teaching Hours
I	**Crystallography and Imperfections:** Concept of Unit Cell Space Lattice, Bravais-Lattices, Atomic Packing Factor and Density calculations, Miller indices, Imperfections, Dislocations Theory, Diffusion in solids, Mechanical properties, elastic and visco-elastic properties **Fatigue**: Stress cycles, Factors affecting fatigue, crack propagation, **Creep:** Creep curve, stages in creep curve Stress relaxation, Ductile and Brittle fracture, Griffith theory, Season cracking **Strengthening Mechanism:** Concept of Grain and Grain Boundary, Hall-Petch strengthening, Solid solution strengthening, precipitation strengthening, dispersion strengthening. **Equilibrium Diagrams:** Types of Equilibrium-Diagrams: Solid-Solution Type, Eutectic Type and Combination Type. Iron-Carbon Equilibrium-Diagram and Its Importance.	21
II	**Heat Treatment:** Various Types of Heat Treatment Such As Annealing, Normalizing, Quenching, Tempering and Case Hardening. Time Temperature Transformation (TTT) Diagrams. **Corrosion Science:** Definition and importance, Electrochemical reactions, Polarization, Passivity, Environmental effects, Eight forms of corrosion, Cathodic protection, Coatings and inhibitors. High temperature materials and Materials for cryogenic application Concept of Magnetism and Magnetic materials, Superconductors and its types and phenomenon of Superconductivity, Metallic foams, Ceramics, Polymers, Composites, Carbon fibre, Graphene, Nano Materials, Smart Materials.	23

Text Books:

- Gupta K.M., "Materials Science", Umesh Publication.
- Raghvan V., "Material Science", Prentice Hall.
- Narula, "Material Science", TMH.
- Fontana, M.G., "Corrosion Engineering", Tata McGraw-Hill.

Reference Books:

- Callister W.D., JR, "Material Science & Engineering", Addition-Wesley Publication.
- Vlack Van, "Elements of Material Science & Engineering", John Wiley & Sons.
- Avner "Introduction to Physical Metallurgy" TMH Pub

Focus: This course focuses on Employability/Skill development and aligned with CO's 1 and 2

Outcome: After completion of course, the student will be able to:

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Understand the limits of materials and the change of their properties with use.	PO2, PO4/PSO3	U	F	10
2	Create a new material that will have some desirable properties.	PO2, PO3/PSO3	C	F, C, P	11
3	Create advanced composite materials for space and missile application.	PO2, PO3/PSO3	C	F, C, P	12
4	Design of engineering materials that must simultaneously fulfill dimensional, property, qualitycontrol aspects.	PO2, PO3/PSO3	C	F, C, P	11

BMEE 0001 REFRIGERATION AND AIR CONDITIONING

Pre-requisite: *Applied Thermodynamics*
Objective: *To study the working of different Refrigerating and Air Conditioning System & Analysis of their performance parameters.*

Credits: 03 **L–T–P: 3–0–0**

Module No.	Content	Teaching Hours
I	**Refrigeration:** Introduction to Refrigeration & Methods of Refrigeration, Carnot Refrigeration Cycle and Its Limitations, C.O.P. **Refrigerants:** Classification of Refrigerants, Nomenclature, Desirable Properties of Refrigerants, Secondary Refrigerants and CFC Free Refrigerants. Green House Effect. **Air Refrigeration Cycle:** Open and Closed Air Refrigeration Cycles, Reversed Carnot Cycle, Bell Coleman or Reversed Joule Air Refrigeration Cycle, Aircraft Refrigeration System, Classification of Aircraft Refrigeration System. Boot Strap Refrigeration, Regenerative, Reduced Ambient, Dry Air Rated Temperature (DART). Refrigerant Compressors; Classification, workdone, thermodynamic process, volumetric efficiency, principal dimensions of reciprocating compressors, performance characteristics, **Vapour Compression System:** Single Stage System, Analysis of Vapour Compression Cycle, Effect of Pressure, Sub Cooling & Superheating on C.O.P of the Cycle. Actual Vapour Compression Refrigeration Cycle.	22
II	**Multistage Vapour Compression System**: Removal of Flash Gas, Intercooling,Different Multistage System, Cascade System. **Vapour Absorption System:** Working Principle of Vapour Absorption Refrigeration System, Ammonia – Water Vapour Absorption System, **Air Conditioning:** Introduction to Air Conditioning, Psychometric Propertiesand Their Definitions, Different Psychometric Processes, Thermal Analysis of Human Body, Effective Temperature and Comfort Chart, Cooling and Heating Load Calculations. Infiltration & Ventilation, Internal Heat Gain, Sensible Heat Factor (SHF), by Pass Factor, Grand Sensible Heat Factor (GSHF), Apparatus Dew Point (ADP). Elementary Knowledge of Transmission and Distribution of Air Through Ducts.**Refrigeration Equipment & Application:** Air Washers, Food Preservation, Cold Storage, Refrigerator, Ice Plant, Water Coolers, Centralized A.C.	21

Text Books:

- Prasad Manohar, "*Refrigeration and Air conditioning*", New Age International (P) Ltd. Pub.
- C.P. Arora, "*Refrigeration and Air conditioning*", TMH.
- Arora and Domkundwar, "*Refrigeration and Air conditioning*", Dhanpat Rai & Co.

Reference Books:

- Stoecker and Jones, "*Refrigeration and Air conditioning*", TMH.
- Roy J. Dossat, "*Refrigeration and Air conditioning*", Prentice Hall India.
- P.L. Baloney, "*Refrigeration and Air conditioning*", SNTI, Publications.

- Kuhen, Ramsey & Thelked, "*Thermal Environment Engg*", Central Book Agency.

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: *At the end of the course a student will be able to:*

CO1: illustrate the fundamental principles of refrigeration and air conditioning systems.
CO2: understand different properties, designation and environmental issues of refrigerants
CO3: understand the working of vapour compression and vapour absorption refrigeration systems.
CO4: determine the cooling capacity and COP of refrigeration system.
CO5: analyze the performance of psychometric processes used for human comfort.
CO6: determine the cooling load/heating load for a given air conditioning application
CO7: understand the working of Ice plant and cold storage, air washer.

Mapping of Course Outcomes (COs) with Program outcomes (POs) and Program Specific Outcomes(PSOs):

COs	POs/PSOs
CO1	PO1, PO10 / PSO1
CO2	PO1, PO7, PO12/ PSO1
CO3	PO1, PO10/ PSO1
CO4	PO1, PO4, PO10/PSO1
CO5	PO1, PO4, PO6, PO10/ PSO1
CO6	PO1, PO4, PO10/PSO1
CO7	PO1, PO10, PO12/ PSO1

BMEE 0170 REFRIGERATION AND AIR-CONDITIONING LAB

Objective: *To make students familiar with the various devices associated with Refrigeration & Air -Conditioning. The experiments are designed to provide exposure of practical aspects of the various theoretical concepts developed during the refrigeration and air conditioning course.*

Credits: 01 **L–T–P: 0–0–2**

Module No.	Content	Teaching Hours
	List of Experiments: • To Study Basic Components of Air-Conditioning System. • Experiment on Refrigeration Test Rig and Calculation of Various Performance Parameters. • To Study Different Types of Expansion Devices Used in Refrigeration System. • To Study Different Types of Evaporators Used in Refrigeration Systems. • Experiment on Air-Conditioning Test Rig & Calculation of Various Performance Parameters. • To Study Air Washers. • Study of Window Type Air Conditioner. • Visit of a Central Air Conditioning Plant and Its Detailed Study. • Visit of Cold-Storage and Its Detailed Study. • Experiment on Ice-Plant to Find Out the Capacity of Plant. • Experiment on Two Stage Reciprocating Compressor for Determination of Volumetric Efficiency, PV Diagram. • Study of Compressors - Hermetically Sealed. • Experiment on Desert Coolers. • Study of Central Air-Conditioning Systems	

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

CO	CO Statement	PO/PSO	CL	KC	Duration
1					
2					
3					
4					
5					
6					
7					

Outcome: *On completion of the lab students will be able to*

CO1: illustrate the fundamental working principles of vapour compression refrigeration system.
CO2: recognize the components (expansion devices, evaporators, condensers, compressors) and understand their use in refrigeration system.
CO3: illustrate the working of vapour compression and vapour absorption refrigeration systems.

CO4: analyze the performance parameters of vapour compression and vapour absorption refrigeration systems.
CO5: analyze the performance of psychometric processes used in air conditioning.
CO6: develop prototype model of refrigeration system used in Ice plants, air washer.
CO7: determine the capacity of window and split air conditioning system.

Mapping of Course Outcomes (COs) with Program outcomes (POs) and Program Specific Outcomes(PSOs):

COs	POs/PSOs
CO1	PO1, PO10 / PSO1
CO2	PO1, PO10, PO12 / PSO1
CO3	PO1, PO10/ PSO1
CO4	PO1, PO4/PSO1
CO5	PO1, PO4, PO6, PO9, PO8, PO10/PSO1
CO6	PO1, PO4, PO10, PO12/PSO1
CO7	PO1

BMEE 0002 INTERNAL COMBUSTION ENGINE

Pre-requisite: *Applied Thermodynamics*

Objective: *The objective of this course is to give an introduction of internal combustion engines with emphasis on their engineering applications. The focus is on explaining engine performance in terms of power, energy utilization and exhaust emissions, its relation to internal processes like combustion and varying engine operatingconditions.*

Credits: 03 **L–T–P: 3–0–0**

Module No.	Content	Teaching Hours
I	**Introduction to I.C. Engines**: Engine classification and basic terminology, Two and four stroke engines, SI and CI engines, Valve timing diagram, Engine performance parameter. Thermodynamic analysis of Air standard cycles, Otto cycle, Diesel cycle, Dual cycle, Comparison of Otto, Diesel and Dual cycles. Introduction to Fuel air cycle & Actual cycle, factors affecting the fuel air cycle & Actual cycle. **SI Engines:** Combustion in SI engine, Stage of Combustion, Flame speed, Ignition delay, Abnormal combustion and its control, combustion chamber design for SI engines, Carburetor, Carburetion, Mixture requirements, Carburetors and fuel injection system in SI Engine, Ignition system requirements, Magneto and battery ignition systems.	23
II	**CI Engine:** Combustion in CI Engines, Ignition Delay, Knock, Abnormal Combustion, Combustion chamber design of CI engines, Fuel Injection System of CI Engines and Their Components, Injection Timings. **Fuels:** Fuels for SI and CI engine , Important qualities of SI and CI engine fuels, Rating of SI engine and CI engine fuels, Gaseous fuels, LPG, CNG, Biogas, Alternative fuels for IC engines, Norms like Euro and Bharat Norms. **Supercharger & Turbocharger***:* Introduction to supercharger and turbocharger, Types of Supercharging Methods, Calculation of Supercharger. Basic Concepts of Advanced Engines.	22

Text Books:

- Mathur& Sharma, "A Course in International Combustion Engines", Dhanpat Rai& Sons.
- R. Yadav, "I.C Engine", Central Publishing House, Allahabad.
- Ganeshan, "I.C Engine", Tata McGraw Hill Publishers.

Reference Books:

- Gill, Smith &Ziurs, "*Fundamentals of Internal Combustion Engine*", Oxford & IBH Publishing Co.
- Rogowsky, "*IC Engines*", International Book Co.
- E.F Obert, "*I.C Engine Analysis & Practice*", S. Chand.
- Engineering Fundamentals of Internal Combustion Engines by W.W. Pulkrabek, Pearson Education.

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: *After completion of course, the student will be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Recognize and understand the reasons for differences among operating characteristics of different engine types and designs.	PO2, PO4/PSO3	U	C	

2	Analysis of different power cycle of internal combustion engines using ideal gas cycles, air cycles, and fuel-air cycles.	PO2, PO3/PSO3	AN	C	
3	Characteristic of homogeneous combustion in SI-engines and spray combustion in CI-engines. Fuel quality requirements of SI- and CI-engines.	PO2, PO3/PSO3	R	F	
4	Fuel economy trends with its history and norms.	PO2, PO3, PO4/PSO3	R	F	

BMEE 0003: AUTOMOBILE ENGINEERING

Pre-requisite: *Internal Combustion Engine*

Objective: *To make student aware of basic knowledge of automobile systems and sub systems. To make students aware of maintenance and overhauling of a vehicle. To show students how various system and sub- system in vehicle works together. To tell students about latest development in the field of automobile engineering.*

Credits: 03 **L–T–P: 3–0–0**

Module No.	Content	Teaching Hours
I	**Power and Transmission System:** Power and Torque Characteristics, Rolling Resistance, Air Resistance, Gradient Resistance, Tractive Effort on Power of Automobile, Concept of Gear Ratio, Gear Box and Their Types, Selector Mechanism of Gear Box. Requirements of Good Transmission Systems, Clutches and Their Types, Over Drive and Free Wheel, Torque Converters Differential Gear Mechanism, Automatic Transmission and Its Components, Propeller Shaft, Slip Joints, Universal Coupling, Final Drive and their Types, Advances in Transmissions. **Vehicle Handling and Control System:** Types of Steering Mechanism, Steering Geometry, Working of Electrical & Hydraulic Power Steering.	20
II	**Vehicle Handling and Control System:** Requirement of Braking System, Various Types of Braking System, Anti Locking Braking System, EBD (Electronic Breaking Force Distribution). Frame and Their Types, Load onFrame, Geometry of Suspension System, Dampers, Various Types of Suspension Springs Types of Front Axle Independent Suspension System. Advances in Vehicle Handling & Control System. ***Electrical System:*** Types of Ignition System Used in Automobiles and Their Working, Alternator, Battery, Starting Motor, Lighting System, Horn, Relays, Windscreen Wiper, Speedometer Etc. ***Cooling & Lubrication System:*** Requirements, Various Components, Types of Cooling and Lubrication Systems, Heating and Cooling Unit of Automobiles. Features, Technical Specifications, Advances in Automobile Engineering.	20

Text Books:

- Jain K.K. and Asthana.R.B, "Automobile Engineering" Tata McGraw Hill Publishers, New Delhi, 2002.
- Singh Kripal, "Automobile Engineering", Vol. 1 & Vol. 2, Standard Publisher New Delhi, 2007.
- K.M. Gupta, Automobile Engineering, Vol. 1 & Vol. 2, Umesh Publications. New Delhi, 2001.
- Nakra C P, Basic Automobile, Dhanpat Rai Publication Co. Ltd 7th Edition2005.

Reference Books:

- Josepe Heitner Automotive Mechanics – Principle and Practice, East West Press 2nd edition 1999
- Crouse W and Anglin D, Automotive Mechanics, Tata Mcgraw Hill Publication ltd 10th edition 2004

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

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

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Understand and explain the effects of Resistance forces on the power of an automobile	POs/PSOs			
2	Describe functioning of Transmission system, conventional and non-conventional drives, Clutches, Gear boxes, Synchromesh device, Propeller shaft, Differential axle, Overdrive, Free wheel.	PO1, PO2, PO3, PO4/ PSO1			
3	Understand the concept of firing order for multi-cylinder engines for igniting of fuels.	PO1, PO3, PO4, PO6, PO10/ PSO1			
4	Describe functioning of steering system, steering geometry wheel alignment and wheel angles for modernAutomobile.	PO2, PO3, PO4, PO6/ PSO1			
5	Demonstrate and explain various types of suspension system, braking system and new safety system for anautomobile like EBD, ABS.	PO1, PO2, PO3, PO4, PO6, PO12/ PSO1			
6	Understand the importance of electrical systems in Automobile and number of subsystems like startingsystem, Charging system, Alternators.	PO3, PO6, PO9/ PSO1			
7	Develop concept and define working of Automobile Engine cooling and lubrication system.	PO1, PO3, PO6/PSO1			

BMEE 0171: AUTOMOBILE ENGINEERING LAB

Objective: *The main objective of this lab is to make students aware of various systems like braking system, Steering system, suspension system and electrical system of a vehicle. This lab is also dedicated to engine testing and performance in which various parameters of engine are calculated. Working of some new and modern technology like automatic transmission and MPFI is also demonstrated to the students.*

Credits: 01 **L–T–P: 0–0–2**

Module No.	Content	Teaching Hours
	List of Experiments: • Performance Analysis of Four Stroke S.I. Engine- Determination of Indicated and Brake Thermal Efficiency, Specific Fuel Consumption At Different Loads, and Preparation of Energy Balance Sheet. • Determination of Indicated H.P. of I.C. Engine by Morse Test. • Performance Analysis of Four Stroke C.I. Engine- Determination of Indicated and Brake Thermal Efficiency, Specific Fuel Consumption At Different Loads, and Prepare Energy Balance Sheet. • To Study the Working Principle of Gear Boxes. • Trouble Shooting on Differential Gear Mechanism of Rear Axle. • Measurement of Steering Geometry Angles and Their Impact on Vehicle Performance.. • Trouble Shooting on Automobile Braking System. • Trouble Shooting on Ignition System of I.C. Engine. • Trouble Shooting on Fuel Supply System of S.I. Engines- Carburetor,Fuel Injection Pump and MPFI. • Trouble Shooting on Fuel Supply System of C.I. Engines- Injector &Fuel Pump. • Study of Air Conditioning System of an Automobile.	

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Course Outcome: *Students have studied about:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	*The student will be able to perform Brake Performance test analysis of Four Stroke S.I & C.IEngine and willbe able to diagnose the fault.*	POs/PSOs			
2	*The student will be able to understand the routine servicing, testing and trouble shooting,overhauling of aclutch and gear box assembly.*	PO2, PO3, PO4, PO6/ PSO1			
3	*The student will be able to understand trouble shooting on Fuel Supply System of S.I & C.IEngines.*	PO3, PO6, PO9/ PSO1			
4	*The student will be able to understand the functioning of Ignition System & Braking System of I.C.Engine.*	PO1, PO2, PO4, PO10/ PSO1			
5	*The student will be able to determine Indicated H.P. of I.C. Engine by Morse Test.*	PO1, PO2, PO3, PO4, PO6, PO12/ PSO1			
6	*The Student will be able to perform minor and major tuning of gasoline and diesel engines.*	PO2, PO3, PO6, PO9/ PSO1			

BMEE 0004 POWER PLANT ENGINEERING

Pre-requisite: *Applied Thermodynamics*
Objective: *To make student conversant with various components and operations of different power plantsand power plant economics.*

Credits: 03 **L–T–P: 3–0–0**

Module No.	Contents	Teaching Hours
I	**Introduction:** The Sources of Energy, Development of Power Generation in India, Ranking Cycle, Reheat. Regeneration. **Power Plant Economics and Environmental Considerations**: Costs of power generation, General Arrangement of Power Distribution, Load Curves, Load Duration Curve, Economic Scheduling, Definitions of Connected Load, Maximum Demand, Demand Factor, Average Load, Load Factor, Diversity Factor– Related Exercises. **Effluents from Power Plant:** Impact on Environment, Pollutants and Pollution Standards, Methods of Pollution Control. **Steam Power Plant**: Plant Layout, Working of Different Circuits, Types of coal, Coal Handling, Dust and Ash Handling Systems. **Combustion Process:** Coal Stokers, Pulverized Fuel Burning System and Its Components, Combustion Needs and Draught System, Cyclone Furnace. Feed water treatment, Plant Auxiliaries**.**	20
II	**Hydro Electric Power Plant**: Hydrological Cycle, Hydrographs,. Plant Classification, Typical Layouts, Plant Auxiliaries, Classification of Dams and Spill Ways, Plant Operation. **Nuclear Power Station**: Nuclear Fuels, Nuclear Reactors, Reactor Operation. Pressurized Water Reactor, Boiling Water Reactor, Sodium- Graphite Reactor, Fast Breeder Reactor, Homogeneous Reactor, Gas Cooled Reactor, Radiation Hazards and Shielding – Radioactive Waste Disposal. **Gas Turbine Plant**: Introduction, Classification, Construction – Layout with Auxiliaries, Principles of Working of Closed and Open Cycle Gas power plant. Combined Cycle Power Plants and Comparisons. **Power from Non-Conventional Sources**: Solar energy. Wind Energy based power plant- Principle of Working, MHD power Generation.	22

Text Books:

- P.K.Nag, "*Power Plant Engineering*": Tata McGraw- Hill Publishing Company, Ltd.
- P.C. Sharma "*Power Plant Engineering*", S.K. Kataria Pub.

Reference Books:

- M.M. El Wakil, "*Power Plant Technology*": Tata McGraw- Hill Publishing Company, Ltd.
- A.J. Wood and B.F. Wollenberg "Power Generation Operation and Control": Wiley.
- G.D. Rai, "Non-Conventional Energy Sources": Khanna Publishers.

