VIT®

Vellore Institute of Technology

(Deemed to be University under section 3 of UGC Act, 1956)

SCHOOL OF MECHANICAL ENGINEERING

B.Tech Mechanical Engineering (BME)

Curriculum & Syllabi

(*2021-2022 admitted students*)

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VISION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

- Transforming life through excellence in education and research.

MISSION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

- **World class Education:** Excellence in education, grounded in ethics and critical thinking, for improvement of life.
- **Cutting edge Research:** An innovation ecosystem to extend knowledge and solve critical problems.
- **Impactful People:** Happy, accountable, caring and impactful workforce and students.
- **Rewarding Co-Creations:** Active collaboration with national & international industries & universities for productivity and economic development.
- **Service to Society**: Service to the region and world through knowledge and compassion.

VISION STATEMENT OF THE SCHOOL OF MECHANICAL ENGINEERING

- To be a leader in imparting world class education in Mechanical Engineering, with a vision to nurture scientists and technocrats of the highest caliber engaged in global sustainable development.

MISSION STATEMENT OF THE SCHOOL OF MECHANICAL ENGINEERING

- To create and maintain an environment fostering excellence in instruction & learning, Research and Innovation in Mechanical Engineering and Allied Disciplines.
- To equip students with the required knowledge and skills to engage seamlessly in higher educational and employment sectors ensuring that societal demands are met.

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B. Tech Mechanical Engineering

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

1. Graduates will be engineering practitioners and leaders, who would help solve industry's technological problems.
2. Graduates will be engineering professionals, innovators or entrepreneurs engaged in technology development, technology deployment, or engineering system implementation in industry.
3. Graduates will function in their profession with social awareness and responsibility.
4. Graduates will interact with their peers in other disciplines in industry and society and contribute to the economic growth of the country.
5. Graduates will be successful in pursuing higher studies in engineering or management.
6. Graduates will pursue career paths in teaching or research.

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B. Tech Mechanical Engineering

PROGRAMME OUTCOMES (POs)

PO_1: Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO_2: Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

PO_3: Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO_4: Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions for complex problems

PO_5: Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO_6: The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO_7: Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO_8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO_9: Individual and Teamwork: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO_10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO_11: Project Management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO_12: Life-long Learning: Recognize the need for and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.

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B. Tech Mechanical Engineering

PROGRAMME SPECIFIC OUTCOMES (PSOs)

On completion of B. Tech. (Mechanical Engineering) programme, graduates will be able to

PSO_1: Model, design and analyse mechanical systems and components taking into account social, economic and environmental implications

PSO_2: Realize components and products using appropriate materials and machine tools

PSO_3: Work professionally in mechanical and related systems

Bachelor of Technology in Mechanical Engineering

School of Mechanical Engineering

Programme Credit Structure	**Credits**
Foundation Core Courses	56
Basic Sciences and Mathematics	24
Engineering Sciences	17
Humanities, Social Sciences and Management (HSM)	15
Discipline-linked Engineering Science Courses	13
Discipline Core Courses	49
Discipline Elective Courses	12
Open Elective Courses	12
Project and Internship	09
Total Graded Credit Requirement	151
Non-Graded Credit Requirement	11

Basic Sciences and Mathematics — 24

		L	T	P	C
BPHY101L	Engineering Physics	3	0	0	3
BPHY101P	Engineering Physics Lab	0	0	2	1
BCHY101L	Engineering Chemistry	3	0	0	3
BCHY101P	Engineering Chemistry Lab	0	0	2	1
BMAT101L	Calculus	3	0	0	3
BMAT101P	Calculus Lab	0	0	2	1
BMAT102L	Differential Equations and Transforms	3	1	0	4
BMAT201L	Complex Variables and Linear Algebra	3	1	0	4
BMAT202L	Probability and Statistics	3	0	0	3
BMAT202P	Probability and Statistics Lab	0	0	2	1

Engineering Sciences — 17

BMEE102P	Engineering Design Visualisation Lab	0	0	4	2
BEEE101L	Basic Electrical Engineering	2	0	0	2
BEEE101P	Basic Electrical Engineering Lab	0	0	2	1
BECE101L	Basic Electronics	2	0	0	2
BECE101P	Basic Electronics Lab	0	0	2	1
BMEE201L	Engineering Mechanics	2	1	0	3
BCSE101E	Computer Programming: Python	1	0	4	3
BCSE103E	Computer Programming:Java	1	0	4	3

Humanities, Social Sciences and Management — 15

BENG101N	Effective English Communication (NGC)	0	0	4	2
BENG101L	Technical English Communication	2	0	0	2
BENG101P	Technical English Communication Lab	0	0	2	1
BENG102P	Technical Report Writing	0	0	2	1
BSTS101P	Quantitative Skills Practice I	0	0	3	1.5
BSTS102P	Quantitative Skills Practice II	0	0	3	1.5
BSTS201P	Qualitative Skills Practice I	0	0	3	1.5
BSTS202P	Qualitative Skills Practice II	0	0	3	1.5
BFLE200L	Foreign Language	2	0	0	2
BHSM200L	HSM Elective	3	0	0	3

Discipline-linked Engineering Science Courses — 13

BMEE209L	Materials Science and Engineering	3	0	0	3
BMEE209P	Materials Science and Engineering Lab	0	0	2	1
BMEE211L	Engineering Optimization	2	1	0	3
BMEE407L	Artificial Intelligence	2	1	0	3
BMEE308L	Control Systems	2	0	0	2
BMEE308P	Microcontrollers and Interfacing Lab	0	0	2	1

Discipline Core Courses — 49

BMEE202L	Mechanics of Solids	3	0	0	3
BMEE202P	Mechanics of Solids Lab	0	0	2	1
BMEE203L	Engineering Thermodynamics	2	1	0	3
BMEE204L	Fluid Mechanics and Machines	3	0	0	3
BMEE204P	Fluid Mechanics and Machines Lab	0	0	2	1
BMEE206P	Machine Drawing Lab	0	0	4	2
BMEE207L	Kinematics and Dynamics of Machines	3	0	0	3
BMEE207P	Kinematics and Dynamics of Machines Lab	0	0	2	1
BMEE210L	Mechatronics and Measurement Systems	3	0	0	3
BMEE210P	Mechatronics and Measurement Systems Lab	0	0	2	1
BMEE301L	Design of Machine Elements	3	1	0	4
BMEE302L	Metal Casting and Welding	3	0	0	3
BMEE302P	Metal Casting and Welding Lab	0	0	2	1
BMEE303L	Thermal Engineering Systems	3	0	0	3
BMEE303P	Thermal Engineering Systems Lab	0	0	2	1
BMEE304L	Metal Forming and Machining	3	0	0	3
BMEE304P	Metal Forming and Machining Lab	0	0	2	1
BMEE306L	Computer Aided Design and Finite Element Analysis	3	0	0	3
BMEE306P	Computer Aided Design and Finite Element Analysis Lab	0	0	2	1

BMEE401L	Computer Integrated Manufacturing	3	0	0	3
BMEE401P	Computer Integrated Manufacturing Lab	0	0	2	1
BMEE402L	Heat and Mass Transfer	3	0	0	3
BMEE402P	Heat and Mass Transfer Lab	0	0	2	1

Discipline Elective Courses **12**

BMEE205E	Renewable Energy Systems	2	0	2	3
BMEE208L	Industrial Engineering	3	0	0	3
BMEE212L	Quality Control and Improvement	3	0	0	3
BMEE213E	Automotive Vehicles	2	0	2	3
BMEE214E	Automotive Electricals and Electronics	2	0	2	3
BMAT206L	Numerical Analysis	3	0	0	3
BMEE305L	Manufacturing Planning and Control	3	0	0	3
BMEE307L	Product Design and Development	3	0	0	3
BMEE309L	Lean Manufacturing	3	0	0	3
BMEE310L	Supply Chain Management	3	0	0	3
BMEE311L	Welding Engineering	3	0	0	3
BMEE312L	Engineering Tribology	3	0	0	3
BMEE313E	Non-destructive Testing	3	0	2	4
BMEE314E	Mechanical Vibrations and Acoustics	3	0	2	4
BMEE315L	Micro-Electromechanical Systems	3	0	0	3
BMEE316E	Industrial Robotics	3	0	2	4
BMEE317L	Mechatronic Systems Design	3	0	0	3
BMEE318E	Fluid Power Systems	3	0	2	4
BMEE319E	Advanced Material Characterization Methods	3	0	2	4
BMEE320L	Refrigeration and Air-conditioning	3	0	0	3
BMEE321L	Composite Materials	3	0	0	3
BMEE322L	Engineering Failure Analysis	3	0	0	3
BMEE323L	Gas Dynamics	3	0	0	3
BMEE324E	Turbomachines	2	0	2	3
BMEE325L	Internal Combustion Engines	3	0	0	3
BMEE326L	Power Plant Engineering	3	0	0	3
BMEE327E	Vehicle Dynamics	2	0	2	3
BMEE328E	Hybrid and Electric Vehicles Technology	2	0	2	3
BMEE329E	Noise, Vibration, and Harshness	2	0	2	3
BMEE403L	Design of Jigs, Fixtures and Press Tools	3	0	0	3
BMEE404L	Design of Transmission Systems	2	1	0	3
BMEE405L	Industrial Automation	3	0	0	3
BMEE406E	Advanced Manufacturing Process	3	0	2	4
BMEE408E	Additive Manufacturing	3	0	2	4
BMEE409E	Computational Fluid Dynamics	2	0	2	3
BMEE410L	Industrial Revolution 4.0	3	0	0	3
BMEE411L	Society 5.0	3	0	0	3
BMEE412E	Manufacturing Systems Design	3	0	2	4
BMEE413L	Design of Chassis Components	2	1	0	3
BMEE414L	Vehicle Body and Aerodynamics Engineering	3	0	0	3
BMEE415L	Electrical Machines, Drives and Power Systems	3	0	0	3
BMEE416L	Autonomous Vehicle Systems	3	0	0	3
BMEE391J	Technical Answers to Real Problems Project				3
BMEE392J	Design Project				3
BMEE393J	Laboratory Project				3
BMEE394J	Product Development Project				3
BMEE395J	Computer Project				3
BMEE396J	Reading Course				3
BMEE397J	Special Project				3
BMEE398J	Simulation Project				3