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: *After the completion of course, Students will be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Describe the layout and components of thermal power plant.	PO1, PO10, PO12/ PSO1			
2	analyze the performance of thermal power plant based on the Rankin cycle.	PO1, PO2, PO4/ PSO1			
3	Describe the layout and component details of hydroelectric power plant.	PO1, PO10/ PSO1			
4	Describe the layout, component details of gas power plant and nuclear power plant.	PO1,PO6,PO7, PO10 /PSO1			
5	Analyze the performance of gas power plant based on the Brayton cycle.	PO1,PO2, PO4/ PSO1			
6	Understand the basic principles of economics of power generation and environmental hazards of power plants.	PO1,PO7, PO10 /PSO1			

BMEE 0005 GAS DYNAMICS

Pre-requisite: *Applied Thermodynamics*

Objective: *The main objective of the course is to provide an insight into the applications of compressible flow and to enable the students formulate and solve problems in one dimensional steady compressible flow including isentropic nozzle flow, constant area flow with friction or with heat transfer.*

Credits: 04 **L–T–P: 3–1–0**

Module No.	Content	Teaching Hours
I	**Basics of Fluid Mechanics**: Conservation laws for mass and Momentum, Velocity of sound, Bulk modulus of elasticity, Coefficient of Compressibility, Stagnation state, Critical state, Various regions of flow, Differences between Incompressible and Compressible flows, Reynolds number and its significance. **Fundamentals of compressible flow:** Objective and applications of compressible flow, Ideal gas relationship, The adiabatic energy equation, Physical significance of Crocco number and Mach number, Characteristic Mach number, Critical Mach number, Mach waves, Mach cone and Mach angle, static and stagnation states, relationship between stagnation temperature, pressure,density and enthalpy in terms of Mach number, stagnation velocity of sound, reference speeds, various regions of flow, Effect of Mach number on compressibility, Area velocity relationship. **Isentropic flow through a variable area duct**: General features of isentropic flow, performance curve, Comparison of adiabatic and isentropic process, One dimensional isentropic flow in ducts of varying cross-section- nozzles and diffusers, operation of nozzles under varying pressure ratio, Mach number variation, Area ratio as a function of mach number, Impulse function, Mass flowrate through nozzles and diffusers, Phenomenon of choking, subsonic and supersonic designs.	22
II	**Flow through constant area ducts with friction:** Objective, outcome and assumptions of Fanno flow, Fanno curves, Equation and its solution, Variation of flow properties with duct length. Isothermal flow with friction, Variation offlow properties. Tables and charts for Fanno flow. Applications of Fanno flow. **Flow through constant area ducts with heat transfer**: Rayleigh flow, Rayleigh flow equation, Rayleigh line, Variation of flow properties, Maximumheat transfer. Basic formulation of non Isothermal flow with heat transfer and friction. **Normal Shock Gas Dynamics:** Development of shock wave, governing equations, Prandtl–Meyer relation, Rankine Hugoniot relation, Impossibility of rarefaction shock, Mach number downstream of shock, Property variation across shock, Strength of shock wave, entropy change, supersonic diffuser. Normal shocks in Fanno and Rayligh flow. Introduction to oblique shock flow.	21

Text Books:

- Fundamental of Compressible flow, S. M. Yahya, New age international Publication, Delhi
- Fundamentals of compressible fluid dynamics- P. Balachandran, PHI Learning, New Delhi
- Gas Dynamics, E. Rathakrishnan, PHI Learning Pvt. Ltd

Reference Books:

- The dynamics and thermodynamics of Compressible fluid low Volume-I, Ascher H. Shapiro, the Ronald Press Company, New York.
- Gas Dynamics and Jet Propulsion- P. Murugaperumal, Scitech Publication, Chennai.

- Modern Compressible Flow: With Historical Perspective, John D. Anderson, McGraw-Hill HigherEducation

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: *After completion of course, the student will be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Concepts and results for the compressible flow of gases and introduction to the numerical method of characteristics.	PO2, PO4/PSO3	U, An	F, Pc, D	11
2	Conservation laws, propagation of disturbances, isentropic flow, compressible flow in ductswith area changes, normal and oblique shock waves and applications.	PO2, PO3/PSO3	U, Ap	Pc, D	8
3	Prandtl-Meyer flow, Fanno flow and Rayleigh flow with applications to nozzles and one dimensional unsteady isentropic flow	PO2, PO3/PSO3	U, E, An, Ap,	Pc, D, C	12
4	Physical understanding of the phenomena and basic analytical results.	PO2, PO4/PSO3	U, An, E	F, Pc, C	12

BMEE 0006 GAS TURBINE AND JET PROPULSION

Pre-requisite: *Applied Thermodynamics*

Objective: *Students will be able to understand propulsion systems in aircraft that are essential to graduate engineers who are intended to work in aircraft system/component manufacturing/maintenance environments. Students should be able to describe the key aeronautical engineering features in the context of which the relevant industry operates.*

Credits: 04 **L–T–P: 3–1–0**

Module No.	Content	Teaching Hours
I	**Introduction to Gas Turbine:** Simple gas turbine and review of Brayton cycle. **Cycle Arrangements:** Open cycle arrangement, closed cycle arrangement. Basic requirements of working medium and its properties. **Ideal cycles and their analysis:** Simple gas turbine cycle, heat exchange cycle, reheat cycle, intercooled cycle, combinations of various cycles, comparison of various cycle. **Impulse turbine and reaction turbines:** Introduction to impulse turbine and reaction turbines, Multistage machine, compounding of turbines.	22
II	**Elementary turbine design:** Velocity triangle of single stage turbine, Expression for work output, blade loading and flow coefficients, blade and stage efficiencies, Blade to gas speed ratio, losses and efficiencies. **Aircraft Propulsion:** Introduction, types of aircraft engines and their analysis (gas turbine engines, turbojet engines, turbofan engines, turboprop engines) **Aircraft propulsion theory:** Thrust, thrust power, propulsive efficiency, ram efficiency, thermal efficiency and overall efficiency.	23

Text Books:

- Cohen and Rogers, "Gas Turbine Theory", Dorling Kindersley (India) Pvt. Ltd., Noida.
- V.Ganesan, "Gas Turbines", Tata McGraw Hills, New Delhi.
- S.M.Yahya, "Turbines, Compressors and fans", McGraw Hills, New Delhi.

Reference Books:

- Jack D. Mattingly, "Elements of Gas Turbine Propulsion", Tata McGraw Hills, New Delhi.
- Mathur and Sharma, "Gas Turbine and Jet & Rocket Propulsion", Standard publishers, Delhi.
- Ahmed and Sayed, "Aircraft propulsion and Gas Turbine Engines", CRC press, Taylor and Francis.

Focus: This course focuses on Employability/Skill development and aligned with CO's 1 and 2

Outcome: After completion of course, the student will be able to:

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Outline governing equations of compressible fluid flow	PO2, PO4/PSO3	U, E	F,	7
2	Analyze one dimensional compressible flow through variable	PO2,PO3/PSO3	An	D, PC	8

	area duct				
3	Analyze compressible flow having normal shock	PO2,PO4/PSO3	An	D, C	8
4	Apply governing equations to compressible flow through constant area duct with friction	PO2,PO4/PSO3	Ap	PC, D	7
5	Apply governing equations to compressible flow through constant area duct with heat transfer.	PO2,PO3/PSO3	Ap	PC, D	7
6	Interpret propulsive systems for their working and application.	PO3,PO4/PSO3	U, An	PC, D	8

BMEE 0007 ADVANCED HEAT TRANSFER

Pre-requisite: *Heat & Mass Transfer*
Objective: *To develop the understanding of students to solve the real life applications by applying the laws of heat transfer. Analysis of heat transfer mechanisms in combined modes ofheat transfer.*

Credits: 04 **L–T–P: 3–1–0**

Module No.	Content	Teaching Hours
I	Transient Heat Conduction, Convection, Numerical Solution of Conduction problems and Mass Transfer, Finite difference equations method of energy balance, finite difference formulationof unidirectional for Cartesian cylindrical coordinate of various kind of boundary conditions, heat conduction problems, numerical methods of solutions, numerical solution of transient heat diffusion problems. Empirical correlations of Free and forced heattransfer. Heat exchanger heat transfer problems. Thermal boundary layer thickness.	22
II	Convective mass transfer equations and their applications. Boundary layer mass transfer empirical correlations for convective mass transfer. Heat Transfer by Radiation, Boiling and Condensation, nucleate pool boiling and empirical correlations for pool boiling heat transfer, factors affecting pool boiling film coefficients, high heat flux boiling. Laminar film condensation on a vertical plate, turbulent film condensation, drops wise condensation.	23

Text Books:

- J.P. Holman "Heat Transfer" Mac-Graw Hills publication, 2017
- Yadav R., "Heat Transfer", Central Publishing House, Allahabad, 2018

Reference Books:

- Bayazitouglu & Ozisik, "Elements of Heat transfer", T.M.H., 2015
- Pitts & Sisson, "Schaum's outline of Heat Transfer", McGraw-Hill International edition,2018
- Frank Kreith, "Principles of Heat Transfer", McGraw-Hill Book co., 2019

Focus: This course focuses on Employability/Skill development and aligned with CO's 1 and 2

Course Outcomes: After completion of course, the students will be able to:

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Determine the heat transfer through composite wall of a Furnace under given boundaryconditions	PO1, PO2/PSO1	Evaluate	C	6
2	Determine the numerical heat transfer of composite system under steady state condition of heat transfer	PO1, PO3/PSO1, PSO2	Evaluate	C	6
3	Determine the numerical heat transfer of composite system under un-steady state condition of heattransfer	PO1, PO2/PSO1	Evaluate	C	6
4	Establish empirical relation for a given heat transfer application	PO1, PO2, PO3/PSO1	Remember	P	6
5	Understand mass diffusion rate in case of evaporative cooling in cooling towers	PO1, PO2/PSO1, PSO2	Understand	C	8

6	Understand the effects of fouling in boiler tubes of thermal power plant	PO1, PO2/PSO1, PSO2	Understand	C	8

BMEE 0008 SOLAR ENERGY

Objective: *Solar energy is ultimate energy resource available on planet earth. Objective of this course is to make students aware about many facets of solar energy. How solar energy can be harnessed for various applications. Ultimate objective of this course is to train students about integration of solar energy devices in buildings, agricultural and other mechanized means.*

Credit: 03 **L- T –P-J: 3-0- 0-0**

Module No.	Content	Teaching Hours
I	**Introduction:** general introduction to renewable energy technology, Solar energy potential in India, energy demands and renewable energy. current and future scenario. **Solar radiation**: Direct and diffused radiation, Radiation measuringequipment. Basics of solar angles. **Solar collectors**: basic working of collectors, FPSC, PTC, Solar concentrators, , tracking mechanism, Solar energy storage systems designs and performance analysis based on standard norms. **Applications** in water heating systems, steam generating with solar energy. Phase changing materials for energy storage	20
II	Solar air heating systems, Space heating and cooling processes PV Systems, hybrid PV/T systems. Renewable energy desalination systems. Energy conversion systems based on bio-mass, Photosynthesisbasic concept and working of fuel cell. Active & Passive building applications. Economics (IRR, LCOE, ROI)Design, modeling and simulation of solar energy systems.	22

Text Books:

- S.P Sukhatme and J.K Nayak. "Solar energy, principle of thermal collection and storage"
- S. Kalogirou "Solar energy engineering: processes and systems." ISBN 978-0-374501-9

Reference Books:

- Yogi Goswami "Principle of Solar engineering", CRC Press, Third edition.
- J.A Duffie & W.A Beckman "Solar engineering & thermal processes" John Wiley &Sons, 4ed.
- G.N Tiwari "Solar energy: Fundamental, design, Modeling and Applications" ISBN-10: 0849324092
- C.P. Arora "Refrigeration and air conditioning" Tata Mcgraw- Hill Publishing Company,2nd Ed.

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcomes: *After completion of course, the students will be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Understand working of solar radiation measuring equipments	1,2/1	U,R	F	4
2	Determine magnitude of incident radiation	4/1	U,A	F,C	4
3	Understand working of solar collector systems.	1/1	U	C	4
4	Apply knowledge to design improved solar energy based systems	3,5/1,2	A,E	C,P	6
5	Analyze processes of space heating and cooling systems.	3,7,9/1,3	An	C,P	6
6	Can perform modeling and simulation for performance analysis to optimize the system efficiency	3,4,5/1,3	AN,C	C,P,M	8

BMEE 0172 SOLAR ENERGY LAB

Objective: *To develop the capability of students to understand solar energy harvesting systemsand to apply acquired knowledge to fulfill the social needs.*

Credits: 01 **L–T–P-J: 0–0–2-0**

Exp. No	Experiment objective	Hours
1	To determine thermal efficiency of FPSC in indoor condition	2
2	To determine thermal efficiency of FPSC in natural mode	2
3	To determine thermal efficiency of single axis parabolic trough collector	2
4	To determine thermal efficiency of PTC (double axis)	2
5	Determine thermal efficiency of solar air heating system	2
6	To determine charging and discharging efficiency of energy storage system.	2
7	To determine overall heat transfer coefficient of energy storage system.	2
8	To determine overall heat transfer coefficient of FPSC.	2
9	To study solar tracking system in parabolic trough collector	2
10	To analyze the thermal performance of heat pipe use in solar collector system.	2
11	To study working of PV/T system for solar energy absorption	2
12	To study working of thermal imaging camera and its application	2

Text/Reference books:

- "Renewable energy power for sustainable future", oxford university press.
- S.P. Sukhatme and J.K Nayak "Solar energy, principle of thermal collection and storage"
- S. Kalogirou "Solar energy engineering: processes and systems" ISBN 978-0-374501-9

Focus: This course focuses on Employability/Skill development and aligned with CO's 1 and 2

Outcomes: After completion of course, the students will be able to:

CO	CO Statement	PO/PSO	CL	KC	Duration
1	To understand working of solar radiation measuring equipments	1/1	U,R	F/C	2
2	Determine magnitude of incident radiation	2/1	R,A	F,C	2
3	Analyze performance of various solar collector systems	4,5/1	A,E	C,P	6
4	Apply their knowledge to design improved solar energy based systems	3/1	U,AN	C,P	8
5	Design and analyses working of space heating and cooling systems	3/1	U,AN,C	C,P,M	8

BMEE 0186 PROJECT BASED SOLAR ENERGY LAB

Objective: *To train and guide students for modeling, design and fabrication of projects basedon solar energy harvesting and applications in rural and industrial sector.*

Credits: 02 **L–T–P-J: 0–0–0-8**

Exp. No	List of Experiment	Hours
1	Role of nano fluid as a heat transfer fluid in thermal energy storage using phase changematerials. (Like MWCNT)	2
2	Experimental investigation on thermal performance of heat pipe.	2
3	Experimental photovoltaic thermal training system domestic type.	2
4	Thermal energy storage via parabolic trough collector in high melting pointtemp. PCM. (like fatty acids)	2
5	Design and fabrication of flat plate solar collector and investigate the overall efficiency.	2
6	Design and fabrication of parabolic trough collector and investigate the overall efficiency.	2
7	Design and fabrication of solar air heater and analysis on efficiency.	2
8	Determine the performance of parabolic trough collector with fixed parameters and properinsulation of storage tank.	2
9	Design and fabrication of solar dryer and investigate efficiency.	2
10	Design and analysis of PV/T Solar air space heating system.	2

Text/Reference books:

- "Renewable energy power for sustainable future", oxford university press.
- S.P Sukhatme and J.K Nayak "Solar energy, principle of thermal collection and storage"
- S. Kalogirou "Solar energy engineering: processes and systems" ISBN 978-0-374501-9

Focus: This course focuses on Employability/Skill development and aligned with CO's 1 and 2

Outcomes: After completion of course, the students will be able to:

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Apply acquired knowledge in design of basic solar energy apparatus	1/1	U,A	C, P	3
2	Apply knowledge of basic sciences, heat and mass transfer, thermodynamics inanalysis of solar apparatus	2/1	U,A	C,P	3
3	Analyze performance of various solar collector systems	4,5/1	U,AN	C,P	4
4	Apply their knowledge to design improved solar energy based systems	3/1	U,E,CR	C,P,M	6

5	Integrate/apply solar systems for applications in space heating and coolingrequirement	3/1	U,E,CR	C,P,M	6
6	Provide solution to rural and urban people regarding energy saving and utilization	6,1	U,E	C,P	4

BMEE 0009 INTRODUCTION TO VEHICLE DYNAMICS

Objective: *To understand the principle and performance of vehicle in various modes such as longitudinal, vertical and lateral directions. At the end of the course the student will be able to identify the various forces and loads and performance under acceleration, ride and braking.*

Credits: 04 **Semester VI** **L–T–P: 3–1–0**

Module No.	Content	Teaching Hours
I	**Introduction:** Introduction to Vehicle Dynamics, Longitudinal Dynamics, Vehicle Load Distribution – Acceleration and Braking - Brake Force Distribution, Braking Efficiency. **Aerodynamics:** Mechanics of Air Flow Around a Vehicle, Pressure Distribution on a Vehicle, Aerodynamic Forces, Drag Components, Aerodynamics Aids. **Tire Mechanics:** Tire Construction, Size and Load Rating, Terminology and Axis System, Tractive Properties, Cornering Properties, Camber Thrust, Aligning Moment, Combined Braking and Cornering, Conicity and Ply Steer, Slip, Skid	25
II	**Tire Mechanics:** Rolling Resistance, Elastic Band Model for longitudinal slip, Simple model for lateral slip, Combined longitudinal/lateral slip (friction ellipse), Taut string model for lateral slip, Magic Tire Formula. **Motorcycle Dynamics:** Kinematic structure of motorcycle, geometry of motorcycles, importance of trail, Resistance forces acting on motorcycle (tyre rolling resistance, aerodynamic resistance forces, resistant force caused by slope), Location & height of motor cycle's centre of gravity (C.G), Moments of inertia on Motorcycle. Introduction to Front & Rear suspensions of Motorcycle.	25

Text Books:

- Wong J Y, "Theory of Ground Vehicles", John Wiley & Sons, New York, 1978.
- Milliken W F and Milliken D L, Race car Vehicle Dynamics, SAE.
- Garrett T K, Newton K and Steeds W, "Motor Vehicle", Butter Worths & Co., Publishers Ltd., NewDelhi, 2001.

Reference Books:

- R N Jazar, Vehicle Dynamics: Theory and Application, Springer Rogowsky, "IC Engines", International
- Book Co.

- Hans Pacejka, Tire and Vehicle Dynamics, Elsevier, 2012.
- Thomas D Gillespie, "Fundamentals of Vehicle dynamics", SAE USA 1992.
- Rajesh Rajamani, Vehicle Dynamics & control, Springer.

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Course Outcome: *At the end of the course, a student will be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Understand the dynamics of vehicle ride.	POs/PSOs			
2	Calculate and refer the loads and forces associated to the vehicles.	PO1, PO2,PO3, PO4/ PSO1			
3	Analyse the behavior of the vehicles under acceleration, ride and braking	PO3, PO6, PO9, PO10/ PSO1			
4	Understand how passenger comfort is achieved along with vehicle stability.	PO2, PO3, PO4, PO6/ PSO1			
5	Understand and explain the effects of Resistance forces on the power of an automobile.	PO1, PO2, PO3, PO4, PO6, PO12/ PSO1			
6	Ability to understand about suspension and tyre related vibrations.	PO1, PO3, PO6/PSO1			

BMEE 0173 VEHICLE DYNAMICS LAB

Credits: 01 **L–T–P-J: 0–0–2-0**

Exp. No	List of Experiment	Hours
1	Experimental study of mechanism for air flow over different geometry of vehicles.	2
2	Experimental studies of measurements of drag and lift coefficient for different geometry vehicle using wind tunnel apparatus.	2
3	To study the effect of tyre pressure and temperature on the performance of the tyre.	2
4	To simulate and study a quarter car models using MBD software.	2
5	To simulate and understand behaviour of sprung / un-sprung mass & lumped mass system MBD software.	2
6	Finding the stiffness of tyre with variation of air pressure.	2
7	To simulate and study the effect of different conditions on vehicle loading.	2
8	Study of latest technologies available nowadays in vehicles helping to maintain stability of the vehicle on the road.	2
9	Study geometry of motorcycles as well as various types of forces faced by the motorcycle & its rider	2
10	Study the location & height of Centre of gravity (C.G) of a motorcycle	2

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Course Outcome: *At the end of the course, a student will be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	*The student will be able to determine the effects of air flow over different geometry of vehicles.(Apply)*	POs/PSOs			
2	*The student will be able to determine coefficient of drag and lift for different vehiclegeometryby using wind tunnel apparatus. (Analyze)*	PO2, PO3, PO4, PO6/ PSO1			
3	*The student will be able to understand quarter car models and Behaviour of sprung / un-sprungmass & lumped mass system. (Understand)*	PO3, PO6, PO9/ PSO1			
4	*The student will be able to understand geometry of motorcycles as well as various typesofforces faced by the motorcycle & its rider. (Understand)*	PO1, PO2, PO4, PO10/ PSO1			
5	*The student will be able to understand geometry of motorcycle and various forces effectonvehicle and its rider. (Understand)*	PO1, PO2, PO4, PO10/ PSO1			
6	*The Student will be able to locate and find height of Centre of*	PO1, PO2,			

	gravity (C.G) of a motorcycle.(Analyze)	PO3, PO4, PO6, PO12/ PSO1			

BMEE 0101: ADVANCED FLUID MECHANICS

Objective: *Aims to give Mechanical Engineering students a deeper and more thorough grounding in principles and basic applications of fluid mechanics. Topics include: review of the conservation principles; constitutive relations of Newtonian fluid; Navier-Stokes equation; inviscid flow – inertial properties ofvortex, 2D potential flows; viscous flow – basic laminar flows, boundary layer theories; introduction to turbulent flow – flow separation, sources of drag.*

Credits: 04 **L–T–P: 3–1–0**

Module No.	Content	Teaching Hours
I	**Basic Concepts and Fundamentals:** Definition and properties of Fluids,Fluid as continuum, Langragian and Eulerian description, Velocity and stress field, Fluid statics, Fluid Kinematics **Governing Equation of Fluid Motion:** Reynolds transport theorem, Integral and differential forms of governing equations: mass, momentum and energy conservation equations, Navier- Stokes equations, Euler's equation, Bernoulli's Equation. **Exact Solution of Navier – Stokes Equation:** Couette flows, Poiseuille flows, Fully developed flows in noncircular cross-sections, Unsteady flows, Creeping flows. **Potential Flows:** Revisit of fluid kinematics, Stream and Velocity potential function, Circulation, Irrotational vortex, Basic plane potential flows: Uniform stream; Source and Sink; Vortex flow, Doublet, Superposition of basic plane potential flows, Flow past a circular cylinder, Magnus effect; Kutta-Joukowski lifttheorem; Concept of lift and drag.	20
II	**Laminar Boundary Layer:** Boundary layer equations, Boundary layer thickness, Boundary layer on a flat plate, similarity solutions, Integral form of boundary layer equations, Approximate Methods, Flow separation, Entry flowinto a duct. **Turbulent Flow:** General equations of turbulent flow, Turbulent boundary layer equation, Flat plate turbulent boundary layer, Turbulent pipe flow, Prandtlmixing hypothesis, Turbulence modeling, Free turbulent flows. **Compressible Flow:** Speed of sound and Mach number, Basic equations for one dimensional flows, Isentropic relations, Normal-shock wave, Rankine Hugoniot relations, Fanno and Rayleigh curve, Mach waves, Oblique shock wave, Prandtl- Meyer expansion waves, Quasione dimensional flows, Compressible viscous flows, Compressible boundary layers.	21

Text Books:

- Gupta Vijay and Gupta S.K., "Fluid Mechanics and its Applications", Wiley Eastern Ltd,1984.
- Som, S.K. & Biswas G., "Introduction of fluid mechanics & Fluid Machines", TMH,2000, 2nd Edition
- Shames, I.H., "Mechanics of Fluids", McGraw Hill, Int. Student, Education, 2016
- Frank M. White, Viscous Fluid Flow, Third Edition, McGraw-Hill Series of MechanicalEngineering, 2006

Reference Books:

- Fox W. Robert, McDonald T. Alan, Introduction to Fluid Mechanics, Fourth Edition,John Wiley & Sons, 1995
- Muralidhar K. and Biswas G., Advanced Engineering Fluid Mechanics, Second Edition,Narosa, 2005.
- Schlichting H., Boundary Layer Theory, Springer Verlag, 2000.
- McCormack , P.S. & Crane, L.J. Physical Fluid Dynamics, Academic Press, 1973

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: *On learning this subject, students will be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Apply the fundamentals of kinematics, dynamics and conservation laws of fluid flow systems.	PO1, PO2, PO3/PS1	Apply	Fundamental design principle	
2	Apply the principles of high and low Reynolds number flows to fluid flow systems.	PO1, PO2, PO3/PS1	Apply	Fundamental design principle	
3	Review the concepts of boundary layer and flow in transition.	PO1, PO2 /PS1	Analyze	Practical Constraint	
4	Apply the fundamentals of turbulent flow to various fluid flow systems.	PO1, PO2, PO3/PS1	Apply	Fundamental design principle	
5	Apply the fundamentals of one-dimensional isentropic flow to variable area duct.	PO1, PO2 /PS1	Apply	Fundamental design principle	
6	Analyse the concept of normal shock formation and its effects.	PO1, PO2, PO12/PS1	Analyze	Practical constraint	
7	Apply the principles of compressible flow to constant area duct subjected to friction or heat transfer	PO1, PO2, PO12/PS1	Apply	Practical constraint	

BMEE 0102 COMPRESSIBLE FLUID FLOW

Prerequisites: *Advanced Fluid Mechanics*

Objectives: *The objective of this course for post-graduation students is to provide a solid background on the pertinent mathematical, physical, and engineering concepts that make up the foundations of the compressible flows.*

Credits: 04 **L-T-P: 3:1:0**

Module No.	Contents	Teaching Hours
I	**Brief Review of Fluid Mechanics and Thermodynamics:** Introduction, Dynamics Laws of motion, Kinematics, Equation of motion, Review of thermodynamics, concepts of entropy and vorticity, Ideal gases, Special forms of the governing equations, Transport properties. **Physical Acoustic & Nature of Steady Compressible Fluid Introduction,** One dimension wave motion, Transport of energy & momentum, propagation of sound in duct, Mach number, Inviscid Energy equation, Potential Flow, Isentropic flow. **One Dimensional Steady Flow:** Introduction, Isentropic flow of perfect gases in duct, Flow with friction, Flow with heat addition, Flow with friction in a constant area pipe.	25
II	**One Dimensional Unsteady Flow**: Shock conditions, the properties of shock waves, weak & strong shock approximation, Characteristic equations for homentropic & isentropic flow, Method of characteristics, piston analogy, Detonations and deflagrations. **Two Dimensional Steady Flow** Prandtl-Mayer function, Method of characteristics, Oblique shocks, shock polar, Reflected and intersecting shocks, expansion waves, Curved shocks, Nozzle design, Linearized potential flow, thin airfoil and slender body theories, Conical flow, Transonic flow. **Viscous Effects & Analogs of Compressible Flow**: Compressible boundary layers, Shock thickness, Shock wave-boundary layer interactions, Shallow water flow, Traffic flow, Electro-acoustical analogy	25

Text Books:

- Balachandran P., Fundamentals of Compressible Fluid Dynamics, PHI Learning.2006
- Rathakrishnan E., Gas Dynamics, PHI Learning, 2014
- Yahya S. M., Fundamentals of Compressible Flow with Aircraft and Rocket Propulsion, New Age International Publishers, 2003

Reference Books:

- Anderson, Modern compressible flow, 3e McGraw Hill Education,2012.
- Shapiro, Dynamics and Thermodynamics of Compressible Flow –Vol 1., John Wiley & Sons,1953

Focus: This course focuses on Employability/Skill development and aligned with CO's 1 and 2

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

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Formulate and solve problems in one -dimensional steady compressible flow including: isentropic nozzle flow, constant area flow with friction (Fanno flow) and constant	PO1, PO2, PO3, PO5/ PSO1	An	F	8

	area flow with heat transfer (Rayliegh flow)**.**				
2	Derive the conditions for the change in pressure, density and temperature for flow through a normal shock.	PO1, PO2, PO3/ PSO1	An	C	8
3	Determine the strength of oblique shock waves on wedge shaped bodies and concave corners.	PO2, PO3, PO3/ PSO1	E	D	8
4	Understand the various measuring instruments used in compressible flow.	PO1, PO3, PO5/ PSO1	U	P	8
5	Understand the effect of viscosity & analogy of compressibility on boundary layer formation	PO1, PO3, PO5/ PSO1	U	P	8

BMEE 0103 AERODYNAMICS

Objective: *Students will be able to understand the determination of forces, moments considering the thermal effects (heat transfers) on the bodies moving in a fluid. They will also learn the movement of wings or use of the wind force, thisway it requires the calculations to be done for the aerodynamic heating of the flight vehicles and the hydrodynamic forces applied on the surface of the vehicle.*

Credits: 04 **Semester** **L–T–P: 3–1–0**

Module No.	Content	Teaching Hours
I	**Introduction:** Airfoils, wings and their nomenclature; lift, drag andpitching moment coefficients; center of pressure and aerodynamic center. Potential flow Analysis; Scalar and vector fields, velocity potential, line, surface and volume integrals, circulation and lift generation, Kutta-Joukovskii theorem. Method of superposition, thin airfoil theory, source and vortex methods. **Subsonic Flow:** Subsonic compressible flow past airfoils; Critical Mach number, drag divergence Mach number, supercritical airfoils, effect of sweep, area rule.	20
II	Full and perturbation velocity potential formulations; Prandtl andGlauert compressibility corrections. Transonic flow past airfoils, transonic similarity rules; Supersonic flowpast airfoils, linearized supersonic flow. Potential flow over lifting wing, lifting line theory, vortex lattice method, slender body theory, variation of lift and drag coefficients in subsonic flows with angle of attack, Reynolds number, thickness-to- chord ratio. Supersonic flow over airfoils and wings; subsonic/supersonic leadingedge Hypersonic flows, Newtonian theory, lift and drag in hypersonic flows	20

Books/References:

- Anderson. JD, Jr., Fundamentals of Aerodynamics, McGraw Hill 2001.
- L.M. Milne/Thompson, Theoretical Aerodynamics.
- Houghton, E.L. and Carpenter, P.W., Aerodynamics for Engineers, Butterworth-Heinemann, 2001.

Online Education:

- MIT Open Courseware: Muddy Point Aerodynamics.
- www.edx.org: Aerodynamics Courses: Problems & Assignments.
- https://www.grc.nasa.gov/www/k-12/airplane/presar.html

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: *At the end of this course students will be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Define physical characteristics of air and atmosphere.	PO1, PO3, PO5/ PSO1, PSO3	R	C	10
2	Define basic aerodynamic forces acting on an aircraft and the factors affecting aerodynamic forces.	PO1, PO2, PO3, PO5/ PSO1, PSO2, PSO3	R	C	10
3	Define geometric characteristics of airfoil and wing.	PO1, PO2, PO3, PO4/ PSO1, PSO2, PSO3	R	C	10
4	Explain the effects of camber, angle of attack and thickness on the aerodynamic characteristics of an airfoil.	PO1, PO2, PO3, PO5/ PSO1, PSO2, PSO3	An	F	10

BMEE 0104: TURBULENT FLOW

Pre-requisite: *Advanced Fluid Mechanics*
Objective: *To provide a general introduction to the physics and mathematical description of turbulence; To introduce the methods of analysis used in turbulence study, to understand the principles of turbulence simulation and modeling.*

Credits: 4 **L–T–P: 3–1–0**

Module No.	Content	Teaching Hours
I	**Introduction**: Properties of laminar flow, Properties of turbulent flow, Boundary Layer, Growth rate of Boundary layer for Laminar and Turbulent Flows. **Characteristics of Turbulent Flow**: The Origin of Turbulence, Nature of Turbulence, Swirling Structure, Mean Motion and Fluctuations, Consequences of Turbulence, Homogeneous- Isotropic Turbulence. **Correlation Functions & Kolmogorov Hypothesis**: Correlation Functions, Ideas about eddy size, Intensity of Turbulence or Degree of Turbulence, Kolmogorov Universal Law for the Fine Structure, Energy Cascade, Kolmogorov Length Scale, Kolmogorov's First Hypothesis, Kolmogorov's Second Hypothesis. **Reynolds' Averaged Navier-Stokes Equations:** Further on Laws of Averaging, Reynolds' Decomposition, Examples of Turbulent Fluctuations, and Some Measurements on FluctuatingComponents. **Measurements on Fluctuating Components**: Shear Stress due to the Fluctuations, The boundary layer measurements of Klebanoff.	19
II	**Turbulent Boundary Layer Equations**: Turbulent Boundary Layer Equations for a two dimensional flow. **Classical Idealization of Turbulent Stresses**: Introduction, The Boussinesq or eddy viscosity model, Eddy viscosity. **Vorticity Dynamics**: Introduction, Vorticity and the equations of motion, Reynolds stress and vorticity, Vortex Stretching. The Vorticity Equation, Vorticity in Turbulent Flows. **Dynamics of Turbulence**: Kinetic Energy of the Mean Flow,Kinetic Energy of Fluctuations, Some Scaling Relations. **The Law of the Wall for Wall Bounded Flows**: The Law of the Wall for Wall Bounded Flows, The Universal Velocity Profile,Free Shear Flows, Turbulent Jets, Uniform Eddy Viscosity model.	21

Text Books:

- R J. Garde, *"Turbulent Flow"* New Age International Pvt Ltd Publishers

Reference Books:

- Stephen B. Pope, "*Turbulent Flows*", Cambridge University Press
- H. Tennekes and J. L. Lumley, *"A First Course in Turbulence"*, MIT Press

Focus: This course focuses on Employability/Skill development and aligned with CO's 1 and 2

Outcome: At the end of this course students will be able to:

CO	CO Statement	PO/PSO	CL	KC	Duration

1	Understand the characteristics of turbulent flow	PSO/PO	U	F	6
2	Explain the Correlation Functions & Kolmogorov Hypothesis.	PSO1/PO1/PO2	U	F, C	7
3	Understand Reynolds' Averaged Navier-Stokes Equations and Turbulent boundary layerequation.	PSO1/PO1/PO2/PO3	U	F, C	6
4	Understand measurement of fluctuating components and turbulent stresses	PSO1/PO1/PO2/PO3	U	F, C	7
5	Understand Vorticity and Turbulence dynamics	PSO1/PO1/PO2/PO3	U	F, C	7
6	Understand the concept of wall bounded flows	PSO1/PO1/PO2	U	F, C	7

BMEE 0105: COMPUTATIONAL FLUID DYNAMICS

Objective: *The objective of CFD is to model the continuous fluids with Partial Differential Equations (PDEs) and discretize PDEs into an algebra problem (Taylor series), solve it, validate it and achieve simulation based design.*

Credits: 03 **L–T–P: 3–0–0**

Module No.	Contents	Teaching Hours
I	**Introduction:** What is CFD, How Does A CFD Code Work, Applications of CFD and Problem Solving With CFD. Classification of Physical Behavior, The Role of Characteristics in Hyperbolic Equations, Classification Method for Simple Partial Differential Equation, Classification of Fluid Flow Equations, Auxiliary Conditions for Viscous Fluid Flow Equation. **Conservation Laws of Fluid Motion and Boundary Conditions:** Stress tensor over a control volume, Eienstein Indecies, Kronwer Delta Concept, Governing Equations of Fluid Flow, Equation of State, Continuity equation in Cartesian coordinate, polar coordinate and spherical coordinate system, Navier – Stokes Equations for A Newtonian Fluid, Conservative Form of the Governing Equations for Fluid Flow, Differential and Integral Forms of the General Transport Equation, Applications of Navier Stokes equation of motion- Flow through pipe, flow between two parallel plates etc. **Turbulent Flow:** Turbulence, types of turbulence, continuity equation for turbulent flow. Navier stokes equation for turbulent flow. Reynolds stress tensor for turbulent flow **Turbulence and Its Modeling** Turbulence Models Such as Boussinesque model, Mixing Length Model, application of mixing length model, Von-Karman turbulence model, application of Von-Karman turbulence model, The K –Ɛ Model, Reynolds Stress Equation Models.	20
II	**Potential Flow:** Source flow, Sink flow, Doublet, flow past a half body, flow over cylinder, pressure distribution. **The Finite Volume Method for Diffusion Problem:** Introduction, Finite Volume Method for Steady State Diffusion, Worked Examples: One Dimensional Steady State Diffusion, **The Finite Volume Method for Convection – Diffusion Problem:** Introduction, Steady One Dimensional Convection and Diffusion, The Central Differencing Scheme, Properties of Discretisation Scheme, The Upwind Differencing Scheme, The Hybrid Differencing Scheme, Properties of discretisation scheme.	20

Text Books:

- Anderson J., "Computational Fluid Dynamics An Introduction", III Edition, Springer, 2009.

Reference Books:

- Zikonav Oleg, “Essential Computational Fluid Dynamics”, John Wiley & Sons, 2010.
- Blazek J., “Computational Fluid Dynamics: Principles and Applications”, II Edition, 2009, Elsevier Ltd.

Focus: This course focuses on Employability/Skill development and aligned with CO's 1 and 2

Outcome: Students are expected to learn: Course Outcomes On completion of this course, the students will be able to:

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Understand the Mathematical application used in CFD tools and techniques for effective designs of structured grid.	PO1, PO3, PO5/ PSO1, PSO3	U	D	8
2	Apply modeling techniques to all the fluid dynamics, solid dynamics problems with respect to Multi-Disciplinary Industry.	PO1, PO2, PO3, PO5/ PSO1, PSO2, PSO3	A	P	8
3	Classify various computational methods for grid generation and its importance of efficient grid.	PO1, PO2, PO3, PO4/ PSO1, PSO2, PSO3	R	F	8
4	Formulate unstructured grid using various methods by considering different boundary conditions	PO1, PO2, PO3, PO5/ PSO1, PSO2, PSO3	An	D	8
5	Simulate simple CFD models and analyze its results.	PO1,PO3, PO5/ PSO1, PSO2, PSO3	An	D	8

BME E0175: CFD LAB

Objective: *To understand the modeling and analysis using ICEM and Fluent software for various fluid flow and heat transfer problems.*

Credits: 01 **L–T–P: 0–0–2**

Module No.	Content	Teaching Hours
I	**Preprocessor** • Modeling- meshing (ICEM) • ICEM –Geometry creation, Blocking, Association, Part naming, meshing, premeshing, output. **Processing** Geometry- to make coordinate of the point, to make curves, to make 2D/3D surfaces, surfacing. Blocking- to create block, to split block, association, to check wheather association is happened or not, naming of parts, to transform geometry, to trim undesired part of surface, meshing. Preparing file for fluent, select the flow parameters. **Analysis in Fluent-** Read files from storage, select models, materials, boundary conditions, result analysis.	**24**

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: *After completing this course users will be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Able to modeling the in ICEM	PO1, PO3, PO5/ PSO1, PSO3	C	D	8
2	Analyze fluid flow parameters	PO1, PO2, PO3, PO5/ PSO1, PSO2, PSO3	C	D	8
3	Analyze heat transfer parameters.	PO1, PO2, PO3, PO4/ PSO1, PSO2, PSO3	C	D	8
4	Simulate simple fluid flow models and analyze its results.	PO1, PO2, PO3, PO5/ PSO1, PSO2, PSO3	C	D	8
5	Simulate simple heat transfer models and analyze its results.	PO1, PO3, PO5/ PSO1, PSO2, PSO3	C	D	8

BME E0189 PROJECT BASED COMPUTATIONAL FLUID DYNAMICS LAB

Credits: 01 **L–T–P-J: 0–0–0-8**

Exp. No	List of Experiment	Hours
1	CFD analysis of flow through pipe	2
2	CFD simulation of flow through an orifice plate	2
3	CFD Simulation of different geometries of venturimeter	2
4	CFD analysis of rectangular duct.	2
5	CFD analysis of carburetor of an automobile	2
6	CFD Analysis of airflow and temperature distribution in buildings	2
7	CFD application in optimization improvement design of a low specific speed centrifugal pump impeller	2
8	CFD analysis of low pressure turbine blade using vortex generator jets	2
9	CFD Analysis on elliptical annular fin circumscribing circular tube	2
10	A Computational Fluid Dynamics and Heat Transfer Solver for Complex Geometries and Multiphase Flows	2

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*
Outcome: *After completing this course users will be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	*Able to modeling the in ICEM.*	*PO1, PO3, PO5, PSO1, PSO3*			
2	*Analyze fluid flow parameters*	*PO1, PO2, PO3, PO5, PSO1, PSO2, PSO3*			
3	*Analyze heat transfer parameters.*	*PO1, PO2, PO3, PO4, PSO1, PSO2, PSO3*			
4	*Simulate simple fluid flow models and analyze its results.*	*PO1, PO2, PO3, PO5, PSO1, PSO2, PSO3*			
5	*Simulate simple heat transfer models and analyze its results.*	*PO1,PO3, PO5, PSO1, PSO2, PSO3*			

BMEE 0184: MACHINE DRAWING LAB

Objective: *Students have an ability to apply knowledge of Modeling, science & engineering. Student can model this drawing even in CAD/CAM software by applying the basic knowledge of machine drawing. Students will able to demonstrate an ability to design and conduct experiments, analyze and interpret data and assembly and disassembly drawings knowledge will be provided.*

Credits: 01 **L–T–P: 0–0–2**

Module No.	Content	Teaching Hours
I	**Orthographic Projections** (1 drawing sheet) Principle of first angle and third angle projection, drawing of machine elements in first angle projection, selection of views, sectional views. **Screwed fasteners** (2 drawing sheet) Thread nomenclature, Forms of thread, Thread series, designation, Representation of threads, Bolted joints, Locking arrangements of nuts, Foundation bolts. **Keys, Cotter Joint and Pin joint** (1 drawing sheet)Types of keys, Cotter joint or Knuckle joint. **Shaft Couplings** (1 drawing sheet) Rigid Coupling or Flexible coupling. **Riveted joints** (1 drawing sheet) Types of rivet heads, Types of riveted joints, Boiler joint. **Assembly Drawing** (1 drawing sheet) Engine parts-stuffing box, cross head, Assembly drawing of eccentric, lathe tailstock, air valve, screw jack, connecting rod safety valve etc. **Free hand sketching** (sketch sheet) Free hand sketching of foundation bolts, studs, pulleys, couplings, helical gear, bevel gear, crank, connecting rod, belt pulley, piston etc. **Production Drawing** (2 drawing sheets) Types, Examples of simple machine elements like helical gear, bevel gear, crank,connecting rod, belt pulley, piston etc. **Computer Aided Drafting** (2 drawings) Introduction, input, output devices, introduction to software like AutoCAD, Pro-E, basic commands and development of 2D and 3D drawings of simple parts.	24

Text Books:

- Dhawan R.K, 'A Text Book Of Machine Drawing': S Chand & Company Pvt. Ltd. New Delhi,2018 .
- Agrawal & Agrawal, C., 'Engineering Drawing' : Tata McGraw Hill,2017.

Reference Books:

- John K.C., 'A Text Book of Machine Drawing': PHI Learning Private Ltd. New Delhi,2010.
- Dhawan R.K, 'A Text Book of Machine Drawing': S Chand & Company Pvt. Ltd. New Delhi, 2018.
- Junnarkar N. D 'Machine Drawing': Pearson India, 2006.
- Agrawal & Agrawal, C., 'Engineering Drawing': Tata McGraw Hill,2017.