Open Elective Courses **12**

Engineering Disciplines | Projects | Sciences | Humanities | Social Sciences | Liberal Arts | Economics | Finance| Entrepreneurship | Management | Skills | Reading

Project and Internship **9**

BMEE399J	Summer Industrial Internship	1
BMEE497J	Project-I	3
BMEE498J	Project-II / Internship	5
BMEE499J	One Semester Internship	14

Non-Graded Credit Requirement **11**

BMEE101N	Introduction to Engineering	1
BSSC101N	Essence of Traditional Knowledge	2
BSSC102N	Indian Constitution	2
BEXC100N	Extracurricular Activities	2
BCHY102N	Environmental Sciences	2
BHUM101N	Ethics and Values	2

Minor (18 – 20 credits)

Bachelor of Technology in Mechanical Engineering with Minor in:

Computer Science and Engineering
Artificial Intelligence and Machine Learning
Data Science
.

BCHY101L	Engineering Chemistry	L	T	P	C
		3	0	0	3
Pre-requisite	NIL	**Syllabus version**			
		1.0			

Course Objectives

1. To enable students to have fundamental understanding of the basic concepts of different disciplines of chemistry.
2. To provide avenues for learning advanced concepts from school to university
3. To empower students with emerging concepts in applied chemistry to be useful in addressing societal needs
4. To integrate analytical and computational ability with experimental skills to create individuals competent in basic science and its by-product of its application.
5. To offer opportunities to create pathways for self-reliant in terms of knowledge and higher learning

Course Outcomes :

1. Understand the fundamental concepts in organic, inorganic, physical, and analytical chemistry.
2. Analyze the principles of applied chemistry in solving the societal issues.
3. Apply chemical concepts for the advancement of materials.
4. Appreciate the fundamental principles of spectroscopy and the related applications.
5. Design new materials, energy conversion devices and new protective coating techniques.

Module:1	**Chemical thermodynamics and kinetics**	**6 hours**

Laws of thermodynamics - entropy change (selected processes) - spontaneity of a chemical reaction and Gibbs free energy - heat transfer; Kinetics - Concept of activation energy and energy barrier - Arrhenius equation- effect of catalysts (homo and heterogeneous) - Enzyme catalysis (Michaelis-Menten Mechanism).

Module:2	**Metal complexes and organometallics**	**6 hours**

Inorganic complexes - structure, bonding and application; Organometallics - introduction, stability, structure and applications of metal carbonyls, ferrocene and Grignard reagent; Metals in biology (haemoglobin, chlorophyll- structure and property).

Module:3	**Organic intermediates and reaction transformations**	**6 hours**

Organic intermediates - stability and structure of carbocations, carbanions and radicals; Aromatics (aromaticity) and heterocycles (3, 4, 5, 6 membered and fused systems); Organic transformations for making useful drugs for specific disease targets (two examples) and dyes (addition, elimination, substitution and cross coupling reactions).

Module:4	**Energy devices**	**6 hours**

Electrochemical and electrolytic cells - electrode materials with examples (semi-conductors), electrode-electrolyte interface- chemistry of Li ion secondary batteries, supercapacitors; Fuel cells: H2"O_2 and solid oxide fuel cell (SOFC); Solar cells - photovoltaic cell (silicon based), photoelectrochemical cells and dye-sensitized cells.

Module:5	**Functional materials**	**7 hours**

Oxides of AB, AB_2, ABO_3 type (specific examples); Composites - types and properties; Polymers - thermosetting and thermoplastic polymers - synthesis and application (TEFLON, BAKELITE); Conducting polymers- polyacetylene and effect of doping - chemistry of display devices specific to OLEDs; Nano materials - introduction, bulk *vs* nano (quantum dots), top-down and bottom-up approaches for synthesis, and properties of nano Au.

Module:6	**Spectroscopic, diffraction and microscopic techniques**	**5 hours**

Fundamental concepts in spectroscopic and instrumental techniques; Principle and applications of UV-Visible and XRD techniques (numericals); Overview of various techniques such as AAS, IR, **NMR,** SEM and TEM.

Module:7	**Industrial applications**	**7 hours**

Water purification methods - zeolites, ion-exchange resins and reverse osmosis; Fuels and combustion -LCV, HCV, Bomb calorimeter (numericals), anti-knocking agents); Protective coatings for corrosion control: cathodic and anodic protection - PVD technique; Chemical sensors for environmental monitoring - gas sensors; Overview of computational methodologies: energy minimization and conformational analysis.		
Module:8	**Contemporary topics**	**2 hours**
Guest lectures from Industry and, Research and Development Organizations		
	Total Lecture hours:	**45 hours**

Textbook

1.	Theodore E. Brown, H Eugene, LeMay Bruce E. Bursten, Catherine Murphy, Patrick Woodward, Matthew E. Stoltzfus, Chemistry: The Central Science, 2017, 14th edition, Pearson Publishers, 2017. UK

Reference Books

1.	Peter Vollhardt, Neil Schore, Organic Chemistry: Structure and Function, 2018, 8th ed. WH Freeman, London
2.	Atkins' Physical Chemistry: International, 2018, Eleventh edition, Oxford University Press; UK
3.	Colin Banwell, Elaine Mccash, Fundamentals for Molecular Spectroscopy, 4th Edition, McGraw Hill, US
4.	Solid State Chemistry and its Applications, Anthony R. West. 2014, 2nd edition, Wiley, UK.
5.	AngA"le Reinders, Pierre Verlinden, Wilfried van Sark, Alexandre Freundlich, Photovoltaic solar energy: From fundamentals to Applications, 2017, Wiley publishers, UK.
6.	Lawrence S. Brown and Thomas Holme, Chemistry for engineering students, 2018, 4t^{h} edition - *Open access version*

Mode of Evaluation: CAT, Written assignment, Quiz and FAT			
Recommended by Board of Studies	128.06.2021		
Approved by Academic Council	No. 63	Date	23.09.2021

BCHY101P	**Engineering Chemistry Lab**	IL IT Ip IC
		IO IO I 2 11
Pre-requisite	**NIL**	**Syllabus version**
		1.0

Course Objective

To apply theoretical knowledge gained in the theory course and get hands-on experience of the topics.

Course Outcome :

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

1. Understand the importance and hands-on experience on analysis of metal ions by means of experiments.
2. Get practical experience on synthesis and characterization of the organic molecules and nanomaterials in the laboratory.
3. Apply their knowledge in thermodynamic functions, kinetics and molecular geometries through the experiments.

Indicative Experiments

1.	Thermodynamics functions from EMF measurements : Zinc - Copper system
2.	Determination of reaction rate, order and molecularity of ethylacetate hydrolysis
3.	Colorimetric estimation of Ni^{2+} using conventional and smart phone digital-imaging methods
4.	Laboratory scale preparation of important drug intermediate - para aminophenol for the synthesis for acetaminophen
5.	Magnesium-sea water activated cell - Effect of salt concentration on voltage generation
6.	Analysis of iron in an alloy sample by potentiometry
7.	Preparation of tin oxide by sol- gel method and its characterization
8.	Size dependent colour variation of Cu_20 nanoparticles by spectrophotometer
9.	Determination of hardness of water sample by complexometric titration before and after ion-exchange process
10.	Computational Optimization of molecular geometry using Avogadro software

Total Laboratory Hours I **30 hours**

Mode of assessment: Mode of assessment: Continuous assessment/ FAT/ Oral examination and others

Recommended by Board of Studies	I 2s.06.2021		
Approved by Academic Council	I No. 63	Date	23.09.2021

BPHY101L	Engineering Physics	ILTTPIC
		3 0 0 3
Pre-requisite	**12th of equivalent**	**Syllabus version**
		1.0

Course Objectives

1. To explain the dual nature of radiation and matter.
2. To apply Schrodinger's equation to solve finite and infinite potential problems and apply quantum ideas at the nanoscale.
3. To understand the Maxwell's equations for electromagnetic waves and apply the concepts to semiconductors for engineering applications.