Focus: This course focuses on Employability/Skill development and aligned with CO's 1 and 2

Outcome: After completing this course users will be able to:

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Draw the assembly from the individual part drawing	PO1/ PSO1	U	F & C	7
2	Analysis complex design systems related to Mechanical Engineering.CO1: Draw the assembly from the individual part drawing	PO1, PO3/ PSO1	A & A	P	5
3	Improve their understanding of machine drawing, which includes clear visualization ofobjects	PO3/ PSO1	U & A	M	4
4	Enhance their proficiency in reading and interpreting a wide variety of production and assembly drawings	PO3, PO10/ PSO1	U	C	4
5	Improve their understanding of drawings of assembled views for the part drawings using conventions and easy drawing proportions	PO3, PO10/ PSO1	C	Criteria and Specifications & Practical Constraints	4

BMEE 0201 COMPUTER AIDED DESIGN

Pre-requisite: *Machine Design II*

Objective:

- *To understand the use of Information technology in the Design Process.*
- *To understand the automation of design process.*
- *To understand the integration of CAD/CAM system.*
- *To understand the concept of numerical technique in automation of design.*

Credits: 03 **L–T–P: 3-0-0**

Module No.	Content	Teaching Hours
I	**Introduction:** Introduction to Design, Elements/ Requirements of CAD, Introduction to CAE and CIMS, Necessity & Its Importance, Engineering Applications of CAD **Computer Graphics-I** CAD Systems, Graphics Input Devices, Output Devices, Graphics Display Devices-CRT, LCD, LED, Touch panel display, Plasma Display, Virtual Display. Graphics display technique:- Random & Raster Scan Display Graphics Standards, Animation and multimedia, Graphics Functions, Rasterization of Output Primitives: Line Drawing Algorithm, Circle Generating Algorithm, **Computer Graphics –II :-** Coordinate Representation, Windowing and Clipping, Object modeling. Geometric Transformations (2D/3D) - Translation, Scaling, Shearing, Rotation & Reflection Matrix Representation and concatenation. Candidate must be submit one mini-project based on Computer graphics- I and II. **Geometric modeling of curve:** Properties of Curve Design and Representation, Interpolation Vs Approximation. Parametric and non-parametric representation of Curves. Importance of Convex Hull. Parametric Continuity Conditions. Geometric modeling of curve:-Hermite Cubic splines, Bezier Curves, Bezier Curves. Introduction to Nub Curve. Introduction to Surface representation.	20

II	**Solid Modelling:-** Surface fitting: Bezier surface patch model, B-spline surface patch model, Quadric and Super-quadric Surfaces. Solid Modelling approaches:- Polygon Mesh Representations, Boundary Representation, Constructive Solid Geometry , Blobby Objects, Sweeping, Lofting and other modeling methods **Animation system :-** Animation system, animation technique, Software used to perform animation. **Application of Numerical method in Automation of design:** Application, algorithm and program of following numerical technique: Root finding method:- N-R methods, Bi-section method. Interpolation: Newton forward and backward interpolation, Lagrange interpolation. Numerical differentiation using Newton forward and backward formula. Numerical Integration. **Introduction to Finite element analysis:** Introduction Classification of Differential Equations, Variational Formulation Approach, Ritz Method, Generalized Definition of An Element, Element Equations From Variations, Introduction, Principles of Finite Elements Modeling, Stiffness Matrix/Displacement Matrix. Stiffness Matrix for Spring System, Bar & Beam Elements,Bar Elements in 2D Space (Truss Element) **Application Software**: Application Commands for Drafting software	20

Text Books:

- *I. Zeid, "CAD/CAM: Theory and Practices": Tata McGraw-Hill.*
- *R.K Srivastava, "Computer Aided Design": Umesh Publication.*

Reference Books:

- *P.N Rao, "CAD/CAM: Principles and applications": Tata McGraw-Hill.*
- *R. B Patil : "Computer aided design": Tech-Max Publication.*
- *J.N Reddy, "Introduction to finite element methods": Tata McGraw-Hill.*
- *B.s.Grewal, "Numerical Method": Khanna Publishers, 2010.*

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: After completion of the course, student will be able to:

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Understand that the computer is not only a tool of visualization but also a tool for automation of design.	1,3,6,10/3	Understand	Fundamental Design Principles	4
2	Collaborate with people of diverse backgrounds and abilities	1,12/3	Apply	Criteria & Specifications	6
3	Identify the factors in the computer aided process and product development.	2,4,11/3	Apply	Practical Constraints	6
4	Create the different wireframe primitives using parametric representations	5,6,9,11/3	Create	Design instrumentalities	5

5	Knowcomputer aided design concept is not limited to computer programs.	3,4,10,12/3	Analyze	Criteria & Specifications	5
6	Evaluate computer aided design models and assemblies based on critical thinking and problem solving skills	3,5,7,8,12/3	Evaluate	Practical Constraints	7
7	Evaluate computer aided design models and assemblies based on critical thinking and problem solving skills	8,9,11,12/3	Evaluate	Design instrumentalities	7

BMEE 0176 ADVANCED SOFTWARE LAB

Objective: *To identify the role of the software in today's Design world.*

Credits: 01 **L–T–P: 0–0–2**

Module No.	Content	Teaching Hours
	• Use of Pro/Engineer and Pro/Mechanical Software for Exercises in: Design and Analysis of Mechanical Component Design Studied in Subjects of MD-I and MD-II. • Optimization of Mechanical Design of Components and Assemblies. • Reverse Engineering Tools and Their Use in Component Design. • Design Automation and User Defined Features, Advanced Assembly. • Structural, Welding, Surfacing, Behavior Modeler and Other Advanced Modules Use and Demonstration of Case Studies. • Application of Finite Element Methods to Elasticity Problems and Heat Transfer Problems. Using ANSYS, HYPERMESH, and FEM Software's.	

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Course Outcome: *At the End of the course, a student will able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Understand the concept AutoCAD, Pro/Engineer and ANSYS.	POs/PSOs			
2	Design and draft the any workshop utility tool with application of AUTOCAD/ProE.(Design) CO3. Understand the concept of drafting of the two daily utility objects like chair and podium using	PO2, PO3,PO9/ PSO1, PSO3			
3	ProE/AUTOCAD.	PO3, PO5, PO9, PO10/ PSO1, PSO3			
4	Design the Flywheel Assembly using ProE/AUTOCAD.	PO2, PO3,PO9/ PSO1, PSO3			
5	Understand the failure condition of ARC welding joint. (Understand) CO6.Understand the concept of analysis of Shaft under load using ANSYS.	PO3, PO5, PO9, PO10, PO12/ PSO1, PSO3			

BMEE 0202 CONTINUUM MECHANICS

Pre-requisite: *Strength of Materials*
Objective: *The aim of the continuum mechanics is to deals with the analysis of the kinematics and the mechanical behavior of materials modeled as a continuous mass rather than as discreteparticles.*

Credits: 04 **L–T–P: 3–1–0**

Module No.	Content	Teaching Hours
I	Cartesian tensors. The linear elastic boundary value problem. Boundary conditions. Naviers equations. Plane waves. General conservation laws for mass, momentum and angular momentum. **Deformation of a continuum:** Euler and Lagrange descriptions,displacement vector, strain tensor, principal strains, compatibilityequations.	20
II	**The state of stress in a continuum:** stress vector, stress tensor, principal stress, equations of motion. **Constitutive equations:** isotropic and anisotropic linear elastic materials. Newtonian fluids: compressible and incompressible fluids, Navier-Stokes equations.	20

Text Books:

- P. Chadwick, "Continuum Mechanics: Concise Theory and Problems": Dover Publications, 2012.
- J. W. Rudnicki, "Fundamentals of Continuum Mechanics": Wiley Publications, 2014.

Reference Books:

- Y. C. fung, "A First Course in Continuum Mechanics": Pearson publication, 1993.
- W. M. Lai and D. H. Rubin, "Introduction to Continuum Mechanics": Butterworth-Heinemann Publication, 2009.

***Focus*:** This course focuses on Employability/Skill development and aligned with CO's 1 and 2

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

CO	CO Statement	PO/PSO	CL	KC	Duration
1	*Apply the tensor formalism,*	PO1, PO2/ PSO3			
2	*Analyze general stresses and deformations in continuous materials.*	PO2, PO3/ PSO3			
3	*Formulate and solve specific technical problems of displacement, strain and stress.*	PO1, PO3/ PSO3			
4	*Numerically model and analyze the stresses and deformations of simple geometries under anarbitrary load in both solids and liquids.*	PO1, PO3, PO4/ PSO3			

BMEE 0203 FINITE ELEMENT METHODS

Pre-requisite: *Continuum Mechanics*

Course objective: *The objective of this course is to teach in a unified manner the fundamentals of the finite element method for the analysis of engineering problems arising in solids, structures and some basic thermal engineering. The course will emphasize the solution of real life problems using the finite element method underscoring the importance of the choice of the proper mathematical model, discretization techniques and element selection criteria. Finally, students will learn how to judge the quality of the numerical solution and improve accuracy in an efficient manner by optimal selection of solution variables.*

Credits: 04 **L–T–P: 3-1-0**

Module No.	Contents	Teaching Hours
1	**Introduction:** Finite element method as a numerical tool for design, Basic concepts, Formulation procedures, Historical development. **Line Elements and Applications:** Structural Problems: Linear and Quadratic elements, 1D Bar element, Formulation of Truss element, Plane truss, Euler – Bernoulli beam element formulation. Thermal and Fluid Problems: Steady state heat transfer: Element formulations, treatment to boundary conditions with application to 1- D heat conduction, heat transfer through thin fins; Potential flow problems **2D Elements**: Triangular (CST, LST): Shape function, Jacobian matrix, strain-displacement matrix, stress-strain relationship matrix, force vector. Quadrilateral Elements (Q4, Q8): Shape function, Jacobian matrix, strain-displacement matrix, stress-strain relationship matrix, force vector.	20
2	**Application to Field Problems**: Thermal problems, Torsion of Non circular shafts, Plane stress, plane strain and axisymmetric problems – Body forces and temperature effects, Stress calculations, Plate and shell elements **Dynamic Problems:** Formulation of dynamic problems, consistent and lumped mass matrices for 1-D and 2-D element, Solution of eigenvalue 1-D problems-Longitudinal and transverse vibration of beams with all possible boundary conditions: Transformation methods, Jacobi method, Vector Iteration methods, subspace iteration method. Solution to 1D transient Heat transfer problems.	20

Text Books

- T. R. Chandrupatla, Finite Element Analysis for Engineering and Technology, University Press, 2018
- P. Seshu, Text Book of Finite Element Analysis, PHI Learning Pvt. Ltd., 2012
- J. N. Reddy, An Introduction to the Finite Element Method, McGraw Hill International Edition, 2005

Reference Books

- S. S. Rao, The Finite Element Method in Engineering, Butterworth Heinemann, 2017
- K. J. Bathe, Finite Element Procedures in Engineering Analysis, Prentice Hall of India, 2007
- O. C. Zienkiewics, R. L. Taylor, The Finite Element Method, Vol I & II, McGraw Hill, 1967

Focus: This course focuses on Employability/Skill development and aligned with CO's 1 and 2

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

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Understand the basic theory of finite-element method.	PO1, PO3, PO6, PO12/ PSO1	U	F	6
2	To understand the use of the basic finite elements for structural applications using truss, beam, frame, etc.	PO1, PO3, PO4, PO6, PO10/ PSO1	U	C	7
3	Understand the role and significance of shape functions in finite element formulations and use linear, quadratic, and cubic shape functions for interpolation.	PO2, PO3, PO4, PO6/ PSO1	U	C	6
4	Understand the formulation of one-dimensional, two dimensional and three dimensional elements.	PO2, PO3, PO4, PO6/ PSO1	U	C&S	7
5	Recognize sources of errors in FEA.	PO1, PO3, PO6, PO10/ PSO1	U&Ap	C	7
6	Describe the mechanism of lubricants like Boundary Lubrication, Hydrodynamic lubrication etc	PO1, PO3, PO6, PO9/ PSO1	U & Ap	U&P	7
7	Understand the basic theory of finite-element method.	PO1, PO3, PO6, PO12/ PSO1	U	F	6

BMEE 0204 VIBRATION AND NOISE

Pre-requisite: *Dynamics of Machine*

Course objective: *The objective of this course is to have a clear understanding of vibrations and modelling of mechanical systems. Students will analyse free and forced vibrations and will develop mathematical techniques to model and design mechanical systems.*

Credits: 04 **L–T–P: 3-1-0**

Module No.	Contents	Teaching Hours
I	**Introduction:** Free and Forced Vibrations of Single Degree of Freedom System, Newton's Second Law, D'Alembert's Principle, Lagrange's Equation, Types of Damping, Algorithmic Decrement, Equivalent Viscous Damping, Support Excitation. **Basic Vibration Control:** reduction at source, Active feedback control, Vibration Isolation and Transmissibility. Two Degree of Freedom Systems: Free and Forced Vibrations With and Without Damping, Principle and Normal Modes, Vibration Absorbers. **Multi Degree of Freedom Systems:** Various Methods of Analysis of Multi Degree Freedom Systems, Influence Coefficients, Coupling of Modes, Rayleigh's Method, Dunkerley's Equation, Holzer's Method.	22
II	**Vibration of Continuous Systems:** Wave Equation, Longitudinal Vibration of Bars, Lateral Vibrations of Beam. **Passive Vibration Control:** Basics, design of absorber, absorber withideal spring, shock absorber, isolators with stiffness and damping. **Active Vibration Control:** Basics, Piezoelectric materials, electro rheological fluids, magneto rheological fluids, Magneto- and Electrostrictive Materials inVibration Control. **Vibration Measurement:** Basics, data acquisition, Introduction to Condition Monitoring of Machinery, FFT analysis and filters	20

Text Books

- G. K.Grover, "Mechanical Vibrations": Nem Chand and Bros, 2009.
- S. S. Rao, "Mechanical Vibrations", Addison Wesley Publishing Company, 1990.
- S. G. Kelly, "Mechanical Vibrations, Schaum's Outlines", Tata McGraw Hill, 2008.

Reference Books

- J. S. rao, "Vibration Condition Monitoring of Machines": Tata Mc-Graw Hill, 2006.
- D. J. Inman, "Vibration and Control": John Willey & Sons Inc, 2002.

Focus: This course focuses on Employability/Skill development and aligned with CO's 1 and 2

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

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Analyze the mathematical modeling of the two degrees of freedom systems and explainabout the working principle of vibration absorber.	PO1, PO2/PSO3			
2	Compute the natural frequencies and mode shapes of a multi degree of freedom system andexplain the modal analysis of a vibrating system.	PO1, PO2/PSO3			
3	Ability to use Lagrange's equations for linear and nonlinear vibratory systems.	PO1, PO2/PSO3			
4	Understood the parameters and variables of a vibrating system.	PO1, PO2/PSO3			
5	Understood the concept of natural frequency and how to find it for a vibrating system.	PO1, PO3/PSO3			
6	Learn the process of vibration measurements and control.	PO1/PSO3			

BME E0205 MACHINE TOOL DESIGN

Pre-requisite: *Machine Design II & Manufacturing Science II*

Objective: *To facilitate the student with theories in metal cutting technology and design aspects of Jigs fixtures and Various cutting tools tooling in use with its application in Industries.*

Credits: 04 **L–T–P: 3–1–0**

Module No.	Content	Teaching Hours
I	**Introduction: C**oncept of specific cutting energy in metal cutting and Numerical based on calculation of machining time on lathe, drilling machine, shaper, milling machine and grinding machines considering specific cutting energy of materials. **Tool Geometry:** Tool Geometry of Single point cutting tool (SPCT) (ASA & ISO), Tool Geometry of Drill Bit Milling Cutter, Form Tool, Broach, Thread Cutting Tool, Gear Cutting Tool **Thermal Analysis of Chip Formation:** Heat generation and temperature distribution in metal cutting. Tool failure and Tool wear, Calculation of temperature in primary and secondary deformation zones and their measuring methods. **Machinability**: Machinability and its criteria, forms of tool-wear in metal cutting, tool-life and its criteria, effect of different cutting parameters on tool-life. Economics of machining and numerical. Cutting fluids, their physical action and applications.	22
II	**Design of Cutting Tool:** Design and Numerical analysis of single point cutting tool, Drill Tool, Milling Cutter (plain and face), Thread Cutting Tool (Tap and Thread Cutting Dies), Geometry and Design of Hob **Tooling for Casting**: Design and analysis of Runner, Riser, Gate, Sprue. Turbulence effect on Gating System, Design of Cavity for shrinkage Tooling for Shell Mould Casting, Casting, Die Casting, Aluminium die Casting **Design of Press Working Tool**: Power press, Shearing Operation, Blanking Die Design, **Design of Jigs and Fixtures**	22

Text Books:

- B.L. Juneja, G. S. Sekhon, Nitin Seth" Fundamental of Metal Cutting and Machine Tools", New Age International 2nd edition,
- NK Mehta "Metal Cutting and Design of Cutting Tool" , jigs and fixtures
- Frank W Wilson "Fundamental of Tool Design"

Reference Books:

- Geoffrey Boothroyd, "Fundamentals of Metal Machining & Machine Tools", TMH
- P.N. Rao, "Manufacturing Technology", Tata McGraw Hill Publication Ltd.
- B.J. Ranganath, "Metal Cutting & Tool Design" Vikas Publishing House Pvt. Ltd
- A.B. Chattopadhyay "Machining and Machine Tools" Wiley India

Focus: This course focuses on Employability/Skill development and aligned with CO's 1 and 2

Outcome: Students will be able to:

Design and selection of jigs and fixtures for conventional machining.
Design and selection of cutting tools under different working conditions.
Select and design progressive, compound or combination dies for press working operations.

CO	CO Statement	PO/PSO	CL	KC	Duration
1	To learn Sheet-metal model fundamentals, creating primary and secondary sheet-metal wall Features	PO1, PO7, PO6/PSO1			
2	To learn Bending and Unbending Sheet-metal Models, Form features and modifying sheet metal models.	PO1, PO7/ PSO1			
3	To learn the process of Sheet-metal Setup and Tools and Detail sheet metal designs	PO1/PSO1			
4	Design of Blanking, Piercing, Progressive and compound dies.	PO1, PO7, PO6			
5	Introduction to Press Tool, Die sets, Guidelines for Design of Press Tools	PO1, PO7/ PSO1			
6	To learn rapid prototyping or additive manufacturing, RPT Data Processing, Data Post Processing, Solid based rapid manufacturing processes.	PO1, PO5/ PSO2			

BMEE 0206 FUNDAMENTALS OF COMPUTER AIDED DESIGN

Pre-requisite: *Machine Design II*

Objective:

- *To understand the use of Information technology in the Design Process.*
- *To understand the automation of design process.*
- *To understand the integration of CAD/CAM system.*
- *To understand the concept of numerical technique in automation of design.*

Credits: 04 **L–T–P: 3-1-0**

Module No.	Content	Teaching Hours
I	**Introduction:** Introduction to Design, Elements/ Requirements of CAD, Introduction to CAE and CIMS, Necessity & Its Importance, Engineering Applications of CAD **Computer Graphics-I** CAD Systems, Graphics Input Devices, Output Devices, Graphics Display Devices-CRT, LCD, LED, Touch panel display, Plasma Display, Virtual Display. Scan Display Graphics Standards, Animation and multimedia, Graphics Functions, Rasterization of Output Primitives: Line Drawing Algorithm, Circle Generating Algorithm, **Computer Graphics –II:** Coordinate Representation, Windowing and Clipping, Object modeling. Geometric Transformations (2D/3D) - Translation, Scaling, Shearing, Rotation & Reflection Matrix Representation and concatenation. **Geometric modeling of curve:** Properties of Curve Design and Representation, Interpolation Vs Approximation. Parametric and non-parametric representation of Curves. Importance of Convex Hull. Parametric Continuity Conditions. Geometric modeling of curve: Hermite Cubic splines, Bezier Curves, Bezier Curves. Introduction to Nub Curve. Introduction to Surface representation.	20
II	**Solid Modelling:** Surface fitting: Bezier surface patch model, B-spline surface patch model, Quadric and Super-quadric Surfaces. Solid Modelling approaches: Polygon Mesh Representations, Boundary Representation, Constructive Solid Geometry, Blobby Objects, Sweeping, Lofting and other modeling methods **Application Software**: Application Commands for Drafting software **Application of Numerical method in Automation of design:** Application, algorithm and program of following numerical technique: Root finding method: N-R methods, Bi-section method. Interpolation: Newton forward and backward interpolation, Lagrange interpolation. Numerical differentiation using Newton forward and backward formula. Numerical Integration. **Introduction to Finite element analysis:** Introduction Classification of Differential Equations, Principles of Finite Elements Modeling, Stiffness Matrix/Displacement Matrix.	20

Text Books:

- *Zeid, "CAD/CAM: Theory and Practices": Tata McGraw-Hill.*
- *R. K. Srivastava, "Computer Aided Design": Umesh Publication.*

Reference Books:

- *P.N. Rao, "CAD/CAM: Principles and applications": Tata McGraw-Hill.*
- *R.B. Patil: "Computer aided design": Tech-Max Publication.*
- *J.N. Reddy, "Introduction to finite element methods": Tata McGraw-Hill.*
- *B.S. Grewal, "Numerical Method": KhannaPublishers,2010.*

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: *After completion of the course, student will be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Understand that the computer is not only a tool of visualization but also a tool for automation of design.	1,3,6,10/3	Understand	Fundamental Design Principles	4
2	Collaborate with people of diverse backgrounds and abilities	1,12/3	Apply	Criteria & Specifications	6
3	Identify the factors in the computer aided process and product development.	2,4,11/3	Apply	Practical Constraints	6
4	Create the different wireframe primitives using parametric representations	5,6,9,11/3	Create	Design instrumentalities	5
5	Know computer aided design concept is not limited to computer programs.	3,4,10,12/3	Analyze	Criteria & Specifications	5
6	Evaluate computer aided design models and assemblies based on critical thinking and problem solving skills	3,5,7,8,12/3	Evaluate	Practical Constraints	7
7	Evaluate computer aided design models and assemblies based on critical thinking and problem solving skills	8,9,11,12/3	Evaluate	Design instrumentalities	7

BME E0301 COMPUTER AIDED MANUFACTURING

Pre-requisite: *Manufacturing Science II*

Objective: *Acquire fundamental understanding of the principles of CAM, including CNC programming,concept of CIM & Robotics.*

Credits: 03 **L–T–P: 3–0–0**

Module No.	Contents	Teaching Hours
I	**Automation:** Introduction to CAM; Automated Manufacturing System; Automation, Need of Automation, Basic Elements of Automation, Levels of Automation, Automation Strategies, Advantages & Disadvantages of Automation, Historical Development and Future Trends. **NC System:** Fundamental of Numerical Control, Elements of NC Machine Tools, Classification of NC Machine Tools, Advantages, Suitability and Limitations of NC Machine Tools, Application of NC System, Methods for Improving Accuracy Considering the Factors Such as Tool Deflection and Chatter and Productivity. Tooling of NC Machines. Configuration of CNC, DNC and Adaptive Control. **NC Part Programming** (A) Manual (Word Address Format) Programming. Examples Drilling, Turning and Milling; Canned Cycles, Subroutine, and Macro. (B) APT Programming. Geometry, Motion and Additional Statements, Macro- Statement.	20
II	**System Devices:** Feed Back Devices, Counting Devices, Digital to Analog Converter and Vice Versa. Interpolators like Digital Differential Integrator Linear, Circular Computer AidedInspection (CAI) and Computer Aided Testing (CAT). **Computer Integrated Manufacturing System** Concept of Computer Integrated Manufacturing System, Impact of CIM on personnel,Role of manufacturing engineers, CIM Wheel to understand basic functions. Group Technology, Flexible Manufacturing System, CAD/CAM, Computer AidedProcess Planning-Retrieval and Generative, Concept of Mechatronics. **Robotics** Robot Anatomy, Laws of Robot, Human System and Robotics, Coordinate system, Specifications of Robot. Power sources, actuators and Transducers, Robotic Sensors, Grippers, Robot Safety, Robot Programming and Robot Applications.	20

Text Books:

- Kundra and Rao, “Computer Aided Manufacturing”, TMH, New Delhi.
- Koren, “Computer control of Manufacturing systems”, TMH, New Delhi.
- Koren, “NC Machines”, TMH, New Delhi.