Course Outcome

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

1. Comprehend the phenomenon of waves and electromagnetic waves.
2. Understand the principles of quantum mechanics.
3. Apply quantum mechanical ideas to subatomic domain.
4. Appreciate the fundamental principles of a laser and its types.
5. Design a typical optical fiber communication system using optoelectronic devices.

Module:1	**Introduction to waves**	**7 hours**

Waves on a string - Wave equation on a string (derivation) - Harmonic waves- reflection and transmission of waves at a boundary - Standing waves and their eigenfrequencies - waves with dispersion - Superposition of waves and Fourier method (qualitative) - Wave packet - phase velocity and group velocity.

Module:2	**Electromagnetic waves**	**7 hours**

Physics of divergence - gradient and curl - surface and volume integral - Maxwell Equations (Qualitative) - Continuity equation for current densities - Displacement current - Electromagnetic wave equation in free space - Plane electromagnetic waves in free space - Hertz's experiment.

Module:3	**Elements of quantum mechanics**	**7 hours**

Need for Quantum Mechanics: Idea of Quantization (Planck and Einstein) - Compton effect (Qualitative) - de Broglie hypothesis - justification of Bohr postulate - Davisson-Germer experiment - Wave function and probability interpretation - Heisenberg uncertainty principle - Gedanken experiment (Heisenberg's microscope) - Schrodinger wave equation (time dependent and time independent).

Module:4	**Applications of quantum mechanics**	**6 hours**

Eigenvalues and eigenfunction of particle confined in one dimensional box - Basics of nanophysics - Quantum confinement and nanostructures - Tunnel effect (qualitative) and scanning tunneling microscope.

Module:5	**Lasers**	**6 hours**

Laser characteristics - spatial and temporal coherence - Einstein coefficients and their significance - Population inversion - two, three and four level systems - Pumping schemes - threshold gain coefficient - Components of a laser - He-Ne, Nd:YAG and CO_2 lasers and their engineering applications.

Module:6	**Propagation of EM waves in optical fibers**	**5 hours**

Introduction to optical fiber communication system - light propagation through fibers - Acceptance angle - Numerical aperture - V-parameter - Types of fibers - Attenuation - Dispersion-intermodal and intramodal. Application of fiber in medicine - Endoscopy.

Module:7	**Optoelectronic devices**	**5 hours**

Introduction to semiconductors - direct and indirect bandgap - p-n junction, Sources: LED and laser diode, Photodetectors: PN and PIN

Module:8	**Contemporary Topics**	**2 hours**

Guest lectures from Industry and, Research and Development Organisations

	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	**H.** D. Young and R. A. Freedman, University Physics with Modern Physics, 2020, 15th Edition, Pearson, USA.
2.	D. K. Mynbaev and Lowell L. Scheiner, Fiber Optic Communication Technology, 2011, Pearson, USA

Reference Books	
1.	**H. J.** Pain, The Physics of vibrations and waves, 2013, 6th Edition, Wiley Publications, India.
2.	R. A. Serway, J. W. Jewett, Jr, Physics for Scientists and Engineers with Modern Physics, 2019, 10th Edition, Cengage Learning, USA.
3.	K. Krane, Modern Physics, 2020, 4th Edition, Wiley Edition, India.
4.	M.N.O. Sadiku, Principles of Electromagnetics, 2015, 6th Edition, Oxford University Press, India.
5.	W. Silfvast, Laser Fundamentals, 2012, 2nd Edition, Cambridge University Press, India.

Mode of Evaluation: Written assignment, Quiz, CAT and FAT			
Recommended by Board of Studies	I 26.06.2021		
Approved by Academic Council	I No. 63	Date	23.09.2021

BPHY101P	**Engineering Physics Lab**	**L**	**T**	**P**	**C**
		0	**0**	**2**	**1**
Pre-requisite	**12th or equivalent**	**Syllabus version**			
		1.0			

Course Objectives

To apply theoretical knowledge gained in the theory course and get hands-on experience of the topics.

Course Outcome

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

1. Comprehend the dual nature of radiation and matter by means of experiments.
2. Get hands-on experience on the topics of quantum mechanical ideas in the laboratory.
3. Apply low power lasers in optics and optical fiber related experiments.

Indicative Experiments

1.	To determine the dependence of fundamental frequency with the length and tension of a stretched string using sonometer.
2.	To determine the characteristics of EM waves using Hertz experiment
3.	To determine the wavelength of laser source (He-Ne laser and diode lasers of different wavelengths) using diffraction grating
4.	To demonstrate the wave nature of electron by diffraction through graphite sheet
5.	To determine the Planck's constant using electroluminescence process
6.	To numerically demonstrate the discrete energy levels and the wavefunctions using Schrodinger equation (e.g., particle in a box problem can be given as an assignment)
7.	To determine the refractive index of a prism using spectrometer (angle of prism will be given)
8.	To determine the efficiency of a solar cell
9.	To determine the acceptance angle and numerical aperture of an optical fiber
10.	To demonstrate the phase velocity and group velocity (simulation)

Total Laboratory Hours I **30 hours**

Mode of assessment: Continuous assessment/ FAT/ Oral examination

Recommended by Board of Studies	26.06.2021		
Approved by Academic Council	No. 63	Date	23.09.2021

BMAT101L	Calculus	ILTTPTC
		3 0 0 3
Pre-requisite	**Nil**	**Syllabus version**
		1.0

Course Objectives

1. To provide the requisite and relevant background necessary to understand the other important engineering mathematics courses offered for Engineers and Scientists.
2. To introduce important topics of applied mathematics, namely Single and Multivariable Calculus and Vector Calculus etc.
3. Enhance to use technology to model the physical situations into mathematical problems, experiment, interpret results, and verify conclusions.

Course Outcomes

At the end of the course the student should be able to:
1. Apply single variable differentiation and integration to solve applied problems in engineering and find the maxima and minima of functions
2. Evaluate partial derivatives, limits, total differentials, Jacobians, Taylor series and optimization problems involving several variables with or without constraints
3. Evaluate multiple integrals in Cartesian, Polar, Cylindrical and Spherical coordinates.
4. Use special functions to evaluate various types of integrals.
5. Understand gradient, directional derivatives, divergence, curl, Green's, Stokes and Gauss Divergence theorems.

Module:1	**Single Variable Calculus**	**8 hours**

Differentiation- Extrema on an Interval Rolle's Theorem and the Mean value theorem-Increasing and decreasing functions.-First derivative test-Second derivative test-Maxima and Minima-Concavity. Integration-Average function value - Area between curves - Volumes of solids of revolution.

Module:2	**Multivariable Calculus**	**5 hours**

Functions of two variables-limits and continuity-partial derivatives -total differential-Jacobian and its properties.

Module:3	**Application of Multivariable Calculus**	**5 hours**

Taylor's expansion for two variables-maxima and minima-constrained maxima and minima-Lagrange's multiplier method.

Module:4	**Multiple integrals**	**8 hours**

Evaluation of double integrals-change of order of integration-change of variables between Cartesian and polar co-ordinates - evaluation of triple integrals-change of variables between Cartesian and cylindrical and spherical co-ordinates.

Module:5	**Special Functions**	**6 hours**

Beta and Gamma functions-interrelation between beta and gamma functions-evaluation of multiple integrals using gamma and beta functions. Dirichlet's integral -Error functions complementary error functions.

Module:6	**Vector Differentiation**	**5 hours**

Scalar and vector valued functions - gradient, tangent plane-directional derivative-divergence and curl-scalar and vector potentials. Statement of vector identities-simple problems.

Module:7	**Vector Integration**	**6 hours**

Line, surface and volume integrals - Statement of Green's, Stoke's and Gauss divergence theorems -verification and evaluation of vector integrals using them.

Module:8	**Contemporary Topics**	**2 hours**

Guest lectures from Industry and, Research and Development Organizations

	Total Lecture hours:	**45 hours**

tBook

George B.Thomas, D.Weir and J. Hass, Thomas Calculus, 2014, 13th edition, Pearson

Reference Books			
1. Erwin Kreyszig, Advanced Engineering Mathematics, 2015, 10th Edition, Wiley India			
2. B.S. Grewal, Higher Engineering Mathematics, 2020, 44th Edition, Khanna Publishers			
3. John Bird, Higher Engineering Mathematics, 2017, 6th Edition, Elsevier Limited.			
4. James Stewart, Calculus: Early Transcendental, 2017, 8th edition, Cengage Learning.			
5. K.A.Stroud and Dexter J. Booth, Engineering Mathematics, 2013, 7th Edition, Palgrave Macmillan.			
Mode of Evaluation: CAT, Assignment, Quiz and FAT			
Recommended by Board of Studies	24.06.2021		
Approved by Academic Council	No. 63	Date	23.09.2021

BMAT101P	**Calculus Lab**	ILTTPIC I0 I0 I 2 I 1
Pre-requisite	**NIL**	**Syllabus version**
		1.0

Course Objectives

1. To familiarize with the basic syntax, semantics and library functions of MATLAB which serves as a tool not only in calculus but also many courses in engineering and sciences
2. To visualize mathematical functions and its related properties.
3. To evaluate single and multiple integrals and understand it graphically.