Reference Books:

- Groover Mikell P., "Automation, Production Systems and Computer Integrated Manufacturing", Prentice Hall Publishers.
- S.J. Martin, "NC Machine Tools", TMH, New Delhi.
- Groover, "CAD/CAM", Prentice Hall Publishers.

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	*Understand the need of automation and its strategies used for development in manufacturing.*	PO3/PSO2			
2	*Describe basic concepts of CAM application and CIM wheel.*	PO1, PO3/PSO2			
3	*Prepare CNC programs for manufacturing of different geometries on milling and lathe machines.*	PO1, PO6/PSO2			
4	*Understand the concept of group technology, CIM, FMS and CAPP system used inindustries.*	PO2/PSO2			
5	*Describe the use of feedback devices used in CNC machines.*	PO1/PSO2			
6	*Illustrate the basic parts and necessity of Robotic system in Industries.*	PO6/PSO2			

Outcome*: After completion of this course, the Students will be able to:*

BMEE 0178 CAD/CAM LAB

Objective: *To Study and acquire knowledge on various computer based designing and machining operations in special purpose machines and its applications in real life manufacture of components in the industry.*

Credits: 01 **L–T–P: 0–0–2**

Module No.	Content	Teaching Hours
	Total TEN Experiments are to Carry Out. FIVE Experiments Each From CAD and CAM. **A. CAD Experiments** • Line Drawing or Circle Drawing Experiment: Writing and Validation of Computer Program. • Geometric Transformation Algorithm Experiment for Translation/ Rotation/ Scaling: Writing and Validation of Computer Program. • Design of Machine Component or Other System Experiment: Writing and Validation of Computer Program. • Understanding and Use of Any 3-D Modeling Software Commands. • Pro/E/Idea Etc. Experiment: Solid Modeling of A Machine Component • Writing A Small Program for FEM for 2 Spring System and Validation of Program or Using A Fem Package. • Root Findings or Curve Fitting Experiment: Writing and Validation of Computer Program. • Numerical Differentiation or Numerical Integration Experiment: Writing and Validation of Computer Program. **B. CAM Experiments** • To Study the Characteristic Features of CNC Machine. • Part Programming (in Word Address Format) Experiment for Turning. Operation (Including Operations Such as Grooving and Threading) and Running on CNC Machine. • Part Programming (in Word Address Format or ATP) Experiment for Drilling Operation (Point to Point) and Running on CNC Machine. • Part Programming (in Word Address Format or ATP) Experiment for Milling Operation (Contouring) and Running on CNC Machine. • Experiment on Robot and Programs. • Experiment on Transfer Line/Material Handling. • Experiment on Difference between Ordinary and NC Machine, Study or Retrofitting. • Experiment on Study of System Devices Such as Motors and Feed Back Devices. • Experiment on Mecatronics and Controls.	

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

CO	CO Statement	PO/PSO	CL	KC	Duration
1					
2					
3					
4					

5					
6					
7					

Outcome: *Upon successful completion students should be able to:*

CO1:Use an understanding of General and Machine (G & M) code to generate or edit a program.(Apply)
CO2:Understand the use of 3-D model software commands.(Apply)
CO3:Operate CNC lathe& CNC Milling machines.(Apply)
CO4:Use Additive manufacturing equipment 3D scanner and printer.(Apply)

Mapping of Course Outcomes (Cos) with Program Outcomes (Pos) and Program Specific Outcomes (PSOs) :

COs	POs/PSOs
CO1	PO1/PSO2
CO2	PO3/PSO2
CO3	PO1/PSO2
CO4	PO5/PSO2

BMEE 0192 PROJECT BASED CAD/CAM LAB

Credits: 02 **L–T–P-J: 0–0–0-8**

Objectives

- To impart fundamental knowledge to students in the latest technological topics on Computer Aided Design, Computer Aided Manufacturing and Computer Aided Engineering Analysis and to prepare them for taking up further research in the areas.
- To create congenial environment that promotes learning, growth and imparts ability to work with interdisciplinary groups in professional, industry and research organizations.
- To broaden and deepen their capabilities in analytical and experimental research methods, analysis of data, and drawing relevant conclusions for scholarly writing and presentation.
- To provide guidance to students for their choices in research and professional career outlook and to encourage students to take up research.

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

CO	CO Statement	PO/PSO	CL	KC	Duration
1					
2					
3					
4					
5					
6					
7					

Course Outcomes
After completion of this course, students will be able to

CO1: Apply/develop solutions or to do research in the areas of Designand simulation in Mechanical Engineering. (Apply)
CO2: Model & Analyze mechanical component using 3-D model softwarecommands.(Apply)
CO3: Programming on CNC lathe& CNC Milling machines.(Apply)
CO4: Illustrate Use of Additive manufacturing.(Apply)

Mapping of Course Outcomes (Cos) with Program Outcomes (Pos) and Program Specific Outcomes(PSOs) :

COs	POs/PSOs
CO1	PO1,PO2,PO11/PSO2
CO2	PO3/PSO2
CO3	PO1/PSO2

CO4	PO4/PSO2

BMEE 0302 WELDING SCIENCE AND TECHNOLOGY

Pre-requisite: *Manufacturing Science I*

Objective: *To impart the comprehensive insight into various basic and advanced Welding processes and their application to different materials.*

Credits: 03 **L–T–P: 3–0–0**

Module	Contents	Teaching Hours
1	**Introduction:** Welding as compared with other fabrication processes, Importance and application of welding, classification of welding processes, Health & safety measures in welding. Welding Power Sources: Physics of welding Arc Basic characteristics of power sources for various arc welding processes, Physics of **Welding Arc:** Welding arc, arc initiation, arc efficiency, heat generation at cathode and anode, Effect of shielding gas on arc, isotherms of arcs and arc blow. **Metal Transfer:** Mechanism and types of metal transfer in various arc welding processes. **Weldability:** Effects of alloying elements on weld ability, welding of plain carbon steel, CastIron and aluminium. **Welding Processes:** Shielded Metal Arc Welding (SMAW),TIG, MIG, Plasma Arc, Submerged Arc Welding, Electrogas and Electroslag, Flux Cored Arc Welding, Resistance welding,	23
2	**Welding Processes (Contd…):**Friction welding,, Friction Stir Welding, Ultrasonic welding, Explosive welding , Laser beam, welding, Electron beam welding, Underwater welding, Brazing, Soldering and Braze welding processes. **Heat Flow Welding:** Calculation of peak temperature; Width of Heat Affected Zone (HAZ); cooling rate and solidification rates; weld thermal cycles; residual stresses and their measurement; weld distortion and its prevention. **Repair & Maintenance Welding:** Hardfacing, Cladding, Surfacing, Metallizing processes and Reclamation welding. Micro & Macro structures in welding. **Weld Design:** Types of welds & joints, Joint Design, Welding Symbols, weld defects, Inspection/testing of welds, Introduction to Welding Procedure Specification & Procedure Qualification Record.	22

Text Books:

- Parmar R.S., “Welding Processes & Technology”, Khanna publishersNadkarni, S.V., “Modern Arc Welding Technology”,
- Oxford & IBH Cary Hobart B., “Modern Welding Technology”, Prentice Hall
- Smit, Dave, “Welding Skills”
- Little R. “Welding technology”, Tata McGraw-Hill Kearns, W.H., “Welding Handbook” Vol. 3, AWS, Miami

Focus: *This course focuses on Employability/Skill development and aligned with CO’s 1 and 2*

Outcomes: On completion of this course, the students would be able to:

CO	CO Statement	PO/PSO	CL	KC	Duration
1	The student will be able to understand the fundamental principles of welding processes.	PO1 / PSO2	U	C	
2	The student will be able to ascertain the key parameters of each process,	PO2 / PSO2	U	C	
3	The student will be able to Predict the material behaviour upon welding,	PO4 / PSO2	U	C	
4	The student will able to Design appropriate Pre and post welding Heat treatments (PWHT).	PO5 / PSO2	A	P	
5	The student will able to understand Inspection/testing of welds, Procedure Specification & Procedure Qualification Record etc.	PO3 / PSO2	AN	P	

Mapping of Course Outcomes (Cos) with Program Outcomes (Pos) and Program Specific Outcomes (PSOs):

COs	POs /PSOs
CO1	PO1 / PSO2
CO2	PO2 / PSO2
CO3	PO4 / PSO2
CO4	PO5 / PSO2
CO5	PO3 / PSO2

BMEE 0185 WELDING SCIENCE AND TECHNOLOGY LAB

Pre-requisite: *Manufacturing Science -I Lab*

Objective*: This course introduces the fundamentals latest techniques and procedures for beginning to advanced welding processes, The Course will provide hands on training welding theory training topics, weld joints and positions, welding safety, weld and base metal nomenclature, defects, inspection criteria, weld techniques and troubleshooting. Sample work will undergo inspection as part of testing to ensure that they conform to American Welding Society (AWS).*

Credits: 01 **L–T –P: 0–0–2**

Module No.	Content	Teaching Hours
1	**List of Experiments:** 1. Welding Groove preparation as per the American WeldingSociety (AWS)Code 2. Butt and lap Joint preparation by Shielded Metal ArcWelding (SMAW) process. 3. To prepare butt and lap joint by Gas Tungsten ArcWelding (GTAW) process 4. To prepare butt and T joint by Gas Welding Process (Withvarying Flame). 5. To prepare butt joint by Submerged Arc Welding (SAW)process. 6. HAZ micro structural analysis using optical Microscope 7. Comparison of Hardness in Fusion Zone(FZ), Heat Affected Zone(HAZ) and Parent metal of arc weldment. 8. Sheet Metal fabrication Using Resistance Spot Welding 9. Impact strength analysis of weld joint through Charpyand Izod Test. 10. Friction Stir welding of Aluminium alloys	24

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: At the end of the course the student will be able

CO	CO Statement	PO/PSO	CL	KC	Duration
1	The student will be able to know the practical skills to weld in (flat, horizontal, vertical positions,) using the basic welding processes SMAW, GTAW etc.	PO1 / PSO2	A	P	
2	The student will be able to know the basic fundamentals of welding processes and applications and metallurgy	PO2 / PSO2	R	F	
3	The student will be able to know to develop basic know how and awareness to deal with practical aspects of advanced welding and their micro structural analysis.	PO4 / PSO2	U	C	
4	The student will be able to know about the mechanical properties and their requirements for structures.	PO5 / PSO2	U	C	
5	The student will be able to know different advanced joining operations.	PO3 / PSO2	U	C	

Mapping of Course Outcomes (Cos) with Program Outcomes (Pos) and Program Specific Outcomes (PSOs) :

COs	POs /PSOs
CO1	PO1 / PSO2
CO2	PO2 / PSO2
CO3	PO4 / PSO2
CO4	PO5 / PSO2
CO5	PO3 / PSO2

BMEE 0303 COMPOSITE MATERIALS

Pre-requisite: *Material Science*

Objective: *The objective for this course is to develop an understanding of the linear elastic analysis of composite materials. This understanding will include concepts such as anisotropic material behavior and the analysis of laminated plates. The students will undertake a design project involving application of fiber reinforced laminates. Detailed study of biaxial strength theories of orthotropic materials are also of interest. Fundamentals of engineering constants, special cases of laminates are emphasized. The students are introduced to reinforced materials, their base materials, selection and applications.*

Credits: 03 **L–T–P: 3–0–0**

Module No.	Contents	Teaching Hours
I	**Introduction to Composite Materials:** Classification of various composite materials. Reinforcements: Fibers: fabrication, properties and applications of glass fibers, boron fibers, carbon fibers, organic fibers, Kevelar fibers, ceramic fibers, metallic fibers (metallic glasses). **Particulates:** Properties and application of SiC, Al_2O_3, Si_3N_4 and TiC particulates. **Matrix Materials:** Functions of a Matrix, Desired Properties of a Matrix, Polymer Matrix (Thermosets and Thermoplastics), Metal matrix, Ceramic matrix, Carbon Matrix, Glass Matrix etc. **Metal Matrix Composites:** Solid state, liquid state and in-situ fabrication techniques of MMCs, Discontinuous reinforcement of MMCs, Properties and applications of MMCs.	20
II	**Ceramic Matrix Composites:** Fabrication, properties and interfaces in CMCs. Toughness of CMCs, applications of CMCs. Carbon Fiber Composites: Fabrication, properties and interfaces. **Mechanics of Composite Materials:** Density, mechanical properties, predication of elastic constants, transverse stresses, and thermal properties. Mechanics of load transfer from matrix to fibers, relationship between engineering constants, analysis of laminated composites. **Strength, Fracture and Design of Composites:** Tensile and compressive strength of composites, Fracture modes in composites, Strength of orthotropic lamina, maximum stress theory, maximum strain criterion, maximum work criterion.	20

Text Book:

- *S.W. Tsai and H.T. Hahn, "Introduction to Composite Materials": Technomic Publishing Co.,1980.*
- *A.K. Kaw, "Mechanics of composite materials": CRC Press, 1997.*
- *Mukhopadhyay Madhujit, "Mechanics of Composite Materials and Structures": UniversityPress, 2005.*

Reference Books:

- *Rober M. Joness, "Mechanics of Composite Materials": Mc-Graw Hill Kogakusha Ltd, 1975.*
- *Michael W. Hyer, "Stress Analysis of Fiber Reinforced Composite Materials":MGH*

International, 2009.

- *Krishan K. Chawla, "Composite Material Science and Engineering": Springer,1987.*

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2.*

Outcome: *After successful completion of this course, the student will be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	*Understanding of smart materials, manufacturing processes, advantages and applications*	PO1/PSO3	R	F	4
2	*Identify and Evaluate the properties of fiber reinforcements, particulates, matrix materials and commercial composites*	PO1/PO4/PO5/PSO1/PSO2/PSO3	U	C	6
3	*Develop competency in one or more common composite manufacturing techniques and be able toselect appropriate technique for manufacture of composite products*	PO1/PSO2	E	P	6
4	*Analyze and understand the mechanical properties and mechanics of load transfer from matrixto fibers.*	PO1/PSO1	A	C	7
5	*Understand and predict the mechanical performance and failure behaviour of the composites*	PO1/PO4/PSO3	U	C	7
6	*Apply the knowledge of manufacturing methods and composite mechanical performance of agiven composites design project*	PO1/PO2/PSO2/ PSO3	A	P	5
7	*To understand the different testing methods/ Characterization of smart materials*	PO1/PSO2/PSO3	U	M-C	5

BMEE 0304 MODERN MANUFACTURING PROCESS

Objective: *In this course students acquire the ability to know and understand the advance machines and their operations. Students will be able to formulate problems in advanced metal cutting and evaluate the cutting parameters, establish a complete solution to metal cutting problems using mathematical or graphical techniques.*

Credits: 03 **L–T–P: 3–0–0**

Module	Contents	Contact Hours
1	**Introduction:** Types of advanced manufacturing processes; Evolution, need, and classification of advanced machining processes (AMPs). **Mechanical Type MMPs:** USM, AJM, WJM, AWJM processes: Process principle and elements; Tool design; Mechanism of material removal, parametric analysis; Shape and material applications; Operational characteristics; Limitations. **Advanced Super Finishing Process:** Abrasive Flow Machining; Magnetic Abrasive Finishing; Magneto Rheological AbrasiveFinishing: Processprinciple, process equipment; Analysis and modeling of finishing mechanism; Parametric analysis; Applications. **Chemical Type AMPs:** Process principle and details of Chemical Machining; Photo-Chemical Machining, and Bio-Chemical Machining processes.	21
2	**Electro Chemical Type AMPs:** ECM-Process principle, mechanism of material removal; Kinematics and dynamics of ECM; Tooling design; Choice and analysis of process parameters; Surface finish and accuracy **Thermal Type AMPs:** EDM, LBM, EBM, IBM, PAM processes: Working principle; Power circuits; Mechanism of material removal; Process parameters and characteristics; Surface finish and accuracy: Shape and materials applications, limitations. **Derived and Hybrid AMPs:** Introduction of processes like rotary ultrasonic machining, electro stream drilling, shaped tube electro machining, wire electro discharge machining, electro chemical grinding, electro chemical honing, electro chemical deburring and electro-chemical spark machining. **Misc. Topics:** Process selection and process planning for AMPs.	21

Text Book:

1. Mishra, P.K., “Nonconventional Machining”, Narosa Publishing House.
2. Pandey, P.C., and Shan, H.S., “Modern Machining Processes”, Tata McGraw-Hill.
3. Jain, V.K., “Advanced Machining Processes”, Allied Publishers.
4. Benedict, G.F., “Nontraditional Manufacturing Processes”, Marcel Dekker.
5. McGeough, J.A., “Advance Method of Machining”, Chapman and Hall.
6. Ghosh, A., and Mallik, A.K., “Manufacturing Science”, Affiliated East-West Press.

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

CO	CO Statement	PO/PSO	CL	KC	Duration
1					
2					
3					
4					
5					
6					
7					

Outcomes:

Students are expected to learn:

On completion of this course, the students would be able to:

CO1. The student will be able to perform advance operations in manufacturing processes.

CO2. The student will be able to apply engineering mathematics to solve the basic problems of metal cutting.

CO3. The student will be able to have in-depth knowledge of machines, mechanisms and theiroperations for material removal using advance machines.

CO4 The student will be able to perform process selection and planning for advanced manufacturingprocesses.

CO5 The student will be able to understand different operations of manufacturing for different types of machines and processes.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs /PSOs
CO1	PO1 / PSO2
CO2	PO2 /PSO2
CO3	PO3 /PSO2
CO4	PO5 /PSO2
CO5	PO4 / PSO2

BMEE 0179 MODERN MANUFACTURING PROCESS LAB

Pre-requisite: *Manufacturing Science -I Lab*

Objective*: This course introduces the latest techniques and procedures for advanced manufacturing processes, The Course will provide hands on training of some manufacturing theory training topics. Sample work will undergo inspection as part of testing to ensure that they conform to set standards.*

Credits: 01 **L–T–P-J: 0–0–2-0**

- To determine the metal removal rate of AJM process by controlling machining parameters.
- To determine the MRR of USM by controlling the slurry flow rate frequency and amplitude.
- To determine the MRR effect of electrolyte flow role on MRR in ECM.
- To investigate the surface roughness of machined surface by EDM under variable parameter.
- To determine the metal removal rate by EDM under control parameter.
- To determine the MRR of LBM by variable parameter & its effect on metal structure.
- To design& manufacture a component by 3D printing.
- To investigate the machined zone by wire cut EDM.
- To fabricate & study a hybrid machining setup (mini project)

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

CO	CO Statement	PO/PSO	CL	KC	Duration
1					
2					
3					
4					
5					
6					
7					

Outcome: At the end of the course the student will be able

CO1. The student will be able to know the practical skills to work with different manufacturing machines.

CO2. The student will be able to know the basic fundamentals of some advanced importantmanufacturing operations.
CO3. The student will be able to know to develop basic know how and awareness to deal with practical aspects of advanced manufacturing operations.
CO4. The student will be able to knowabout the mechanical properties and their requirements for various structures.
CO5. The student will be able to investigate different modern manufacturingoperations.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs /PSOs
CO1	PO1 / PSO2
CO2	PO2 / PSO2
CO3	PO4 / PSO2
CO4	PO3 / PSO2
CO5	PO5 / PSO2

BMEE 0193 PROJECT BASED MODERN MANUFACTURING PROCESS LAB

Pre-requisite: *Manufacturing Science –I and II Labs*

Objective*: This course introduces the fundamentals latest techniques and procedures for advanced advanced manufacturing processes, The Course will provide hands on training different manufacturing processes. Sample work will undergo inspection as part of testing to ensure that they confirm to different standards.*

Credits: 02 **L–T–P-J: 0–0–0-8**

1. Design and fabrication of micro abrasive jet for machining brittle materials.
2. Design and fabrication of self centering table vice for drilling machine.
3. Application of just-in -time manufacture strategy in a small scale industry.
4. Design and fabrication of drill tool dynamometer.
5. Toe load measuring device.
6. Application of Taugchi technique/ design of experiment to helment manufacturing process.
7. Design and fabrication of gear cutting attachment for lathe.
8. Computer aided feature extraction and cnc part program generation for rotational parts.
9. Design and fabrication of melting pot for indirect arc furnace.
10. Design and fabrication of progressive die.

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

CO	CO Statement	PO/PSO	CL	KC	Duration
1					
2					
3					
4					
5					
6					
7					

Outcome: At the end of the course the student will be able

CO1. The student will be able to know the practical skills to design and fabricatedifferent manufacturing processes.

CO2. The student will be able to know to know the basic fundamentals of different manufacturing processes.

CO3. The student will be able to know to develop basic know how and awareness to deal with practical aspects of advanced manufacturing processes. CO4. The student will be able to know about the programs developed to enhancethe working capability.

CO4. The student will be able to know different advanced machining and manufacturing operations.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes(PSOs):

COs	POs / PSOs
CO1	PO1 / PSO2
CO2	PO2 / PSO2
CO3	PO3 / PSO2
CO4	PO3 / PSO2
CO5	PO4 / PSO2

BMEE 0305 METAL FORMING ANALYSIS

Pre-requisite: *Manufacturing Science I*
Objectives: *To make the students understand the mechanics of metal forming and their behavior undervarious metal forming processes.*

Credits: 03 **L–T–P: 3–0–0**

Module No.	Contents	Teaching Hours (Approx.)
I	Review of two-dimensional stress and strain, state of stress in three dimensions, Stress tensor, Invariants, Mohr's circle for 3-dimensional state of stress, strain at a point-Mohr's circle for strain, Hydrostatic & Deviatory components of stress, Elastic stress strain relations. Elements of theory of plasticity; Flow curve, True stress & true strain, Yield criteria for ductile metals, Von Misses & Teresa yield criteria, combined stress tests. The yield locus, Anisotropy in yielding, Yield surface, levy-Misses, Prandtl-Reuss Stress-Strain relation, Classification of forming processes variables in metal forming and their optimization Analysis of deformation processes- Method based on homogeneous compression slip line field theory, Upper bounds and lower bounds, Slab method of analysis.	22
II	Flow stress determination, Hot working, Cold working, Strain rate effect, Friction and lubrication, Deformation zone geometry, Workability, Residual stress. Analysis of metal forming processes (only limited portion), Forging: Load calculation in plane strain forging, rolling: Forces & geometricalrelationship in rolling, Rolling load and torque in cold rolling, Von-Karman work equation, Extrusion: Analysis of extrusion process, extrusion pressure, Drawing: Drawing load	20

Text Books:

- R.H Wagoner, Metal Forming Analysis, Cambridge University Press
- G. W. Rowe, Principles of Industrial Metal working processes, CBS publishers and Distributors
- B. L. Juneja, Fundamentals of Metal forming processes, New age international publishers
- Ghosh and A. K. Malik, Manufacturing Science, East West Press

Reference Books:

- Johson & Mellor, Van Nostrand: Engineering Plasticity.
- Avitzur, Mc Graw Hill: Metal working.