Course Outcomes

At the end of the course the student should be able to:
1. Demonstrate MATLAB code for challenging problems in engineering
2. Using plots/displays, interpret and illustrate elementary mathematical functions and procedures.

Indicative Experiments

1.	Introduction to MATLAB through matrices and general Syntax
2.	Plotting and visualizing curves and surfaces in MATLAB - Symbolic computations using MATLAB
3.	Evaluating Extremum of a single variable function
4.	Understanding integration as Area under the curve
5.	Evaluation of Volume by Integrals (Solids of Revolution)
6.	Evaluating maxima and minima of functions of two variables
7.	Applying Lagrange multiplier optimization method
8.	Evaluating Volume under surfaces
9.	Evaluating triple integrals
10.	Evaluating gradient, curl and divergence
11.	Evaluating line integrals in vectors
12.	Applying Green's theorem to real world problems

Total Laboratory Hours I **30 hours**

Text Book

1. Brian H. Hahn, Daniel T. Valentine, Essential MATLAB for Engineers and Scientists, Academic Press, 7th edition, 2019.

Reference Books

1. Amos Gilat, MATLAB: An Introduction with Applications, Wiley, 6/e, 2016.
2. Maritn Brokate, Pammy Manchanda, Abul Hasan Siddiqi, Calculus for Scientists and Engineers, Springer, 2019

Mode of assessment: DA and FAT

Recommended by Board of Studies I 24.06.2021

Approved by Academic Council I No. 63 Date 23.09.2021

BMAT102L	Differential Equations and Transforms	L	T	P	C
		3	1	0	4
Pre-requisite	**BMAT101L, BMAT101P**	**Syllabus version**			
		1.0			

Course Objectives

1. To impart the knowledge of Laplace transform, an important transform techniques for Engineers which requires knowledge of integration.
2. Presenting the elementary notions of Fourier series, this is vital in practical harmonic analysis.
3. Enriching the skills in solving initial and boundary value problems.
4. Impart the knowledge and application of difference equations and the Z-transform in discrete systems that are inherent in natural and physical processes.

Course Outcomes

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

1. Find solution for second and higher order differential equations, formation and solving partial differential equations.
2. Understand basic concepts of Laplace Transforms and solve problems with periodic functions, step functions, impulse functions and convolution.
3. Employ the tools of Fourier series and Fourier transforms.
4. Know the techniques of solving differential equations and partial differential equations.
5. Know the Z-transform and its application in population dynamics and digital signal processing.

Module:1	**Ordinary Differential Equations (ODE)**	**6 hours**

Second order non- homogenous differential equations with constant coefficients- Differential equations with variable coefficients- method of undetermined coefficients-method of Variation of parameters-Solving Damped forced oscillations and LCR circuit theory problems.

Module:2	**Partial Differential Equations (PDE)**	**5 hours**

Formation of partial differential equations - Singular integrals - Solutions of standard types of first order partial differential equations - Lagrange's linear equation-Method of separation of variables

Module:3	**Laplace Transform**	**7 hours**

Definition- Properties of Laplace transform-Laplace transform of standard functions - Laplace transform of periodic functions-Unit step function-Impulse function. Inverse Laplace transform-Partial fractions method and by Convolution theorem..

Module:4	**Solution to ODE and PDE by Laplace transform**	**7 hours**

Solution of ODE's - Non-homogeneous terms involving Heaviside function, Impulse function - Solving Non-homogeneous system using Laplace transform - solution to First order PDE by Laplace transform.

Module:5	**Fourier Series**	**6 hours**

Fourier series - Euler's formulae- Dirichlet's conditions - Change of interval - Half range series - RMS value - Parseval's identity.

Module:6	**Fourier Transform**	**6 hours**

Complex Fourier transform - properties - Relation between Fourier and Laplace Transforms- Fourier sine and cosine transforms - Parseval's identity- Convolution Theorem and simple applications to solve PDE.

Module:7	**Z-Transform**	**6 hours**

Definition of Z-transform and Inverse Z-transform - Standard functions - Partial fractions and

convolution method. Difference equation - first and second order difference equations with constant coefficients - solution of simple difference equations using Z-transform.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours: **Total Tutorial hours:**	**45 hours** **15 hours**

Text Book(s)

1. Erwin Kreyszig, Advanced Engineering Mathematics, 2015, 10th Edition, John Wiley India.
2. B.S. Grewal, Higher Engineering Mathematics, 2020, 44th Edition, Khanna Publishers.

Reference Books

1. Michael D. Greenberg, Advanced Engineering Mathematics, 2006, 2nd Edition, Pearson Education, Indian edition.
2. A First Course in Differential Equations with Modelling Applications, Dennis Zill, 2018, 11th Edition, Cengage Publishers.

Mode of Evaluation: CAT, written assignment, Quiz, FAT

Recommended by Board of Studies	**24-06-2021**		
Approved by Academic Council	No. 64	Date	16-12-2021

BMAT201L	Complex Variables and Linear Algebra	L	T	p	C
		3	1	0	4
Pre-requisite	**BMAT102L**	**Syllabus version**			
		1.0			

Course Objectives

1. To present comprehensive, compact, and integrated treatment of one of the most important branches of applied mathematics namely Complex variables to the engineers and the scientists.
2. To present comprehensive, compact, and integrated treatment of another most important branches of applied mathematics namely Linear Algebra to the engineers and the scientists.
3. To provide students with a framework of the concepts that will help them to analyse deeply about many complex problems.

Course Outcomes

At the end of the course the student should be able to

1. Construct analytic functions and find complex potential of fluid flow and electric fields.
2. Find the image of straight lines by elementary transformations and to express analytic functions in power series.
3. Evaluate real integrals using techniques of contour integration.
4. Use the power of inner product and norm for analysis.
5. Use matrices and transformations for solving engineering problems.

Module:1	**Analytic Functions**	**7hours**

Complex variable - Analytic functions and Cauchy - Riemann equations; Laplace equation and Harmonic functions; Construction of Harmonic conjugate and analytic functions; Applications of analytic functions to fluid-flow and electric field problems.

Module:2	**Conformal and Bilinear transformations**	**7 hours**

Conformal mapping - Elementary transformations; Translation, Magnification, Rotation, Inversion; Exponential and Square transformations ($w = e^{z^2}$, z^2); Bilinear transformation; Cross-ratio-Images of the regions bounded by straight lines under the above transformations;

Module:3	**Complex Integration**	**7 hours**

Functions given by Power Series - Taylor and Laurent series-Singularities - Poles - Residues; Integration of a complex function along a contour; Statements of Cauchy-Goursat theorem- Cauchy's integral formula-Cauchy's residue theorem-Evaluation of real integrals-Indented contour integral.

Module:4	**Vector Spaces**	**6 hours**

Vector space - subspace; linear combination - span - linearly dependent - Independent - bases; Dimensions; Finite dimensional vector space. Row and column spaces; Rank and nullity.

Module:5	**Linear Transformations**	**6 hours**

Linear transformations - Basic properties; Invertible linear transformation; Matrices of linear transformations; Vector space of linear transformations; Change of bases; Similarity.

Module:6	**Inner Product Spaces**	**5 hours**

Dot products and inner products; Lengths and angles of vectors; Matrix representations of inner products; Gram - Schmidt - Orthogonalization.

Module:7	**Matrices and System of Equations**	**5 hours**

Eigenvalues and Eigen vectors; Properties of Eigenvalues and Eigen vectors; Cayley-Hamilton theorem; System of linear equations; Gaussian elimination and Gauss Jordan methods.

Module:8	**Contemporary issues:**	**2 hours**

	Total Lecture hours: **Total Tutorial hours** :	**45 hours** **15 hours**

Text Book(s)

1. G. Dennis Zill, Patrick D. Shanahan, A first course in complex analysis with applications, 2013, 3rd Edition, Jones and Bartlett Publishers Series in Mathematics.
2. Jin Ho Kwak, Sungpyo Hong, Linear Algebra, 2004, Second edition, Springer.

Reference Books

1. Erwin Kreyszig, Advanced Engineering Mathematics, 2015, 10th Edition, John Wiley & Sons (Wiley student Edition).
2. Michael, D. Greenberg, Advanced Engineering Mathematics, 2006, 2nd Edition, Pearson Education.
3. Bernard Kolman, David, R. Hill, Introductory Linear Algebra - An applied first course, 2011, 9th Edition Pearson Education.
4. Gilbert Strang, Introduction to Linear Algebra, 2015, 5th Edition, Cengage Learning
5. B.S. Grewal, Higher Engineering Mathematics, 2020, 44th Edition, Khanna Publishers.

Mode of Evaluation: Digital Assignments(Solutions by using soft skill), Quiz, Continuous Assessments, Final Assessment Test.

Recommended by Board of Studies	24-06-2021		
Approved by Academic Council	No. 64	Date	16-12-2021

BMAT202L	Probability and Statistics	L	T	p	C
		3	0	0	3
Pre-requisite	**BMAT101L, BMAT101P**	**Syllabus version**			
		1.0			

Course Objectives :

1. To provide students with a framework that will help them choose the appropriate descriptive methods in various data analysis situations.
2. To analyze distributions and relationship of real-time data.
3. To apply estimation and testing methods to make inference and modelling techniques for decision making.

Course Outcome :

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

1. Compute and interpret descriptive statistics using numerical and graphical techniques.
2. Understand the basic concepts of random variables and find an appropriate distribution for analyzing data specific to an experiment.
3. Apply statistical methods like correlation, regression analysis in analyzing, interpreting experimental data.
4. Make appropriate decisions using statistical inference that is the central to experimental research.
5. Use statistical methodology and tools in reliability engineering problems.

Module:1	**Introduction to Statistics**	**6 hours**

Statistics and data analysis; Measures of central tendency; Measure of Dispersion, Moments-Skewness-Kurtosis (Concepts only).

Module:2	**Random variables**	**8 hours**

Random variables- Probability mass function, distribution and density functions-Joint probability distribution and Joint density functions; Marginal, Conditional distribution and Density functions- Mathematical expectation and its properties- Covariance, Moment generating function.

Module:3	**Correlation and Regression**	**4 hours**

Correlation and Regression - Rank Correlation; Partial and Multiple correlation; Multiple regression.

Module:4	**Probability Distributions**	**7 hours**

Binomial distribution; Poisson distributions; Normal distribution; Gamma distribution; Exponential distribution; Weibull distribution.

Module:5	**Hypothesis Testing-I**	**4 hours**

Testing of hypothesis -Types of errors - Critical region, Procedure for testing of hypothesis- Large sample tests- Z test for Single Proportion- Difference of Proportion- Mean and difference of means.

Module:6	**Hypothesis Testing-II**	**9 hours**

Small sample tests- Student's t-test, F-test- chi-square test- goodness of fit - independence of attributes- Design of Experiments - Analysis of variance - One way-Two way-Three way classifications - CRD-RBD- LSD.

Module:7	**Reliability**	**5 hours**

Basic concepts- Hazard function-Reliabilities of series and parallel systems- System

Reliability - Maintainability-Preventive and repair maintenance- Availability.		
Module:8	**Contemporary Issues**	**2 hours**
	Total lecture hours:	**45 hours**

Text Book:

1. R. E. Walpole, R. H. Myers, S. L. Mayers, K. Ye, Probability and Statistics for engineers and scientists, 2012, 9th Edition, Pearson Education.

Reference Books

1. Douglas C. Montgomery, George C. Runger, Applied Statistics and Probability for Engineers, 2016, 6th Edition, John Wiley & Sons.
2. E. Balagurusamy, Reliability Engineering, 2017, Tata McGraw Hill, Tenth reprint.
3. J. L. Devore, Probability and Statistics, 2012, 8th Edition, Brooks/Cole, Cengage Learning.
4. R. A. Johnson, Miller Freund's, Probability and Statistics for Engineers, 2011, 8th edition, Prentice Hall India.
5. Bilal M. Ayyub, Richard H. Mccuen, Probability, Statistics and Reliability for Engineers and Scientists, 2011, 3rd edition, CRC press.

Mode of Evaluation: Digital Assignments, Continuous Assessment Tests, Quiz, Final Assessment Test.

Recommended by Board of Studies	24-06-2021		
Approved by Academic Council	No. 64	Date	16-12-2021

BMAT202P	Probability and Statistics Lab	L	T	p	C
		0	0	2	1
Pre-requisite	**BMAT101L, BMAT101P**	**Syllabus version**			
		1.0			

Course Objectives:

1. To enable the students for having experimental knowledge of basic concepts of statistics using R programming.
2. To study the relationship of real-time data and decision making through testing methods using R.
3. To make students capable to do experimental research using statistics in various engineering problems.

Course Outcomes:

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

1. Demonstrate R programming for statistical data.
2. Carry out appropriate analysis of statistical methods through experimental techniques using R.

Indicative Experiments		
1.	Introduction: Understanding Data types; importing/exporting data	Total Laboratory hours: 30
2.	Computing Summary Statistics /plotting and visualizing data using Tabulation and Graphical Representations	
3.	Applying correlation and simple linear regression model to real dataset; computing and interpreting the coefficient of determination	
4.	Applying multiple linear regression model to real dataset; computing and interpreting the multiple coefficients of determination	
5.	Fitting the probability distributions: Binomial distribution	
6.	Normal distribution, Poisson distribution	
7.	Testing of hypothesis for one sample mean and proportion from real time problems	
8.	Testing of hypothesis for two sample means and proportion from real time problems	
9.	Applying the t-test for independent and dependent samples	
10.	Applying Chi-square test for goodness of fit test and Contingency test to real dataset	
11.	Performing ANOVA for real dataset for Completely randomized design, Randomized Block design, Latin square Design	

Text Book

1. Statistical analysis with R by Joseph Schmuller, John wiley and sons Inc., New Jersey 2017.

Reference Books:

1. The Book of R: A First course in Programming and Statistics, by Tilman M Davies, William Pollock, 2016.
2. R for Data Science, by Hadley Wickham and Garrett Grolemund, O' Reilly Media Inc., 2017.

Mode of assessment: Continuous assessment, FAT/ Oral examination and others

Recommended by Board of Studies	24-06-2021		
Approved by Academic Council	No. 64	Date	16-12-2021

BMEE102P	Engineering Design Visualization Lab	ILTTPIC
		I0 I0 I4 I2
Pre-requisite	**Nil**	**Syllabus version**
		1.0

Course Objectives

1. Understand the importance of basic concepts and principles of engineering drawing for representing engineering components, sections, views by graphical representation using CAD.
2. Enable the students with various concepts like dimensioning, conventions and standards related to working drawings in order to become professionally efficient.
3. Develop the ability to communicate with others through the language of technical drawing and sketching.
4. Apply the standards for the use of international and traditional units for technical drawing.

Course Outcome

Upon completion of this subject, the student will be able to
1. Apply BIS and ISO standards in engineering drawing.
2. Graphically construct two dimensional drawing for engineering applications.
3. Draw projections of point, lines, solids, sections of solids for regular polyhedrons and solids of revolutions using computer aided drawing.
4. Visualize geometrical solids in 3D space through orthographic and isometric projections.

Module:1	**Introduction to Engineering Drawing**	**8 hours**

Introduction to Engineering Drawing, Drawing instruments, Drawing standards (BIS), Lettering in engineering, Sheet layout, elements of dimensioning - systems of dimensioning.

Module:2	**Free Hand Sketching**	**8 hours**

Free hand sketching- Pictorial representation of engineering objects - representation of three dimensional objects in two dimensional media - need for multiple views - developing visualization skills through free hand sketching of three dimensional objects.

Module:3	**Orthographic Projection**	**8 hours**

Introduction to projections: General principles of orthographic projection - first angle projection - layout of views - Projection of Points, Projection of lines. 2D drawing using CAD.

Module:4	**3D modelling and Projections**	**12 hours**

Projection of Solids: Classification of solids, Projection of solids in simple position-Solid Modelling.

Sections of Solids: Right regular solids and auxiliary views for the true shape of the sections.

Development of Surfaces, Intersection of Solids: Intersection of two solids.

Module:5	**Isometric Projection and Perspective Projection**	**8 hours**

Isometric View/Projection: Isometric scales, Isometric projections of simple and combination of solids. Conversion of pictorial view into orthographic Projection- 2D drawing from 3D drawing - Missing views.

Perspective Projection: Orthographic representation of a perspective views.

Module:6	**Orthographic Projection into Isometric view**	**8 hours**

Conversion of Orthographic projection into isometric view- 3D modelling from 2D drawing.

Module:7	**Project on Product Development**	**8 hours**

Project on a product development related to any engineering application.

	Total Lecture hours	**60 hours**

Text Book

1. Venugopal K and Prabhu Raja V, Engineering Graphics, New AGE International Publishers, 2018.

Reference Books

1. Bhatt N. D., Engineering Drawing, Charotar Publishing House Pvt. Ltd, 2019.
2. Randy H. Shih, SOLIDWORKS 2021 and Engineering Graphics - An Integrated Approach, SOC Publications, 2021.

3.	Dennis K. Lieu, Sheryl A. Sorby, Visualization, Modeling, and Graphics for Engineering Design, Delmar, Cengage Learning, 2009.
4.	Natarajan.K.V,A Textbook of Engineering Graphics, Dhanalakshmi Publishers, Chennai, 2015.