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcomes:

CO	CO Statement	PO/PSO	CL	KC	Duration
1	*Identify various forming process*	PO1, PSO2	An	C	8 Hours
2	*Identify and determine various yield criteria used in forming proces*	PO2, PSO2	An	C	10 Hours
3	*Learn mechanics of forging processes*	PO1, PSO2	U	P	8 Hours
4	*Learn mechanics of extraction processes*	PO2, PSO2	U	P	8 Hours
5	*Learn mechanics of drawing processes.*	PO1, PSO2	U	P	8 Hours

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs / PSOs
CO1	PO1 / PSO2
CO2	PO2 / PSO2
CO3	PO1 / PSO2
CO4	PO2 / PSO2
CO5	PO1 / PSO2

BMEE 0301 CNC & ROBOTICS

Pre – requisite: ***Manufacturing Science-II***

Objective: *To understand the principle and performance of vehicle in various modes such as longitudinal, vertical and lateral directions. At the end of the course the student will be able to identify the various forces and loads and performance under acceleration, ride and braking.*

Credits: 02 **Semester VI** **L–T–P: 2–0–0**

Module No.	Content	Teaching Hours
I	**Automation:** Need of Automation, types of Automation, Automation Strategies, and Advantages & Disadvantages of Automation. **CNC Technology:** History of Numerical control, Introduction to CNC machine tools, classification of CNC machine tool, Designation of axis in CNC systems. **Part Programming:** (A) Manual Programming- G&M codes, Manual part programming for Drilling, Turning and Milling; Canned Cycles.	15
II	**Introduction to Additive Manufacturing:** Introduction to AM, AM evolution, Distinction between AM & CNC machining, types of AM processes, AM process chain, Advantages and Limitations of Additive Manufacturing. Application of AM. **Robotics:** Robot Anatomy, Laws of Robot, Coordinate system, Specifications of Robot. Power sources, actuators and Transducers, Robotic Sensors, Grippers, Robot Safety, Robot Programming and Robot Applications.	15

Text Books:

- Kundra and Rao, "Computer Aided Manufacturing", TMH, New Delhi.
- Koren, "Computer control of Manufacturing systems", TMH, New Delhi.
- Groover Mikell P., "Automation, Production Systems and Computer Integrated Manufacturing", *Prentice Hall Publishers.*

Reference Books:

- John Stenerson and Kelly Curran, Computer Numerical Control: Operation and Programming, PHI, New Delhi, 2009
- Tien - Chien Chang, Richard A Wysk and Hsu-Pin Wang, Computer Aided Manufacturing, PHI, New Dellhi,2006
- Ian Gibson, David W Rosen, Brent Stucker., "Additive Manufacturing Technologies: Rapid *Prototyping to Direct Digital Manufacturing", Springer, 2010*

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

CO1	Understand the need of automation and its strategies used for development in manufacturing.
CO2	Develop manual part programs for machining of complex parts.
CO3	Illustrate the basic parts and necessity of Robotic system in Industries.
CO4	Understand Basics of Additive Manufacturing

Mapping of Course Outcomes (Cos) with Program Outcomes (Pos) and Program Specific Outcomes (PSOs):

COs	*POs/PSOs*
CO1	*PO1, PO2,PO3, PO4/ PSO2*
CO2	*PO1, PO6/ PSO2*
CO3	*PO6/ PSO2*
CO4	*PO1, PO6,/ PSO2*

BMEE 0401 INDUSTRIAL ENGINEERING

Objective:

- *To enable the students understand the demand forecasting techniques and costing.*
- *To provide students an insight into the concepts of industrial engineering andorganization.*
- *To familiarize the students with principles of work-study and Ergonomics.*
- *To introduce students to various aspects of plant design and materials planning.*

Credits: 3 **L–T–P-J: 3–0–0-0**

Module No.	Content	Teaching Hours
I	**Industrial Organization:** Concept, Scope, Objective, Functions, Techniques, & Role of Industrial Engineering. Meaning of Productivity, Difference Between Production & Productivity, Induces of Productivity, Reasons of Low Productivity, Techniques to Improve Productivity. Types of Production, Plant Layout. **Demand Forecasting:** Demand variation, Factors influencing demand, Judgmental Forecast, Time series-Rolling average, Weighted Moving Average, Exponential smoothing, casual forecast-Correlation, Linear regression, Forecast Error. **Work Study:** Meaning & Benefit of Work Study, Method Study, Recording Techniques-Process Chart, Time scale chart, Flow & String Diagram, Micro-Motion Study, SIMO Chart, Cycle &Chrono Cycle Graph, Time Study- Performance Rating, Allowances, Computation of Standard Time, Work Sampling, PMTS. **Material Handling:** Introduction, Objectives, Elements and Principles of Material Handling. **Quality Control:** Process Control, SQC Charts, Single, Double and Sequential Acceptance Sampling, Quality Function Deployment.	26
II	**Production Management:** Production Planning & Control, Inventory Control- Types of Inventory, Cost Associated with Inventory, Deterministic Inventory Models, Inventory Control Techniques, Cost of Production, Brake-Even-Analysis. **Advance Topics in Production Management:** Total Quality Management (TQM)- TQM Approach, Stages of implementation, TQM Model, Just In Time (JIT) Manufacturing – Seven Waste, Basic Elements, JIT Philosophy, Kanban Syatem.	14

Text Books:

- Khanna O.P., “Industrial Engineering & Management”, Dhanpat Rai& Sons.
- Shanker Ravi, “Industrial Engineering”, Galgotia PVT Ltd.
- Telsang Martand, “Industrial Engineering and Production Management”, S. Chand, New Delhi

Reference Books:

- Koontz H. & Donnel C. O., "Principle of Management & Analysis of Management Functions", Tata McGraw Hill Co.
- Moore J., "Manufacturing Management", Prentice Hall Englewool cliffs: New Jersey.

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

CO	CO Statement	PO/PSO	CL	KC	Duration
1					
2					
3					
4					
5					
6					
7					

Outcome: *On successful completion of this lab, the students will be able to:*

- *CO1: Apply concepts of Industrial Engineering in the field of different industries.*
- *CO2: Understand different concepts regarding Organization and Productivity in industries.*
- *CO3: An ability to identify, formulates, and solves engineering problems by analyzing and interpreting data.*
- *CO4: Planning and controlling of production system and use of modern forecasting and management techniques for different types of industries.*
- *CO5: An ability to design, develop, implement, and improve integrated systems that include people, materials, information, equipment, and energy.*
- *CO6: An understanding of professional and ethical responsibility, ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.*

Mapping of Course Outcomes (Cos) with Program Outcomes (Pos) and Program Outcomes (PSOs):

COs	Pos/PSOs
CO1	PSO2, PO1, PO6
CO2	PSO2, PO1
CO3	PO2, PO9
CO4	PSO2, PO2, PO11
CO5	PSO1, PO3
CO6	PSO3, PO3, PO6, PO8

BMEE 0402 PRODUCT DESIGN AND DEVELOPMENT

Objectives:

- *To study the basic concepts of Product design and Development.*
- *To study the applicability of product design and development in industrial applications.*
- *To study the key reasons for design or redesign*.

Credits: 03 **L–T–P: 3–0–0**

Module No.	Contents	Teaching Hours (Approx.)
I	Classification/Specifications of Products. Product life cycle.Product mix, Introduction to product design, The Role and Nature of Design, Old and New Design Methods, Design byEvolution. , Design by Craft, Need Based Development, Technology Based Developments, Economic Feasibility of Design Concepts, Modern product development process, Innovative thinking, Morphology of design. **Reliability:** Reliability Considerations: Reliability Analysis of Systems, Bath Tub Curve, Reliability of Systems in Series and Parallel. Failure Rate, Mean Time to Failure (MTTF) and MeanTime Between Failures (MTBF).	20
II	**Decision Theory:** Decision Making Under Conditions of Certainty, Decision Making Under Conditions of Uncertainty, Decision Making Under Conditions of Risk, Maximum Likelihood Criterion, Variation of Expected Value Criterion. **Break-Even Analysis**: Fixed and Variable Costs, Assumptions ofBreak Even Analysis, Utility of Break Even Analysis, Limitationof Break Even Analysis **Statistical Quality Control (SQC):** Advantages of Statistical Quality Control, Quality Control Charts, Types of Control Charts Such as X(Bar) and R Chart, P Chart and C Chart. **Technological Forecasting**: Characteristics and Importance ofTechnological Forecasting, Different Forecasting Methods, **Patents & IP Acts**-Overview, Disclosure preparation.	20

Text Books:

- Chitab A.K. & Gupta R.C., "*Product Design & Manufacturing*", PHI (EEE).
- Ulrich K. T, and Eppinger S.D, "*Product Design and Development*", Tata McGraw Hill

Reference Books:

- Starr M.K., "*Product Design & Decision Theory*", Prentice Hall.
- Cain C .D, "*Engineering Product Design*", Business Books.
- Mayall W .H. Itiffe, "*Industrial Design for Engineers*", TMH.
- J. Christopher Jones, "*Design Methods – seeds of human futures*", John Wiley & Sons.
- James Boyle, Jennifer Jenkins, intellectual property: law & the information society- cases &materials,

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: Students will be able to:

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Identify and analyze the product design and development processes in manufacturing industry.	PO1 / PSO1	U	C	
2	Define the components and their functions of product design and development processes and their relationships from concept to customer over whole product life cycle.	PO2 / PSO1	U	C	
3	Analyze, evaluate and apply the methodologies for product design, development and management.	PO3 / PSO1	AN	M	
4	Decision making ability of the students will improve, they can take the right decisions regarding the product without the proper information.	PO3 / PSO2	A	P	
5	Undertake a methodical approach to the management of product development to satisfy customer needs.	PO11/ PSO2	A	P	
6	Carry out cost and benefit analysis through various cost models.	PO11/ PSO2	U	C	

Mapping of Course Outcomes (Cos) with Program Outcomes (Pos) and Program Outcomes (PSOs):

COs	POs / PSOs
CO 1	PO1 / PSO1
CO 2	PO2 / PSO1
CO 3	PO3 / PSO1
CO 4	PO3 / PSO2
CO 5	PO11/ PSO2
CO 6	PO11/ PSO2

BMEE 0403 OPERATIONS RESEARCH

Pre-requisite: *Industrial Engineering*

Objective:

- *Provide knowledge of OPTIMIZATION approaches*
- *To develop Decision-making skills.*
- *Provide scope to students to research methods and latest trends in operation research.*
- *To understand the various business situations.*

Credits: 03 **L–T–P: 3-0-0**

Module No.	Content	Teaching Hours
I	**Introduction:**Basics of Operations Research, Application Area, Models, Advantages and Disadvantages of Operations Research. **Linear Models:** **Linear programming:** Problem Formulation, Graphical Method, Simplex Method, Duality in Linear Programming, Big M-Artificial Variable Method, Degeneracy. **Assignment Problems:** Mathematical Formulation, Hungarian Method Problem, Degeneracy in Assignment Problem **Transportation:**Matrix Form, Basic Feasible Solution:- North west method, Least cost method, Vogel's approximation method. Optimum Solution :- MODI method, Unbalanced-Problems, **Dynamic Programming:** Multistage Decision Problems & Solutions, Principle of Optimality. **Game Theory:**Two Persons Zero Sum Game, Solution With/Without Saddle Point, property of Dominance, Graphical methods	20
II	**Sequencing:** Introduction, Assumption, Johnson's Procedure for N Jobs on Two Machines and N Jobs on Three Machines. **Simulations:** Simulation V/S Mathematical Modeling, Monte-Carlo Simulation, Simulation Languages, Uses, Advantages and Limitations. **Inventory Models:** Various cost and concepts, EOQ, Deterministic inventory models-production model-Buffer stock **Queuing Models**: Introduction, Poisson and Exponential Distribution, Single Server and Multi Servers Models. **Networks:** Basic Concepts, Construction of networks, Rules for Network Drawing, CPM Calculations. Pert Calculations Such As Different Times and Different Floats. Case study based 2 Mini projects.	20

Text Books:

- *Gupta Prem Kumar, Hira D.S., "Operations Research": S. Chand & Co.*
- *Taha, Hamdy A., "Operations Research": Prentice Hall International Publications.*

Reference Books:

- *Wagner, Claire, "Principles of Operations Research": Prentice Hall International Publications.*

- *Buffa, Edwood, "Production Planning of Operation Management": TMH Publications.*
- *Rao, S.S., "Optimization Techniques": Wiley Eastern Limited.*
- *Pradeep. p. Pai, "Operation Research": Oxford university Press.*

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: After completion of the course, student will be able to:

CO	CO Statement	PO/PSO	CL	KC	Duration
1	To impart knowledge in concepts and tools of Operations Research.	PO1, PO2, PO6/ PSO3	Remember	Factual	6
2	Apply the knowledge & tools of operation research in various industries.	1,9/3	Apply	Procedural	6
3	Proficient to recognize the importance and value of mathematical modeling in solvingpractical problems in industry by linear programming problems.	2,11/3	Understand	Factual	6
4	Understand the mathematical tools that are needed to formulate & solve transportationproblems for cost optimization.	5,9,11/3	Understand	Factual	5
5	Understand the process of best strategy using decision making methods underuncertainty and game theory.	3,4,10,11/3	Understand	Factual	6
6	Determine the optimum sequence of n job over 2 and 3 machining by sequencing.	3,5/3	Apply	Procedural	5
7	Understand the concept of project network, project schedule and project monitoringactivities by using CPM and PERT method.	8,11,12/3	Apply	Procedural	6

BMEE 0404 VALUE ENGINEERING

Pre-requisite: *Industrial Engineering*

Objective

- Understand the importance of value engineering and its application in their respective fields
- Familiarize with the procedure of Value analysis and Value engineering
- Implementation of value engineering.

Credits: 03 **L–T–P: 3–0–0**

Module No.	Content	Teaching Hours
I	**Introduction:** Meaning of Value Engineering (VE), Value and its types, Relationship between value vis-a-vis person, time and environment, History of ValueEngineering, Value Analysis, Value Management, World b od i e s of Value Engineering & their activities, Multi-disciplinary team approach in Value Engineering study. **Job Planning:** Introduction and comparison of job plans in value engineering, Finance and human relations in VE. **Orientation Phase:** Training associates in Value Analysis and Value Engineering (VAVE). Different training and certifications available in VAVE, Method to conduct VAVE studies. **Information Phase**: Information needed for VAVE, method to collect and analyze information, ABC Analysis, Pareto Analysis, Breakeven analysis. **Function Analysis Phase**: Breakdown item into elements and sub-elements, Introduction to functions, practice session, types of functions (use and sell function), levels offunction (basic and secondary), identify various functions.	22
II	**Function Analysis Phase**: Elements of cost, procedure for cost allocation, cost allocation to function, concept of worth, process flow for determining worth, discussions on worth, meaning of FAST, use of FAST, development history of FAST, different types of FAST. Ground rules of FAST, FAST diagram **Creative Phase:** Definition of creativity, misconceptions about creativity and introduction to creative techniques like TRIZ, 3P, lateral adoption and others **Evaluation Phase:** Selection criteria, feasibility analysis, weighted evaluation methods, decision matrix. **Recommendation Phase**: Need for recommendation, method to make presentation, impact analysis and justification report, implementation plan, presentation skills. **Implementation Phase**: Detailed design, verification and validation, certification, change implementation. **Audit Phase**: Need for audit, types of audit, how to audit.	22

Text Books:

- *Lawrence D. Miles, Techniques of Value Analysis and Engineering, 3rd Edition, New York*
- *K R.Chari, Value engineering, NPC, New Delhi*

Reference Books:

- *SS Iyer, Value Engineering: A How-to Manual, New age International Publisher- 2"d edition009*
- *Anil Kumar Mukhopadhaya, Value Engineering Mastermind: From Concept to Value Engineering Certification. SAGE, New Delhi*
- *Del. LYonker, Value engineering analysis and methodology, CRC press, New York*
- *Dr. M.A. Bulsara, Dr. H.R. Thakkar, Product Design and Value Engineering, charter publishers,1st edition 2015.*

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: *After completion of the course, student will be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	To impart knowledge in concepts and tools of Value Engineering	*PO2, PSO2*	U	C	8 Hours
2	Apply the knowledge & tools of Value Engineering in industries.	*PO1, PSO2*	A	C	9 Hours
3	Understand the Different phases of value engineering and their sequence	*PO3, PSO2*	U	P	9 Hours
4	Understand and apply the methods of job planning.	*PO5, PSO2*	A	C	9 Hours
5	Analyze the product design & development by applying concept of value engineering.	*PO2, PSO2*	An	P	9 Hours

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program SpecificOutcomes (PSOs)

COs	POs/PSOs
CO1	**PO1, PO2, PO6 / PSO2**
CO2	**PO1, PO9, PO11 / PSO2**
CO3	**PO1, PO3 / PSO2**
CO4	**PO1, PO3, PO5, PO9 / PSO2**
CO5	**PO2, PO3, PO11 / PSO2**

BMEE XXXX SUPPLY CHAIN MANAGEMENT

Pre-requisite: *Industrial Engineering*

Course Objectives: *To impart knowledge and understanding to students on Supply Chain Management and its relevance to today's business decision making.*

- *Develop an understanding of the role of supply chain in a market-oriented society*
- *Examine the major functions of supply chain*
- *Provide an opportunity for comprehensive analysis and discussion of key contemporary issues*
- *and problems in supply chain management*
- *Examine the details of planning and control processes in supply chain management*

Credits: 3 **L–T–P: 3–0–0**

Module No.	Contents	Teaching Hours (Approx.)
I	**Applied Supply Chain Management:** Introduction, Definition, Objectives & Importance of supply chainmanagement, complexity & key issues, Centralized vs. decentralized systems, Drivers in SCM, SCM decisions and skills, Strategy formulation in SCM, , Bullwhip effect, Push- based, pull based systems **Information technology in supply chain:** Value of information, Enabling supply chain through IT, Criticalbusiness processes and information systems - DBMS, benefits of ERP information system, RFID **Strategic Sourcing:** Source evaluation, collaborative perspective, Buyer-Supplier Relationship, Partner Selection, develop of Partnership, importance of inventory, imbalances, uncertainties, inventory costs, inventory turnover ration	21
II	**Transportation decision:** Tradeoff, Modes of Transportation, Models for Transportation and Distribution, Factors affecting Network Effectiveness, 3 PL advantages, Bar CodingVendor analysis model, Coordinated SCM, Reverse Vs forward supply chain, types of reverse flows, collaborative SCM's and CPFR, agile systems, sources of variability, characteristics, supplier interface Supply Chain Management and profitability, quality management, mass customization and globalization, ethical Supply Chains, e-business and SCM, Balanced Score Card, Benchmarking, Performance measurement	19

Text Books:

- R P Mohanty, S.G Deshmuki "Supply Chain Management" Biztantra, New Delhi,2005
- Chopra and Meindl, Supply Chain Management 2007
- Janat Shah, Supply Chain Management , 2016

Reference Books:

- Bowersox, Logistical Management, Mc-Graw Hill, 2000
- Sahay B S, Supply Chain Management for Global Competitiveness, Macmillan India Ltd., New Delhi.
- Reguram G, Rangaraj N, Logistics and Supply Chain Management Cases and Concepts, Macmillan India Ltd., New Delhi, 1999.
- Coyle, Bradi&Longby, The Management of Business Logistics, 3rd Ed., WestPublishing Co.

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: *After completion of course, the student will be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	*Become familiar with current supply chain management trends Understand and apply the current supply chain theories, practices and concepts utilizing case problems and problem-based learning situations*	PO2/PSO3	U	C	6
2	*Develop a sound understanding of the important role of supply chain management in today's business environment*	PO1/PSO2, PSO3	U	C	6
3	*Learn to use and apply computer-based supply chain optimization tools including the use of selected state of the art supply chain software suites currently used in business*	PO5/PSO3	U	C	6
4	*Develop and utilize critical management skills such as negotiating, working effectivelywithin a diverse business environment, ethical decision making and use of informationtechnology*	PO8/PSO3	A	P	6
5	*Demonstrate the use of effective written and oral communications, critical thinking, teambuilding and presentation skills as applied to business problems*	PO4/PSO3	R	P	8
6	*Successfully complete a case project concluding with a written and oral presentationof the findings*	PO3, PO4/PSO3	A	P	8

BMEE 0405 OPERATION RESEARCH FOR TECHNOCRATE

Objective:

- *Provide knowledge of OPTIMIZATION approaches*
- *To develop Decision-making skills.*
- *Provide scope to students to research methods and latest trends in operation research.*
- *To understand the various business situations.*

Credits: 03 **L–T–P: 3-0-0**

Module No.	Content	Teaching Hours
I	**Introduction:** Basics of Operations Research, Application Area, Models, Advantages and Disadvantages of Operations Research. **Linear programming:** Problem Formulation, Graphical Method, Simplex Method, Duality in Linear Programming, Big M-Artificial Variable Method, Degeneracy. **Assignment Problems:** Mathematical Formulation, Hungarian Method Problem, Degeneracy in Assignment Problem **Transportation:** Matrix Form, Basic Feasible Solution:- North west method, Least cost method, Vogel's approximation method. Optimum Solution :- MODI method, Unbalanced-Problems, **Game Theory:** Two Persons Zero Sum Game, Solution With/Without Saddle Point, property of Dominance.	20
II	**Sequencing:** Introduction, Assumption, Johnson's Procedure for N Jobs on Two Machines and N Jobs on Three Machines. **Simulations:** Simulation V/S Mathematical Modeling, Monte-Carlo Simulation, Uses, Advantages and Limitations. **Inventory Models:** Various cost and concepts, EOQ, Deterministic inventory models, Concept of Buffer stock **Queuing Models**: Introduction, Poisson and Exponential Distribution, Single Server and Multi Servers Models. **Networks:** Basic Concepts, Construction of networks, Rules for Network Drawing, CPM Calculations. PERT Calculations Such as Different Times and Different Floats.	20

Text Books:

- *Gupta Prem Kumar, Hira D.S., "Operations Research": S. Chand & Co.*
- *Taha, Hamdy A., "Operations Research": Prentice Hall International Publications.*

Reference Books:

- *Wagner, Claire, "Principles of Operations Research": Prentice Hall International Publications.*
- *Buffa, Edwood, "Production Planning of Operation Management": TMH Publications.*
- *Rao, S.S., "Optimization Techniques": Wiley Eastern Limited.*
- *Pradeep. p. Pai, "Operation Research": Oxford university Press.*

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome:

After completion of the course, student will be able to:

CO1: To impart knowledge in concepts and tools of Operations Research.