Indicative Experiments	
1	Free Hand Sketching
2	2D drafting using CAD software
3	Dimensioning of 2D figures
4	Projection of points and lines -2D drafting
5	Projection of solids in simple position- 3D modelling
6	Section of solids- 3D modelling
7	Conversion of pictorial drawing into orthographic projection-CAD
8	Conversion of orthographic projection into isometric view-CAD
9	Engineering design and visualization of an engineering product -I
10	Engineering design and visualization of an engineering product -II
	Total Laboratory Hours l 60 hours

Mode of Evaluation: Examination and evaluation is done for CAD exercises. Continuous assessments in terms of CAD exercises, models/ products designed and created; FAT & Oral examination

Recommended by Board of Studies	02.07.2021		
Approved by Academic Council	No. 63	Date	23.09.2021

BEEE101L	Basic Electrical Engineering	ILTTPTC
		1 2 1 0 1 0 1 2
Pre-requisite	**NIL**	**Syllabus version**
		1.0

Course Objectives

1. Provide insights into relevant concepts and principles in electrical engineering
2. Facilitate understand and comprehend laws, rules and theorems to compute parameters of electric circuits
3. Enable comprehend and analyze the concepts of electrical machines and measuring instruments

Course Outcome

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

1. Evaluate DC and AC circuit parameters using various laws and theorems
2. Analyze the parameters of magnetically coupled circuits and compare various types of electrical machines
3. Comprehend the measurement techniques of electrical parameters
4. Understand the concept of electric supply system and comprehend essential electrical safety requirements

Module:1	**DC Circuits**	**6 hours**

Basic circuit elements and sources; Ohms law, Kirchhoff's laws; Series and parallel connection of circuit elements; Source transformation; Node voltage analysis; Mesh current analysis; Maximum power transfer theorem

Module:2	**AC Circuits**	**6 hours**

Alternating voltages and currents, RMS, average, form factor, peak factor; Single phase RL, RC, RLC series and parallel circuits; Power and power factor; Balanced three phase systems

Module:3	**Magnetic Circuits**	**4 hours**

Electromagnetic Induction: Self and mutual; Magnetically coupled circuits; Series and parallel magnetic circuits; Dot convention

Module:4	**Electrical Machines**	**5 hours**

Principle of operation, construction and applications of DC machines, transformers, induction motors, synchronous generators, stepper motor, Brushless DC (BLOC) motor

Module:5	**Electrical Measurements**	**4 hours**

Principle, Construction and operation of moving coil and moving iron instruments; Power and energy measurement in single phase and three phase systems

Module: 6	**Electrical Supply Systems & Safety**	**3 hours**

Concepts of electrical power generation, transmission and distribution systems; Wiring; Electrical safety; Earthing; Protective devices

Module: 7	**Contemporary Issues**	**2 hours**

Guest lectures from Industry and, Research and Development Organizations

	Total Lecture hours:	**30 hours**

Text Book(s)

1.1Allan R. Hambley, Electrical Engineering: Principles & Applications, 2019, ?1h edition, Pearson Education

Reference Books

1. DP Kothari & I J Nagrath, Basic Electric Engineering, 2019, 4th edition, McGraw Hill Education
2. John Bird, Electrical Circuit Theory and Technology, 2013, 5th edition, Routledge Publications
3. S. Salivahnan, R Rengaraj, G R Venkatakrishnan, Basic Electrical, Electronics and Measurement Engineering, 2018, McGraw Hill Education
4. E.W Golding, F.C Widdis, Electrical Measurements and Measuring Instruments,

I 2011, Reem Publications			
5. I V K Mehta and Rohit Mehta, Principles of Power System, 2005, S. Chand			
Mode of Evaluation: CAT, Written Assignment, Quiz, FAT			
Recommended by Board of Studies I 03.07.2021			
Approved by Academic Council	No. 63	Date	23.09.2021

BEEE101P	Basic Electrical Engineering Lab	L	T	p	C
		0	0	2	1
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives

1. Understanding the concepts of electrical engineering for development and implementation of electrical systems
2. Impart knowledge and skill in wiring and its standards
3. Facilitate comprehend and identify appropriate measuring devices for an electric circuit

Course Outcome

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

1. Understand, analyze and validate the electric circuit parameters
2. Design and develop electrical systems for domestic and commercial applications
3. Acquire skills for interpretation of measurement during experimentation
4. Attain skills to use modern engineering tools for electrical system layout planning

Indicative Experiments	
1	Verification of Kirchhoff's voltage law
2	Verification of Kirchhoff's current law
3	Verification of maximum power transfer theorem
4	Sinusoidal steady state response of RLC circuits
5	Wiring circuit for a single lamp and a fan with regulator
6	Wiring circuit for Godown with two-way switch
7	Load test on single phase transformer/DC motor
8	Measurement of power in a single phase AC Load
9	Measurement of power and energy consumed by a given three phase AC load
10	Study of earthing and measurement of earth pit resistance
11	Cost estimation of residential electrical wiring
12	Electrical layout for a residential/commercial/industrial application using CAD software
	Total Laboratory Hours **30 hours**

Text Book(s)

1 Allan R. Hambley, Electrical Engineering: Principles & Applications, 2019, ?1h edition, Pearson Education

Mode of assessment: CAT, FAT, Oral examination

Recommended by Board of Studies	03.07.2021		
Approved by Academic Council	No. 63	Date	23.09.2021

BECE101L	Basic Electronics	L	T	P	C
		2	0	0	2
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives

1. To introduce the students to the basic concepts of electronic components, sources, measurements. and instrumentation.
2. To apply the inculcated knowledge for developing simple circuits using various electronic components and devices
3. To familiarize the students with the basic concepts of number systems and digital logic.
4. To analyse the concepts associated with multiple sensors and their sensing mechanisms.

Course Outcome

Students will be able to

1. Understand the basic electronic components, sources, and measuring equipment
2. Comprehend the characteristics of diodes, transistors and their applications
3. Design and analyse the amplifiers and oscillators
4. Design and implement simple digital circuits
5. Analyse the performance metrics of the measurement systems.
6. Comprehend the basic concept of various sensors and their sensing mechanisms.

Module:1	**Electronic Components, Sources, and Measuring Equipment**	**3 hours**

Evolution of Electronics - Impact of Electronics in Industry and Society - Familiarization of Resistors, Capacitors, Inductors - Colour Coding - types and specifications, - Electro-mechanical components - Relay and Contactors - Regulated Power supply, Function Generator - Multimeter - CRO

Module:2	**Junction Diodes**	**4 hours**

Intrinsic and extrinsic semiconductors - doping - PN Junctions, Formation of Junction, Physical operation of diode, Barrier Potential, I - V Characteristics, Rectifiers, Zener diode - I-V Characteristics, Zener diode as Voltage regulator.

Module:3	**Transistors**	**5 hours**

Bipolar Junction Transistor (BJT) - Device structure and physical operation, Concept of CB, CE and CC Configuration, Transistor as a Switch, - Metal-Oxide Field Effect Transistor (MOSFET) - Device Structure, mode of operation and Characteristics, MOSFET configurations (CS, CD, CG).

Module:4	**Amplifiers and Oscillators**	**4 hours**

BJT as an amplifier (CE configuration), MOSFET as an amplifier (CS configuration), Feedback concept, Oscillators - Barkhaunsen's criteria for sustained oscillation, RC Phase Shift Oscillator, LC Oscillator.

Module:5	**Digital Logics**	**4 hours**

Number systems, conversion of bases, Boolean algebra, Logic Gates, Concept of universal gate, Simplification and implementation of Boolean functions.

Module:6	**Principles of Measurement and Analysis**	**3 hours**

Units and standards, Errors, Functional Elements of a Measurement System and Instruments, Applications and Classification of Instruments, Types of measured Quantities, Measures of Dispersion, Sample deviation and sample mean, Calibration and standard.

Module:7	**Sensors and Transducers**	**5 hours**

Sensor fundamentals and characteristics - General concepts and terminology of measurement systems, Sensors and transducers - Classification of sensors, Static and dynamic characteristics. Principle of Resistive Sensors, Capacitive Sensors, Inductive Sensors, Magnetic sensors, Optical sensor, Self-generating Sensors

Module:8	**Contemporary issues**	**2 hours**

Guest lectures from Industry and, Research and Development Organisations

	Total Lecture hours:	**30 hours**

Text Book(s)			
1.	A. P. Malvina, D. J. Bates, Electronic Principles, 2017, 7/e, Tata McGraw-Hill.		
2	Albert D. Helfrick and William D. Cooper, "Modern Electronic Instrumentation and Measurement Techniques", 2016, First Edition, Pearson Education, Naida, India.		
Reference Books			
1.	David A Bell, Electronic Devices and Circuits, Oxford Press, 5th Edition, 2008		
2	Robert L. Bolysted and Louis Nashelsky, Electronic Devices and Circuit Theory, Prentice Hall of India, 11th Edition, 2017		
3	D. Patranabis - Sensor and Transducers (2e) Prentice Hall, New Delhi, 2003		
4	A.K. Sawhney, Puneet Sawhney, A Course In Electrical and Electronic Measurements, and Instrumentation, Dhanpat Rai & Co., 2015		
Mode of Evaluation: Internal Assessment (CAT, Quizzes, Digital Assignments) & FAT			
Recommended by Board of Studies	08.07.2021		
Approved by Academic Council	No. 63	Date	23.09.2021

BECE101P	Basic Electronics Lab	ILTTPIC
		0 0 2 1
Pre-requisite	**Nil**	**Syllabus version**
		1.0

Course Objectives

1. To learn the various characteristics of diodes and transistors
2. To understand the concept of digital logic functions and verify the truth tables
3. To learn the performance metrics of measurement systems and characteristics of various sensors

Course Outcome

Students will be able to
1. Analyse the various characteristics and applications of diodes and transistors
2. Design logic circuits using logic gates and verify their truth tables
3. Measure the physical parameters using different transducers

Indicative Experiments

1	Identify, mark the terminal and find the value of a particular component from the given group of electronic components, Study of electronic measurement devices (Multimeter, DSO, function generator)
2	V-I Characteristics of PN Junction diodes and Zener diodes
3	Half Wave and Full Wave Rectifier circuits
4	Zener Diode as a voltage regulator
5	Characteristics of BJT in Common Emitter Configuration
6	Characteristics of MOSFET in Common Source Configuration
7	Frequency response of BJT single stage amplifier
8	Study of the signal generation using RC Phase Shift Oscillator
9	Study of logic gates and implementation of Boolean Functions
10	Strain gauge sensors for measurement of normal strain.
11	Displacement measurement using LVDT and LOR.
12	Temperature measurement using RTD, Thermistor and Thermocouple.