CO2: Apply the knowledge & tools of operation research in various industries.

CO3: Proficient to recognize the importance and value of mathematical modeling in solvingpractical problems in industry by linear programming problems.

CO4: Understand the mathematical tools that are needed to formulate & solve transportationproblems for cost optimization.

CO5: Understand the process of best strategy using decision making methods underuncertainty and game theory.

CO6: Determine the optimum sequence of n job over 2 and 3 machining by sequencing.

CO7: Understand the concept of project network, project schedule and project monitoringactivities by using CPM and PERT method.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

COs	**POs/PSOs**
CO1	**PO1,PO2,PO6/PSO3**
CO2	**PO1,PO9/PSO3**
CO3	**PO2,PO11/PSO3**
CO4	**PO5,PO9,PO11/PSO3**
CO5	**PO3,PO4,PO10,PO12/PSO3**
CO6	**PO3,PO5/PSO3**
CO7	**PO8,PO11,PO12/PSO3**

BMEE 0406 APPLIED ERGONOMICS

Pre-requisite: *Product Development & Design*
Objective: *The objective of this course is to introduce industrial ergonomics and the vast application of ergonomics in industry and design research for product system.*

Credits: 03 **L–T–P: 3–0–0**

Module No.	Content	Teaching Hours
I	**Introduction:** Definition of Ergonomics / Human Factors. The evolution of Ergonomics, reasons to use ergonomics, micro- and macro- ergonomics, performing ergonomics, judging the effectiveness of ergonomics intervention. **Human Body:** Human capabilities and limitations in terms of engineering. Anthropometrical, Physiological, Psycho-social considerations in Ergonomics. **Ergonomics design methodology:** Occupational safety and stress at workplace; Workstation design; Furniture and Environment factors affecting human performance; Design development and usability evaluation. **Office Workstation**: Theories of healthy standing and sitting, free posturing, ergonomics design of the office computer workstation. **Methods, Standards and Work Design:** Determination of work content, workstation, work methods, and times required for various occupational jobs/tasks. Design of tasks/jobs, workplace, and work environment to increase productivity, eliminate waste, and decrease occupational injury/illness.	22
II	**Musculo-skeletal system**: Joint motion study, Basic model on calculation of biomechanical stresses on our body. **Product Ergonomics:** Product ergonomics and design, design from the view point of biomechanics, Work posture analysis, static and dynamic work, the visual, auditory and thermal environment and their impact on design. design for the physically challenged. **Research technique:** Ergonomic data generation, interpretation and application of statistical methods. Case analysis. **Mini project:** Mini Project work involving ergonomic design research for product system.	18

Text Books:

- M. S. Sanders and Ernest J. McCormick: Human factors in engineering and design, sixth Edi. McGraw-Hill International Editions, 1987.
- P.O. Astrand and K. Rodahl : Textbook of work physiology, McGraw Hill, New York, 1970.
- Konz SA & Johnson S. Work Design: Industrial Ergonomics. 6thEdition, Holcomb Hathaway Publishers, 2004. ISBN: 1-890871-48-6

Reference Books:

- R.S Bridger, Introduction to Ergonomics, McGraw-Hill Inc., 1995.
- G. Salvendy Ed., Handbook of Human Factors and Ergonomics, John Wiley and Sons, 1997.
- D. Chakrabarti, Indian Anthropometric Dimensions for Ergonomic Design Practice, National Institute of Design, Ahmedabad, 1997.

Outcome: *Upon completion of the course, students should be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Apply basic knowledge of physical ergonomics such as physical load, anthropometry, biological variation and biomechanics	PO3/PSO1	A	C	8
2	Explain and apply basic knowledge of cognitive ergonomics such as perception, memory, information processing, attention, learning, decision-making, stress, mental workload and maltreatment	PO2/PSO1	U	C	8
3	Apply basic knowledge of physical factors affecting human beings in relation to light, lighting, soundand noise, climate and vibrations	PO5/PSO1	A	C	8
4	Identify and relate factors affecting human performance in the interaction with products, analyse and reflect on the results of ergonomic analysis of product systems and draw conclusions and give recommendations for product improvement	PO1/PSO1	U	P	8
5	Present a completed ergonomic analysis of product and workplace orally and inwriting	PO1/PSO1	R	P	8

BMEE 0501 ROBOTICS & FMS

Pre-requisite: *Industrial Engineering*

Objective: *To introduce the foundations of robotics. Also, a course on Robotics must use one or more software to not only visualize the motion and characteristics of robots but also to analyser/synthesize/design robots for a given application.*

Credits: 03 **L–T–P: 3–0–0**

Module No.	Content	Teaching Hours
I	**Fundamentals of Robot Technology**: Robot definition, automation and robotics, Robot anatomy, Work volume, Drive systems. Control systems and dynamic performance. Accuracy and repeatability. Sensors and actuators used in robotics. Machine Vision, Robot configurations, Path control. Introduction to robot languages. Applications; Types (Mobile, Parallel); Serial: Cartesian, Cylindrical, etc.; Social Issues **Robot Kinematics**: Mapping, Homogeneous transformations, Rotation matrix, Forward Kinematics (DH Notation) and inverse kinematics: Closed form solution. **Robot Differential Motion:** Linear and Angular velocity of rigid link, Velocity along link, Maipulatorjacobian, Statics: Use of jacobian.	20
II	**Robot Dynamics:** Lagrangian Mechanics, Lagrangian Formulation and numerical. Dynamics, Newton-Euler Recursive Algorithm, Simulation. Euler-Lagrange Equations of motion/Any one other formulation like using Decoupled Natural Orthogonal Complements (DeNOC) **End effectors**: Mechanical and other types of grippers. Tools as end effectors. Robot and effector interface. Gripper selection and design. **Applications for Manufacturing**. Flexible automation. Robot cell layouts. Machine interference. Other considerations in work cell design. Work cell control, interlocks. Robot cycle time analysis. Mechanical design of robot links. Typical applications of robots in material transfer, machine loading/unloading; processing operations; assembly and inspection.	20

Text Book:

- R.K. Mittal, I.J. Nagrath, "Robotics & Control", Tata McGraw & Hills, 2005.
- Mikell P Groover, Mitchell Weiss "Industrial Robotics: Technology, Programming and Application"
- Tata McGraw & Hills, 2009.
- S.K.Saha,"Introduction to Robotics", 2nd Edition, McGraw-Hill Education, New Delhi, 2014

Reference Books:

- John J.Craig; "Introduction to Robotics Mechanics & Control", Pearson Education, 2004.
- Robert J. Schilling, "Fundamentals of Robotics, analysis & Control", Prentice Hall (I) P. Ltd., 2002
- Mark W. Spong, Seth Hutchinson, M. Vidyasagar "Robot Modeling and Control" John Wiley 2nd Ed
- J Srinivasan, R.V .Dukkipati, K. Ramji, "Robotics control & programming", Narosa.
- Ghosal, Ashitava, "Robotics: Fundamental Concepts and Analysis," Oxford University Press, 2006
- M. Murray, M., Li, Zexiang, Sastry, S.S., "A Mathematical Introduction to Robotic Manipulation," CRC Press, 1994
- Tsai, L.W., "Robot Analysis: The Mechanics of Serial & Parallel Manipulators," Wiley 1999

- Niku, S. B., "Introduction to Robotics: Analysis, Systems, Applications", Prentice Hall, 2001

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: *Upon completion of the course, students should be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Understand the fundamentals of robot technology functions such as dynamicperformance, Sensors and actuators used in robotics.	PO1/PSO2/PSO3	U	F, C	6
2	Knowledge of Machine Vision, Robot configurations, Path control languages.	PO1/PO2/PO12/PSO3	An	F, PC	8
3	Understand of Cartesian, cylindrical, spherical and various application in robotics	PO1/PSO2/PSO3	U	C, PC	7
4	Knowledge of modeling for kinematic and dynamics verification of any robotstructure using suitable software	PO1/PO2/PO12/PSO3	U	F, C&S	8
5	Understand robot differential motion, grippers and end effectors	PO1/PO3/PSO2/PSO3	U	P, FDP	5
6	Understand of various sensors, FMS integration and programming for linearand nonlinear path in robotic applications	PO1/PO2/PO12/PSO3	U	FDP, C	9

Mapping of Course Outcomes (COs) with Program outcomes (POs) and Program SpecificOutcomes (PSOs):

COs	POs/PSOs
CO1	PO1/PSO2/PSO3
CO2	PO1/PO2/PO12/PSO3
CO3	PO1/PSO2/PSO3
CO4	PO1/PO2/PO12/PSO3
CO5	PO1/PO3/PSO2/PSO3
CO6	PO1/PO2/PO12/PSO3

BMEE 0182 ROBOTICS & FMS LAB

Credits: 01 **L–T–P-J: 0–0–2-0**

Module No.	Content	Teaching Hours
I	• Development of multiple sensor fusion use in various roboticapplication • Demonstration of articulated SCARA, PUMA and otherrobots. • Demonstration of Cartesian, cylindrical, spherical and variousapplication in robotics • Virtual modeling for kinematic and dynamics verification ofany robot structure using suitable software • Forward, inverse kinematics and trajectory planning for PUMA, SCARA and Stanford using robotics tool box forMATLAB	12
II	• Study of various sensors integration in robotic applications • Programming for linear and non linear path using roboticapplication • Simulation of planner and spatial mechanism using multi bodydynamics software. • Design, modeling and analysis of different types of grippersand manipulators. • To introduce and demonstrate flexible manufacturing system • To study and integrate various FMS component like machinesand actuators in different application of factory automation • Study and programming of sensors integration in various FMSapplications	12

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: *At the end of this course students will be able to:*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Understand the functions of multiple sensor fusion use in various robotic application.	PO1/PSO2/PSO3	U	F, C	4
2	Knowledge of articulated SCARA, PUMA and other robots.	PO1/PO2/PO3/PO12/PSO3	U	C	4
3	Understand of Cartesian, cylindrical, spherical and various application in robotics	PO1/PSO3	U	C	4
4	Knowledge of modeling for kinematic and dynamics verification of any robot structure using suitable software	PO1/PO2/PO12/PSO3	An	C, P	4
5	Knowledge of forward, inverse kinematics and trajectory planning for PUMA, SCARA and Stanford using robotics tool box for MATLAB.	PO1/PSO2/PSO3	Ap	P	4
6	Understand of various sensors, FMS integration and programming for linear and nonlinear path in robotic applications	PO1/PO2/PO12/PSO3	U	F, C	4

BMEE 0196 PROJECT BASED ROBOTICS & FMS LAB

Credits: 02 **L–T–P-J: 0–0–0-8**

Module No.	Content	Teaching Hours
	• Study of DTMF Controlled Robot without Microcontroller: The main aim of this project is to control a robotic vehicle by giving the instruction through mobile phone using DTMF technology. This can be used for surveillance systems and industrial applications. • Study of Microcontroller Based Line Following Robot: This project illustrates the concept of tracking or following the path specified to a robotic vehicle using AVR microcontroller. This project uses IR sensor to detect the path specified by the user. • Study of PC Controlled Human Detection Robot: This project aims to detect the humans through a robotic vehicle by using IR sensors and microcontroller unit. This project is very helpful in the time of earth quakes to detect the personnel. • Study of Metal Detector Robot Using Microcontroller: A Metal detector robot is useful to sense the metals in the path ahead of it. This will be necessary requirement in case land mines detection. So this project meets the requirement with simple microcontroller based robot. • Study of Obstacle Avoiding Robot: This is an autonomous intelligent robot which is built with infrared sensors to sense the obstacles coming in the path of the robot and correspondingly changes the direction of the robot. • Study of Automatic Fire Sensing and Extinguishing Robot: This project aims to develop a multi flame sensor based firefighting robot. If the fire takes place, the robot moves towards the fired area and starts sprinkling the water from water pump attached to it. • Study of Automated System Design for Metro Train: This is an automated system for a metro train which announces the station name and displays the relevant information when train arrives at particular station. In this, RFID tags are used for tracking the station data. • Study of Color Guided Material Handling Robot: The main idea of this project is to build a color detecting robot which separates the objects that are moving on a conveyer belt in an industry. This project uses	24

	MATLAB to develop color detective algorithm. • Study of Arduino Based Smart Boat with Obstacle Detection: This is a simple DIY project which helps to design a boat with additional features like light guided control and obstacle detection. • Study of Design of Microcontroller Based Edge Avoider Robot: This project implements a robot which can avoid edge by detecting early and takes further action in time. This project also includes path finding, obstacle detection and line follower capabilities.	

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome: At the end of this course students will be able to

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Understand the functions of multiple sensor fusion use in various robotic application.	PO1/PSO12/PSO2, PSO3	R	F	4
2	Knowledge of DTMF Controlled Robot without Microcontroller, PUMA and other robots.	PO1/PO2/PO12/PSO3	U	C	4
3	Understand the working of Automatic Fire Sensing and Extinguishing Robot	PO1/PSO3	U	C, P	4
4	Knowledge of modeling for kinematic and dynamics verification of structure using suitable software for Obstacle Avoiding Robot.	PO1/PO2/PSO3	A	P	4
5	Knowledge of forward, inverse kinematics and trajectory planning for PUMA, SCARA and Stanford using robotics tool box for MATLAB.	PO1/PSO2/PSO3	R	P	4
6	Understand the various sensors and their applications in Metal Detector Robot Using Microcontroller	PO1/PO2/PO12/PSO3	U	F, C	4

Mapping of Course Outcomes (COs) with Program outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs/PSOs
CO1	PO1/PSO12/PSO2, PSO3
CO2	PO1/PO2/PO12/PSO3
CO3	PO1/PSO3
CO4	PO1/PO2/PSO3
CO5	PO1/PSO2/PSO3
CO6	PO1/PO2/PO12/PSO3

BMEE 0502: INDUSTRIAL AUTOMATION & CONTROL SYSTEMS

Pre-requisite: *Industrial Engineering*

Objective: *Introduction to the concept of industrial automation, scope of automation and study of socio-economic effects. Introduction to the fluid power control and study of the different fluid power systems working. Introduction to the automated material handling system used in automated industry. Study of the working principle mechatronics devices and different types of controllers. Introduction to the control systems*

Credits: 03 **L–T–P: 3–0–0**

Module No.	Contents	Teaching Hours
I	**Introduction:** Concept and Scope of Industrial Automation, Socio-Economic Considerations, And Pneumatic Logic Circuits: Un-Complementation Algorithm. **Fluid Power Control:** Fluid Power Control Elements and Standard Graphical Symbols for Them, Construction and Performance of Fluid Power Generators, Hydraulic & Pneumatic Cylinders - Construction, Design and Mounting, Hydraulic & Pneumatic Valves for Pressure, Flow & Direction Control, Servo Valves and Simple Servo Systems With Mechanical Feedback, Simple Hydraulic and Pneumatic Circuits. **High Volume Production Systems:** Transfer Devices & Feeder, Classification, Construction & Application, Automated Flow Lines, Analysis of Automated Flow Lines for Reliability and Efficiency, Assembly Systems.	22
II	**Mechatronics:** Mechanical System Interfacing, Simple Mechatronics Devices: Servo Motors, Stepping Motors, DC Motors, Analog / Digital Convertors. Types and Function of Controllers. Mathematical Modeling of Physical System and Concept of Transfer Function System. Representation Through Block Diagram and Signal Flow Graph. Time Domain Response Analysis Under Transient Input& Frequency Domain Analysis Root - Locus Techniques, Bode Plot.	18

Text Books:

- Nagrath & Gopal "Control System", McGraw Hill Education; 4th edition, 2012.
- Majumdar S. R., "Pneumatic Systems", Tata McGraw Hill, 2017
- Sundaram K. Shanmuga, "Hydraulic and Pneumatic Controls", S Chand & Company; 1st Edition2006
- Jagadeesha T, "Hydraulics and Pneumatics", Dreamtech Press, 2019

Reference Books:

- Esposito A., "Fluid Power with Applications", Pearson Education India; 7th edition, 2013
- Groover, M.P., "Automation, Production Systems & Computer Integrated Manufacturing",Pearson Education; Fourth edition, 2016.
- Norman S. Nise, "Control system Engineering" Willey, 2018.

Focus: This course focuses on Employability/Skill development and aligned with CO's 1 and 2

Outcome: After completion of course, the student will be able to:

CO	CO Statement	PO/PSO	CL	KC	Duration

1	Understand the Construction, Design and Mounting, Hydraulic & Pneumatic Valves for Pressure, Flow & Direction Control, Servo Valves and Simple Servo Systems With Mechanical Feedback	PO1/ PSO3	R, U	F, C	7
2	*Provide hydraulic solutions for designing automated systems.*	PO1/ PSO3	U, Ap. An	C, P	5
3	Understand devise Assembly automated systems using feeders, orienteers and escapement devices	PO1/ PSO3	U, Ap	P, M	6
4	Understand the principle and construction of Servo Motors, Stepping Motors, DC Motors and Analog / Digital Convertors. Types and Function of Controllers.	PO4/ PSO3	U. Ap	C, P, M	8
5	*Design and implement electro-pneumatic/hydraulic solutions for automated systems.*	PO1/ PSO3	U, Ap, An	C, P, FDP	8
6	Apply the Mathematical Modeling of Physical System and Concept of Transfer Function System	PO1,PO4/PSO3	Ap, An, E	C, M	6

BMEE 0504 ENGINEERING SYSTEM MODELLING AND SIMULATION

Pre-requisite: *Industrial Engineering*

Objective: *To introduce the students about the knowledge of basic and dynamic system models of engineeringand simulation system.*

Credits: 03 **L–T–P: 3–0–0**

Module No.	Content	Teaching Hours
I	**Basic System models:** Mathematical models, Mechanical system building blocks, Electrical system building block, fluid system building block, thermal system building block. **System Models:** Engineering systems, Rotational translational systems, Electro-mechanical systems, linearity, Hydraulic Mechanical systems. **Dynamic Response of Systems:** Modelling dynamic systems, Terminology, First order systems, second order systems, performance measure of second order systems, system identification. **System Transfer Functions:** The transfer function, first order systems, second order systems, systems in series, systems with feedback loops, effect of pole location on transient response.	19
II	**Mechanical Event Simulation (Finite Element modeling and Analysis):** Introduction, General procedure of finite element method, finite element analysis, iso-parametric evaluation of element matrices, finite element modeling, mesh generation, design and engineering applications. Introductionto Pro E software – Mechanical & dynamic simulation module. **System Simulation:** Introduction, Review of probability and statistics, managing the event calendar in a discrete event simulation model, modeling input data. Generation of random numbers and variates, generic features and introduction to Arena Software, Real world applications of simulation, discrete continuous simulation, verification and validation of simulation models.	19

Text Book:

- W. Bolton, "Mechatronics – Electronic control systems in Mechanical & Electrical Engineering", Pearson Education Ltd. 1868
- Ibrahim Zeid, "CAD/CAM Theory and Practice", Tata McGraw-Hill Publishing Company Limited. 1991
- Sankar Sengupta, System Simulation and modelling, Pearson. 2013

Reference Books:

- Deo, Narsingh, Millican Charles E.,"System Simulation With Digital Computer", PHI. 1978
- Gordon, Geoffrey, System Simulation, PHI. 1977
- P. Radhakrishnan, S Subramanyan, V. Raju, CAD/CAM/CIM, New Age International Publishers. 2008

Focus: This course focuses on Employability/Skill development and aligned with CO's 1 and 2

Outcome: After completion of course, the student will be able to:

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Describe the role of important elements of discrete event simulation and modeling paradigm.	PO1, PO3, PO6, PO12/ PSO1	U	F	6
2	Conceptualize real world situations related to systems development decisions, originating fromsource requirements and goals.	PO1, PO3, PO4, PO6, PO10/ PSO1	U	C	6
3	Develop skills to apply simulation software to construct and execute goal-driven system models. Interpret the model and apply the results to resolve critical issues in a real world environment.	PO2, PO3, PO4, PO6/ PSO1	U	C	7
4	Understand the numerical methods involved in Finite Element Theory.	PO2, PO3, PO4, PO6/ PSO1	U&Ap	S	6
5	Understand the role and significance of shape functions in finite element formulations and use linear, quadratic, and cubic shape functions for interpolation.	PO1, PO3, PO6, PO10/ PSO1	U&Ap	C	6
6	Recognize sources of errors in FEA.	PO1, PO3, PO6, PO9/ PSO1	U	U&P	7

BMEO 0001 TOTAL QUALITY ANAGEMENT

Objective: *Study of total quality management will enable the students to develop their mental horizon by enhancing their knowledge and skills which will embed organizational skill & it would be overall beneficial for any organization. The main objective is to provide students with quality, organizational and people management skills and techniques to enable them to make a significant contribution to an organization's quality policy.*

Credits: 04 **L–T–P: 3–1–0**

Module No.	Contents	Teaching Hours
I	**Introduction:** Definition of Quality & Total Quality, World Scenario, Quality Education, Drivers of Quality, Principles of Quality Management, Internal and External Customers, Vision, Mission, Objectives & Targets, Ten Principles of Quality Management, Evaluation of TQM, Stages of Implementation of TQM, TQM Models. **Quality Planning:** SWOT Analysis, Strategic Planning, Organizational Culture, Management of Change. **Customer Orientation:** Customer Focus, Customer Satisfaction Models, Customer Retention, Measurement of Customer Satisfaction, Quality Function Deployment. **Quality Solving Tools:** Process of Solving Problems – Conventional Methods, 7 Modern Management Tools. **Continuous Improvement Strategies:** Deming Wheel, Zero Defect Concept, Benchmarking, Six Sigma (6σ), Preventive Techniques – Failure Mode & Effect Analysis (FMEA), Five S of Housekeeping, Time Management, Total Productive Maintenance	20
II	**Human Dimensions of TQM:** Top Management Commitment, Leadership for TQM, Motivational Strategies, Quality Circles, Team Development & Building, Communication and Transactional Analysis. **Quality Certification:** ISO 9000 Quality Management System (QMS), ISO 14000 Series, Qs 9000 Series, Quality Auditing, Quality Awards, Quality Certifying Agencies, Business Excellence Models. **Cost of Quality** - Prevention Cost, Appraisal Cost, Internal Failure Cost, External Failure Cost, TQM Roadmap, How TQM Fails, TQM Implementation Strategies. **Contribution of TQM Gurus:** W. Edwards Deming, Juran Crosby, Ishikawa, Kaisen and Their Theories for Total Quality.	20

Text Books:

- Suganthi L., A. Samuel Anand, "Total Quality Management", PHI Learning.
- Bedi Kanishka, "Quality Management", Oxford University Press.