Total Laboratory Hours I **30 hours**

Text Book(s)

1. A. P. Malvina, D. J. Bates, Electronic Principles, 2017, 7/e, Tata McGraw-Hill.
2. Albert D. Helfrick and William D. Cooper, "Modern Electronic Instrumentation and Measurement Techniques", 2016, First Edition, Pearson Education, Naida, India.

Reference Books

1. Robert L. Bolysted and Louis Nashelsky, Electronic Devices and Circuit Theory, Prentice Hall of India, 11th Edition, 2017
2. D. Patranabis - Sensor and Transducers (2e) Prentice Hall, New Delhi, 2003

Mode of assessment: Continuous assessment/ FAT/ Oral examination and others

Recommended by Board of Studies	08.07.2021		
Approved by Academic Council	No. 63	Date	23.09.2021

BMEE201L	Engineering Mechanics	L T P C
		2 1 0 3
Pre-requisite	**NIL**	**Syllabus version**
		1.0

Course Objectives:

1. To enable students to apply fundamental laws and basic concepts of rigid body mechanics to solve problems of bodies under rest or in motion.
2. To enable the students to apply conditions of static equilibrium to analyse physical systems.
3. To compute the properties of areas and bodies.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Compute the resultant and analyse equilibrium (without and with friction) of system of forces acting on particles and rigid bodies in plane and space.
2. Predict the support-reactions and the internal forces of the members of trusses and frames.
3. Apply transfer theorems to determine properties of various sections.
4. Calculate motion parameters of particles and rigid bodies.

Module:1	**Statics of Particles**	**5 hours**

Fundamental concepts and principles - Resolution of a force -Resultant of forces in a plane- Equilibrium of a particle in a plane; Addition of concurrent forces in space- Equilibrium of a particle in space.

Module:2	**Statics of Rigid Bodies**	**7 hours**

Equivalent systems of forces- Principle of Transmissibility - Moment of a force about a point and an axis- Couples and force-couple systems- Equilibrium of rigid bodies in two and three dimensions- Types of beams, supports and reactions; Principle of virtual work - System of connected rigid bodies.

Module:3	**Analysis of Structures**	**5 hours**

Analysis of plane trusses - Method of joints and method of sections- Frames

Module:4	**Friction**	**5 hours**

The laws of dry friction - Coefficients of Friction- Angles of Friction- Types of Friction Problems - Wedges and Ladder friction- Belt friction.

Module:5	**Properties of Surfaces and Solids**	**7 hours**

First moments of areas and lines- Centroids of composite areas and lines- - Theorems of Pappus-Guldinus- Second moment of area- Parallel axis theorem- Rectangular and Polar Moments of inertia of composite areas- Radius of Gyration- Product of Inertia- Principal Axes and Principal Moments of Inertia- Mass moments of inertia of thin plates.

Module:6	**Dynamics of Particles**	**8 hours**

Kinematics of Particles: Displacement, Velocity and Acceleration - Rectilinear motion - Curvilinear motion - Tangential and Normal components - Radial and Transverse components.

Kinetics of Particles: Newton's Second Law- Energy and Momentum Methods-Principle of Work and Energy-Principle of Impulse and Momentum- Direct Central Impact

Module:7	**Dynamics of Rigid Bodies**	**8 hours**

Kinematics of rigid bodies: Translation and fixed-axis rotation- General plane motion: velocity- Instantaneous centre of rotation- General plane motion: acceleration.

Kinetics of rigid bodies:Equations of motion -Angular momentum- Plane motion of a rigid body- Principle of work and energy for rigid bodies- Principle of impulse and momentum for rigid bodies.

	Total Lecture hours:	**45 hours**

Text Book(s)

1. Beer, Johnston, Cornwell, David Mazurek, and Sanghi, Vector Mechanics for Engineers: Statics and Dynamics, 1ih Edition, McGraw-Companies, Inc., New York, 2019.

Reference Books			
1.	Russell C Hibbeler, Engineering Mechanics: Statics and Dynamics (14th Edition), Pearson Education Inc., Prentice Hall, 2016.		
2.	Meriam J.L and Kraige L.G., Engineering Mechanics, Volume I - Statics, Volume II - Dynamics, 9th Edition, John Wiley & Sons, New York, 2018.		
Mode of Evaluation: CAT, Assignment, Quiz and FAT			
Recommended by Board of Studies I 02.07.2021			
Approved by Academic Council I 63		Date	23.09.2021

BCSE101E	Computer Programming: Python	ILTTPC
		1 1 0 4 3
Pre-requisite	**NIL**	**Syllabus version**
		1.0

Course Objectives

1. To provide exposure to basic problem-solving techniques using computers.
2. To inculcate the art of logical thinking abilities and propose novel solutions for real world problems through programming language constructs.

Course Outcome

1. Classify various algorithmic approaches, categorize the appropriate data representation, and demonstrate various control constructs.
2. Choose appropriate programming paradigms, interpret and handle data using files to propose solution through reusable modules; idealize the importance of modules and packages.

Module:1	**Introduction to Problem Solving**	**1 hour**

Problem Solving: Definition and Steps, Problem Analysis Chart, Developing an Algorithm, Flowchart and Pseudocode.

Module:2	**Python Programming Fundamentals**	**2 hours**

Introduction to python - Interactive and Script Mode - Indentation - Comments - Variables - Reserved Words - Data Types - Operators and their precedence - Expressions - Built-in Functions - Importing from Packages.

Module:3	**Control Structures**	**2 hours**

Decision Making and Branching: if, if-else, nested if, multi-way if-elif statements - Looping: while loop, for loop - else clauses in loops, nested loops - break, continue and pass statements.

Module:4	**Collections**	**3 hours**

Lists: Create, Access, Slicing, Negative indices, List methods, List comprehensions - Tuples: Create, Indexing and slicing, Operations on tuples - Dictionary: Create, add, and replace values, Operations on dictionaries - Sets: Creation and operations.

Module:5	**Strings and Regular Expressions**	**2 hours**

Strings: Comparison, Formatting, Slicing, Splitting, Stripping - Regular Expressions: Matching,
Search and replace, Patterns.

Module:6	**Functions and Files**	**3 hours**

Functions - Parameters and Arguments: Positional arguments, Keyword arguments, Parameters
with default values - Local and Global scope of variables - Functions with Arbitrary arguments - Recursive Functions - Lambda Function. Files: Create, Open, Read, Write, Append and Close - tell and seek methods.

Module:7	**Modules and Packages**	**2 hours**

Built-in modules - User-Defined modules - Overview of Numpy and Pandas packages.

	Total Lecture hours:	**15 hours**

Text Book(s)

1. Eric Matthes, Python Crash Course: A Hands-On, Project-Based Introduction to Programming, 2nd Edition, No starch Press, 2019

Reference Books

1. Martic C Brown, Python: The Complete Reference, 4th Edition, McGraw Hill Publishers, 2018.
2. John V. Guttag, Introduction to computation and programming using python: with applications to understanding data. 2nd Edition, MIT Press, 2016.

Mode of Evaluation: No separate evaluation for theory component.			
Indicative Experiments			
1.	Problem Analysis Chart, Flowchart and Pseudocode Practices.		
2.	Sequential Constructs using Python Operators, Expressions.		
3.	Branching (if, if-else, nested if, multi-way if-elif statements) and Looping (for, while, nested looping, break, continue, else in loops).		
4.	List, Tuples, Dictionaries & Sets.		
5.	Strings, Regular Expressions.		
6.	Functions, Lambda, Recursive Functions and Files.		
7.	Modules and Packages (NumPy and Pandas)		
Total Laboratory Hours			**60 hours**
Text Book(s)			
1.	Mariano Anaya, Clean Code in Python: Develop maintainable and efficient code, 2nd Edition, Packt Publishing Limited, 2021.		
Reference Books			
1.	Harsh Bhasin, Python for beginners, 1st Edition, New Age International (P) Ltd., 2019,		
Mode of assessment: Continuous assessments and FAT			
Recommended by Board of Studies	03.07.2021		
Approved by Academic Council	No. 63	Date	23.09.2021

BCSE103E	Computer Programming : Java	IL IT Ip IC
		11 I0 14 I 3
Pre-requisite	**NIL**	**Syllabus version**
		1.0

Course Objectives:

1. To introduce the core language features of Java and understand the fundamentals of Object -Oriented programming in Java.
2. To develop the ability of using Java to solve real world problems.