Reference Books:

- Juran J.M., M. Gryna Franic, "Quality Planning and Analysis", Tata McGraw Hill Edition.
- Kumar S., "Total Quality Management", University Science Press.

Focus: This course focuses on Employability/Skill development and aligned with CO's 1 and 2

Outcome: After completion of course, the student will be able to:

CO	CO Statement	PO/PSO	CL	KC	Duration
1	CO1: Understanding of energy conservation and identification of energy conservation, opportunities in various industrial processes.	PO4/PSO2			
2	CO2: Knowledge of various tools and components energy auditing.	PO2/PSO2			
3	CO3: Ability to evaluate the performance of industrial boilers, furnaces etc. by direct and indirect methods.	PO1/PSO2			
4	CO4: to investigate cogeneration in industry and waste heat recovery techniques and devices.	PO7/PSO2			
5	CO5: To conduct energy audits in domestic and small industries.	PO2/PSO2			
6	CO6: Apply knowledge to develop model and prototypes which can recover waste heat for energyefficiency.	PO6/PSO2			

BMEO 0002 ENERGY CONSERVATION AND MANAGEMENT

Objective: *The main objective of this course is to understand the principles associated with effective energy management and to apply these principles in the day-to-day life. To gain exposure to energy auditing, to identify energy conservation opportunities in various industrial processes and to evaluate the performance of boilers, furnaces and other energy intensive equipment/processes.*

Credits: 04 **L–T–P: 3–1–0**

Module No.	Contents	Teaching Hours
I	**Unit-I** **Introduction:** Principles of energy management. Managerial organization, Functional areas for i) manufacturing industry, ii) Process industry, iii) Commerce, iv) Government, Role of Energy manager in each of these organizations. Initiating, Organizing and managing energy management programs **Energy Audit:** Definition and concepts. Types of energy audits, Basic energy concepts, Resources for plant energy studies. Data gathering, Analytical techniques. **Energy Conservation:** Technologies for energy conservation, Design for conservation of energy materials, Energy flow networks. Critical assessment of energy usage. Formulation of objectives and constrains, Synthesis of alternative options and technical analysis of options. Process integration.	23
II	**Unit-II** **Energy Efficiency:** Fuels and Combustion-Boilers-Steam System-Furnaces - Insulation and Refractory -FBC Boilers -Cogeneration -Waste heat recovery, Diesel Generating System. **Energy Performance Assessment:** Equipment and Utility systems - Boilers-Furnaces-Cogeneration, Turbines (Gas, Steam)- Heat Exchangers-Electric Motors and Variable Speed, Drives-Fans and Blowers-Water Pumps-Compressors. **Alternative Energy Sources:** Solar energy: Types of devices for solar energy collections, Thermal storage system, Control systems. Wind Energy, Availability, Wind Devices, Wind Characteristics, performance of turbines and systems. Waste Minimization and Resource Conservation.	22

Text Books:

- *H. Koontz and Cyrill Donnel "Management" McGraw Hill*
- *S.C. Kuchhal "Financial Management" Chaitanya Publishing House.*

Reference Books:

- *W. C., Turner and S. Doty "Energy Management Hand Book" Fairmont Press, 2009, 7th edition.*
- *C.B Smith "Energy Management Principles" Pergamon Press, 2007*
- *W.R Murphy "Energy Management" Elsevier, 2007.*

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

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

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Understanding of energy conservation and identification of energy conservation, opportunities invarious industrial processes	PO1, PO2, PSO1	U	C	6
2	Knowledge of various tools and components energy auditing	PO1, PO3, PSO1	U	C	6

3	Ability to evaluate the performance of industrial boilers, furnaces etc. by direct and indirect methods	PO4, PO5, PSO1	U	C	6
4	To investigate cogeneration in industry and waste heat recovery techniques and devices	PO4, PO5, PSO1	E	C	6
5	To conduct energy audits in domestic and small industries	PO4, PO5, PO6, PSO1	A	P	8
6	Apply knowledge to develop model and prototypes which can recover waste heat for energyefficiency	PO4, PO5, PO6, PO7, PSO1, PSO2	A	P	8

BMEO 0003 SMART MATERIALS

Objective:

Students will be able to understandthe variety of smart materials, their application and advantages. They will also learn composite materials, their manufacturing processes and testing methods.

Credits: 04 **L–T–P: 3–1–0**

Module No.	Content	Teaching Hours
I	**Introduction:** Classifications of Engineering Materials, Concept of composite materials, Matrix materials, Functions of a Matrix, Desired Properties of a Matrix, Polymer Matrix (Thermosets and Thermoplastics), Metal matrix, Ceramic matrix, Carbon Matrix, Glass Matrix etc. Types of Reinforcements/Fibers: Role and Selection or reinforcement materials, Types of fibres, Glass fibers, Carbon fibers, Aramid fibers , Metal fibers, Alumina fibers, Boron Fibers, Silicon carbide fibers, Quartz and Silica fibers, Multiphase fibers, Whiskers, Flakes etc., Mechanical properties of fibres. Material properties that can be improved by forming a composite material and its engineering potential **Various types of composites:** Classification based on Matrix Material: Organic Matrix composites, Polymer matrix composites (PMC), Carbon matrix Composites or Carbon-Carbon Composites, Metal matrix composites (MMC), Ceramic matrix composites (CMC);	23
II	Classification based on reinforcements: Fiber Reinforced Composites, Fiber Reinforced Polymer (FRP) Composites, Laminar Composites, Particulate Composites, Comparison with Metals, Advantages & limitations of Composites **Fabrication methods:** Processing of Composite Materials: Overall considerations, Autoclave curing, Other Manufacturing Processes like filament welding, compression molding, resin-transplant method, pltrusion, pre-peg layer, Fiber-only performs, Combined Fiber-Matrix performs, Manufacturing Techniques: Tooling and Specialty materials, Release agents, Peel plies, release films and fabrics, Bleeder and breather plies, bagging films **Testing of Composites:** Mechanical testing of composites, tensile testing, Compressive testing, Intra-laminar shear testing, Inter-laminar shear testing, Fracture testing etc.	22

Text/Reference Books:

- Thomas J. Bruno and Ryan Deacon, “Vol. 10: Materials characterization”: ASM hand book, 2019.
- G. Dieter, “Mechanical Metallurgy”: Mc-Graw Hill Education, 1961.
- R.E. Speyer and Marcel Decker, “Thermal Analysis of Materials”: CRC Press, 1993.
- A.K Bhargava, “Engineering Materials: Polymers, Ceramics and Composites”: Prentice Hall of

India, 2005.

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	*Understanding of smart materials, manufacturing processes, advantages and applications.*	PO1/PSO3	Remember	Factual	5 hrs
2	*Identify and Evaluate the properties of fiber reinforcements, particulates, matrix materialsand commercial composites.*	PO1/PO4/PO5/PSO1/PSO2/PSO3	Understand	Conceptual	7 hrs
3	*Develop competency in one or more common composite manufacturing techniques and beable toselect appropriate technique for manufacture of composite products.*	PO1/PSO2	Evaluate	Procedural	7 hrs
4	*Analyze and understand the mechanical properties and mechanics of load transfer frommatrixto fibers.*	PO1/PSO1	Analyze	Conceptual	8 hrs
5	*Understand and predict the mechanical performance and failure behaviour of theComposites.*	PO1/PO4/PSO3	Understand	Conceptual	7 hrs
6	*Apply the knowledge of manufacturing methods and composite mechanical performanceof agiven composites design project*	PO1/PO2/PSO2/PSO3	Apply	Procedural	5 hrs
7	*To understand the different testing methods/ Characterization of smart materials*	PO1/PSO2/PSO3	Understand	Meta-Cognitive	6 hrs

BMEO 0004 PROJECT MANAGEMENT

Objective: *The main objectives of project management are as follows: Understand exactly what a project is meant to do and what it is meant to deliver. To learn the scope, timescales, cost and quality of a project. How to maintain a schedule and project plan. To estimate the cost of project. Different finance institute available for financial add. Deliver the agreed outcomes of the project to the right scope, timescales, cost and quality. Provide communications, reports and progress updates throughout the lifecycle of the project. To let students know how to manage risks, issues and dependencies*

Credits: 03 **L–T–P: 3–1–0**

Module No.	Contents	Teaching Hours
I	**Introduction:** Project Characteristics, Attributes of A Good Project Manager, Taxonomy of Projects. **Project Identification & Formation:** Project Identification, Demand Forecasting, Project Preparation, Zero Based Project Formulation, Preliminary Project Report, Comparison of Project Alternatives. **Project Appraisal:** Technical Appraisal, Commercial Appraisal, Economical Appraisal, Management Appraisal, Social Cost Benefit Analysis, NPV, IRR, BCR, NBCR. **Financing of Projects:** Estimation of Cost Components of Projects. Sources of Finances, Role of Financial Institutions, Cash Inflow and Cash Outflow, Cost of Capital.	20
II	**Project Planning & Scheduling:** Scheduling Techniques, PERT & CPM, Network Preparation, Updating Network, Line of Balance Technique, Performance Analysis of Projects, Cost Vs Time of Completion, Normal Time and Crash Time, Resource Allocation Techniques, Work Breakdown Structure. **Project Contracts:** Types of Contract, Sub-Contract, Tenders & Types of Payment to Contractors. **Computer Aided Project Management:** Essential Requirements of Software's, Software Packages, Enterprise-Wide Project Management, Spread Sheets. Project Organization, Post Project Evaluation, Project Sickness – Causes, Prediction of Causes, Rehabilitation, Project Audit, Risk Analysis.	20

Text Books:

- Nagarajan K., *Project Management*, New Age International Publishers.
- Panneerselvam R. & Senthil kumar P., *Project Management*, PHI Learning.

Reference Books:

- Patel Bhavesh M, *Project Management*, Vikas Publishing Home.
- Scelharaman S. & Ramnath Vijay, *Project Management*, Breweries; Education.

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

Outcome:

After completion of the course, student will be able to:

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Understand the project characteristics and Taxonomy of Project.	PO1, PSO2	U	C	6 Hours
2	Apply the knowledge of Demand Forecasting in managing the various projects	PO2, PSO2	A	P	7 Hours
3	Understand the Technical, Commercial, Economical and Management Appraisal	PO1, PSO2	U	C	6 Hours
4	Understand the concept of project network, project schedule and project monitoring activities by using CPM and PERT method.	PO8, PSO3	U	C	7 Hours
5	Proficiently handle the various software packages for managing the project.	PO5, PSO2	A	P	7 Hours
6	Determine the cost components of Projects and identify different Sources of Finances	PO4, PSO2	An	P	7 Hours

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

COs	POs/PSOs
CO1	PO1 / PSO2
CO2	PO1, PO2, PO5, PO11 / PSO2
CO3	PO1, PO11 / PSO2
CO4	PO8, PO11, PO12 / PSO3
CO5	PO5, PO11 / PSO2
CO6	PO1, PO4/PSO2

BMEO 0005 RELIABILITY AND MAINTENANCE ENGINEERING

Objective: *The objective of the course is to provide the students with the fundamental concepts, maintenance workload analysis and calculations, maintenance work scheduling the necessary knowledge and the basic skills related to system reliability and systems maintenance functions*

Credits: 03 **L–T–P: 3–1–0**

Module No.	Contents	Teaching Hours
I	Maintenance Management, Production Maintenance System, Objectives and Functions, Forms, Policy, Planning, Organization, Economics of Maintenance, Evaluation of Maintenance Management. **Maintenance Strategies:** Break Down Maintenance, Preventive Maintenance, Planned Maintenance, Maintenance Programme, Job Report, Strategies. Design Out Maintenance, Planned Lubrication, Total Productive Maintenance, Zero Break Down Manpower Planning, Materials Planning, Spare Parts Planning and Control.	19
II	**Reliability Engineering:** Introduction, Operating Life Cycle, Reliability, Failure Data Analysis, Failure Rate Curve, Hazard Models, Elements in Series, Parallel, Mix, Logic Diagrams, Improving Reliability, Redundancy-Element, Unit, Standby, Maintainability, Availability, Reliability and Maintainability Trade Off. Break Down Maintenance Planning, Replacement Planning Maintain or Replace Decision, Replacement Models/ Decisions, Individual, Group Replacement, Replacement in Anticipation of Failure. **Condition Monitoring:** Objectives and Techniques of Condition Monitoring.	21

Text Book:

- R. C. Mishra and K. Pathak, "*Maintenance Engineering & Management*": Prentice Hall of India, New Delhi, 2015.
- A. K. Gupta, "*Reliability Maintenance & Safety Engineering*": University Science, Press New Delhi, 2009.

Reference Books:

1. Dr. A.K. Gupta, "Reliability Maintenance & Safety Engineering": University Science Press New Delhi, 2009.
2. Kelly and M.J. Harris, "Management of Industrial Maintenance": Boston : Newnes-Butterworths, 1979.
3. B.S. Dhillon, "Engineering Maintainability: How to Design for Reliability and Easy Maintenance": Prentice Hall of India, New Delhi, 1999.

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

CO	CO Statement	PO/PSO	CL	KC	Duration
1					
2					
3					
4					
5					
6					

7					

Outcome: After completion of course, the student will be able to:

CO1: Understand maintenance objectives and evaluate maintenance strategies for processplant applications.
CO2: Evaluate maintenance schedules and assess the corresponding risks with appropriate tools& techniques.
CO3: Understand the concept of maintainability & availability and different techniques availableto improve maintainability & availability.
CO4: To develop the total optimum cost model for a maintenance problem.

CO5: Understand the concept of reliability & its techniques for estimating reliability and characteristics of components/systems.
CO6: Understand and apply the concept of reliability centered maintenance (RCM) and advantages for a company employing them.
CO7: Understand and apply the concept of condition monitoring techniques & its data for predictive maintenance.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs/PSOs
CO1	PO1/PSO2
CO2	PO1/PO5/PSO2
CO3	PO1/PSO2
CO4	PO3/PSO1
CO5	PO4/PSO2
CO6	PO6/PSO2/ PSO3
CO7	PO4/PSO2

BMEO 0006 MECHATRONICS

Objective: *Mechatronics is the combination of mechanical and electronics automation and computers. Nowadays all the mechanical machines have been made computer controlled. The Subject details the basic hardware and software elements used for proper and successful operation of various equipment. The knowledge of this subject will be helpful to students while working in industries.*

Credits: 04 **L–T–P: 3–1–0**

Module No.	Content	Teaching Hours
I	**Introduction:** Automated Manufacturing System, need of Automation, elements of Automation, levels of Automation, Automation strategies, advantages & disadvantages of Automation, CAD/CAM, CIM, FMS and CNC system. **Mechatronics System:** Elements of Mechatronics system, levels of Mechatronics system, Mechatronics Design Process, System and Control, feedback Principle, real time Mechatronics system and application, advantages and disadvantages of Mechatronics system. **Mechanical Actuating Systems:** Types of motion, Degrees of freedom, constraints, Kinematic Chains, Cam, Gear and gear trains, Ratchet and pawl Belt drive, chain drive, bearing, pre loading. Hydraulic & Pneumatic Actuation Systems: Fluid power systems, hydraulic systems, Pneumatic systems, system structure and signal flow, hydraulic pumps and Pressure Control Valves, air compressors and treatment, Cylinders, Direction Control Valves, Rotary Actuators.	20
II	**Electrical Actuation Systems:** Switching Devices, Mechanical Switches – SPST, SPDT, DPDT, Relays, solenoid operating Valve, Solenoid Operated Hydraulic and Pneumatic Valves, Open and Close loop control system, Control of DC Motors, Permanent Magnet DC Motors, braking of DC Motors, AC Motors, Stepper Motors and Controls. **Sensors, transducers and application:** Performance Terminology, Static and Dynamic Characteristics, Displacement, Position and Proximity Sensors, Potentiometer Sensors, LVDT, Optical Encoders, Hall Effect Sensors. **Programmable logic controllers:** Programmable logic controllers (PLC) Structure, Input / Output Processing, principles of operation, PLC versus computer, selecting a PLC. **Case studies:** Mechatronic approach to design, Boat Auto pilot, high speed tilting train, automatic car park system, coin counter, engine management system, autonomous mobile system, antilock brake system control, Using PLC for extending and retracting a pneumatic piston and two pneumatic pistons in different combinations.	24

Text Books:

- W. Bolton, "Mechatronics – Electronic control systems in Mechanical & Electrical Engineering", Pearson Education Ltd., 2003.
- K. P. Ramachandran, G.K. Vijayaraghavan, M.S. Balasundaram, Mechatronics - Integrated Mechanical Electronic Systems, Wiley;

Reference Books:

- Joji P, Pneumatic Controls, Wiley.

- Dan Necsulescu, Mechatronics, Pearson
- David g Alciatore, Michael B Histand, "Introduction to Mechatronics and measurement systems", Mc Graw Hill Education.
- A Smaili, F Mrad, "Mechatronics – Integrated Technologies for Intelligent Machines, Oxford Higher Education.
- NitaigourPremchandMahalik, "Mechatronics Principles, Concepts & Application", Tata McGraw Hill Publishing Co.Ltd., 2003.

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

CO	CO Statement	PO/PSO	CL	KC	Duration
1					
2					
3					
4					
5					
6					
7					

Mapping of Course Outcomes (COs) with Program outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs/PSOs
CO1	PO1/PSO2/PSO3
CO2	PO1/PO2/PO12/PSO3
CO3	PO1/PSO2/PSO3
CO4	PO1/PO2/PO12/PSO3
CO5	PO1/PSO2/PSO3
CO6	PO1/PO2/PO12/PSO3
CO7	PO1/PO2/PO12/PSO3

OPEN ELECTIVE

BMEO 0007: SIX SIGMA & APPLICATIONS

Objectives: *Study of this subject will enable the students to develop their mental horizon by enhancing their knowledge and skills which will embed organizational skill & it would be overall beneficial for any organization. The main objective is to provide to the students its principles and problems associates during implementation so that the students make a significant contribution to an organization by use its applications in various areas.*

Credits: 04 **L-T-P: 3-1-0**

Module No.	Contents	Teaching Hours
I	**Introduction:** Principles of six-sigma, Statistical basis, Tools and Techniques, DMAIC principle, 6S of six sigma, Customer requirements, Elimination of wastes and defects, Evolution of six sigma quality approach, Practical approach to six sigma quality, Basic steps involved in the application of six sigma, TQM and six sigma, Quality improvement, Six sigma and other quality initiatives. **Project Management Applications**: Areas of six sigma and its approach, Six- sigma management method, Integration of project management, Effective management of six-sigma projects and disciplined six-sigma method in managing projects in organization. **Process Control Charts**: X & R charts, p & C charts, Limits calculations; Importance & Applications.	25
II	**Lean Manufacturing**: Concept, goals, components, tools and techniques, JIT, KANBAN system, waste reduction. **Organizational Structure of Six-sigma**: Gains made by the global six sigma stars, six sigma and Indian industries, six sigma concept of process capability, Organizational Structure, Project methodology, Quadruple Constraints of project management, Business systems improvement, Importance of evaluating the success of projects, Importance career path requirements. **Factories of future**: Nature and categories of FOF, Zero bases FOF, Design and planning for futuristic factories.	25

Text Books:

- The Six Sigma Handbook: A Complete Guide for Green Belts, Black Belts, and Managersat All Levels Thomas Pyzdek Paul A. Keller, Mc Graw Hill.
- Lean Six Sigma For Dummies, 2nd Edition Published by John Wiley & Sons, Ltd.,The Atrium Southern Gate Chichester West Sussex PO19 8SQ England.
- THE LEAN SIX SIGMA BLACK BELT HANDBOOK Tools and Methods for Process Acceleration Frank Voehl • H. James Harrington Chuck Mignosa • Rich Charron, CRC Press

Reference Books:

- Skimmar,Wickham, Manufacturing in the corporate Strategy, John Wiley and sons, NewYork

- Hearm Buck and Butler, D.M., Economic product Design, Colhins, London
- Cluttarbuck, JIT – A Global Status Report, IFS publications
- Michael J. Termini, The new manufacturing engineer, Society of manufacture engineer Michigan, USA

Focus: *This course focuses on Employability/Skill development and aligned with CO's 1 and 2*

CO	CO Statement	PO/PSO	CL	KC	Duration
1	Explain complete range of topics starting from its basic idea to its applications in various areas.	PO1, PO3, PO6, PO12/ PSO1	U	C	8
2	Describe tools & techniques, elimination of wastes and their reduction in present scenario.	PO1, PO3, PO4, PO6, PO10/ PSO1	U & Ap	F	9
3	Understand that how to analysis the various control charts for process variations.	PO2, PO3, PO4, PO6/ PSO1	U	C	8
4	Explain the concept of Lean manufacturing and its wide scope.	PO2, PO3, PO4, PO6/ PSO1	U&Ap	C&S	8
5	Understand the Business systems improvement, Importance of evaluating the success of projects.	PO1, PO3, PO6, PO10/ PSO1	U	C	9
6	Understand the concept of Factory of future, Zero bases FOF.	PO1, PO3, PO6, PO9/ PSO1	U	U&P	8