Course Outcome:

At the end of this course, students should be able to:

1. Understand basic programming constructs; realize the fundamentals of Object Orientated Programming in Java; apply inheritance and interface concepts for enhancing code reusability.
2. Realize the exception handling mechanism; process data within files and use the data structures in the collection framework for solving real world problems.

Module:1	**Java Basics**	**2 hours**

OOP Paradigm - Features of Java Language - JVM - Bytecode - Java program structure - Basic programming constructs - data types - variables - Java naming conventions - operators.

Module:2	**Looping Constructs and Arrays**	**2 hours**

Control and looping constructs - Arrays - one dimensional and multi-dimensional - enhanced for loop - Strings - Wrapper classes.

Module:3	**Classes and Objects**	**2 hours**

Class Fundamentals - Access and non-access specifiers - Declaring objects and assigning object reference variables - array of objects - constructors and destructors - usage of "this" and "static" keywords.

Module:4	**Inheritance and Polymorphism**	**3 hours**

Inheritance - types -- use of "super" - final keyword - Polymorphism - Overloading and Overriding - abstract class - Interfaces.

Module:5	**Packages and Exception Handling**	**2 hours**

Packages: Creating and Accessing - Sub packages.
Exception Handling - Types of Exception - Control Flow in Exceptions - Use of try, catch, finally, throw, throws in Exception Handling - User defined exceptions.

Module:6	**10 Streams and Files**	**2 hours**

Java 1/0 streams - FileInputStream & FileOutputStream - FileReader & FileWriter- DataInputStream & DataOutputStream - BufferedInputStream & BufferedOutputStream - PrintOutputStream - Serialization and Deserialization.

Module:7	**Collection Framework**	**2 hours**

Generic classes and methods - Collection framework: List and Map.

	Total Lecture hours:	**15 hours**

Text Book(s)

1. Y. Daniel Liang, "Introduction to Java programming" - comprehensive version-11th Edition, Pearson publisher, 2017.

Reference Books

1. Herbert Schildt , The Complete Reference -Java, Tata McGraw-Hill publisher, 10th Edition, 2017.
2. Cay Horstmann,"Big Java", 4th edition, John Wiley & Sons publisher, 5th edition, 2015
3. E.Balagurusamy, "Programming with Java", Tata McGraw-Hill publishers, 6th edition, 2019

Mode of Evaluation: No separate evaluation for theory component.			
Indicative Experiments			
1.	Programs using sequential and branching structures.		
2.	Experiment the use of looping, arrays and strings.		
3.	Demonstrate basic Object-Oriented programming elements.		
4.	Experiment the use of inheritance, polymorphism and abstract classes.		
5.	Designing packages and demonstrate exception handling.		
6.	Demonstrate the use of 10 streams, file handling and serialization.		
7.	Program to discover application of collections.		
	Total Laboratory Hours	**60 hours**	
Text Book(s)			
1.	Marc Loy, Patrick Niemeyer and Daniel Leuck, Learning Java, O'Reilly Media, Inc., 5th Edition, 2020.		
Reference Books			
1.	Dhruti Shah, 100+ Solutions in Java: A Hands-On Introduction to Programming in Java, BPB Publications, 1st Edition, 2020.		
Mode of assessment: Continuous assessments and FAT			
Recommended by Board of Studies	03.07.2021		
Approved by Academic Council	No. 63	Date	23.09.2021

BENG101L	Technical English Communication	ILTTPTC
		1 2 1 0 1 0 1 2
Pre-requisite	**NIL**	**Syllabus version**
		1.0

Course Objectives:

1. To develop LSRW skills for effective communication in professional situations
2. To enhance knowledge of grammar and vocabulary for meaningful communication
3. To understand information from diverse texts for effective technical communication

Course Outcomes:

1. Use grammar and vocabulary appropriately while writing and speaking
2. Apply the concepts of communication skills in formal and informal situations
3. Demonstrate effective reading and listening skills to synthesize and draw intelligent inferences
4. Write clearly and significantly in academic and general contexts

Module:1	**Introduction to Communication**	**4 hours**
Nature and Process - Types of communication: Intra-personal, Interpersonal, Group-verbal and non-verbal communication / Cross-cultural Communication - Communication Barriers and Essentials of good communication - Principles of Effective Communications		
Module:2	**Grammatical Aspects**	**4 hours**
Sentence Pattern - Modal Verbs - Concord (SVA) - Conditionals - Error detection		
Module:3	**Written Correspondence**	**4 hours**
Job Application Letters - Resume Writing - Statement of Purpose		
Module:4	**Business Correspondence**	**4 hours**
Business Letters: Calling for Quotation, Complaint & Sales Letter - Memo - Minutes of Meeting - Describing products and processes		
Module:5	**Professional Writing**	**4 hours**
Paraphrasing & Summarizing - Executive Summary - Structure and Types of Proposal - Recommendations		
Module:6	**Team Building & Leadership Skills**	**4 hours**
Principles of Leadership - Team Leadership Model - Negotiation Skills - Conflict Management		
Module:7	**Research Writing**	**4 hours**
Interpreting and Analysing a research article - Approaches to Review Paper Writing - Structure of a research article - Referencing		
Module:8	**Guest Lecture from Industry and R&D organizations**	**2 hours**
Contemporary Issues		
	Total Lecture hours:	**30 hours**

Text Book(s)

1.1Raman, Meenakshi & Sangeeta Sharma. (2015). *Technical Communication: Principles and Practice,* (3rd Edition). India: Oxford University Press.

Reference Books

1. Taylor, Shirley & Chandra .V. (2010). *Communication for Business A Practical Approach* 4th Edition. India: Pearson Longman.
2. Kumar, Sanjay & Pushpalatha. (2018). *English Language and Communication Skills for Engineers.* India: Oxford University Press.
3. Koneru Aruna. *(2020). English Language Skills for Engineers.* India: McGraw Hill Education.
4. Rizvi, M. Ashraf. (2018). *Effective Technical Communication* 2nd Edition. Chennai: McGraw Hill Education.
5. Mishra, Sunitha & Muralikrishna,C. (2014). *Communication Skills for Engineers.* India: Pearson Education.

6.1Watkins, P. (2018). *Teaching and Developing Reading Skills: Cambridge Handbooks for Language teachers.* India: Cambridge University Press.			
Mode of Evaluation: CAT/ Assignment/ Quiz/ FAT/ Group Discussion			
Recommended by Board of Studies	28.06.2021		
Approved by Academic Council	No. 63	Date	23.09.2021

BENG101P	**Technical English Communication Lab**	ILTTPIC I0 I0 I 2 I 1
Pre-requisite	**NIL**	**Syllabus version** 1.0

Course Objectives:

1. To use appropriate grammatical structures in professional communication
2. To improve English communication skills for better employability
3. To enhance meaningful communication skills in writing and public speaking

Course Outcomes:

1. Demonstrate professional rhetoric and articulate ideas effectively
2. Interpret material on technology and deliver eloquent presentations
3. Apply receptive and productive skills in real life situations and develop workplace communication

Indicative Experiments

1.	**Grammar** & **Vocabulary** Error Detection **Activity:** -Worksheets
2.	**Listening to Narratives** Interviews of eminent personalities & Ted Talks **Activity:** Listening Comprehension / Summarising
3.	**Video Resume** SWOT Analysis & digital resume techniques **Activity:** Preparing a digital resume for mock interview
4.	**Product** & **Process Description** Describing and Sequencing **Activity:** Demonstration of product and process
5.	**Mock Meetings** Types of meetings and meeting etiquette **Activity: Conduct of meetings and drafting minutes of the meeting**
6.	**Reading research article** Scientific and Technical articles **Activity:** Writing Literature review
7.	**Analytical Reading** Case Studies on Communication, Team Building and Leadership **Activity:** Group Discussion
8.	**Presentations** Preparing Conference/Seminar paper **Activity:** Individual/ Group presentations
9.	**Intensive Listening** Scientific documentaries **Activity:** Note taking and Summarising
10.	**Interview Skills** Interview questions and techniques **Activity:** Mock Interviews

Total Laboratory Hours I 30 hours

Mode of Assessment: Continuous Assessment/ FAT/ Written Assignments/ Quiz/ Oral Presentation and Group Activity.

Recommended by Board of Studies	I 2s.06.2021		
Approved by Academic Council	No. 63	Date	23.09.2021

BENG101N	**Effective English Communication**	ILITIPIC
		Io Io 1412
Pre-requisite	**Nil**	I **Syllabus Version**
		I 1.0

Course Objectives:

1. To hone LSRW skills for effective communication
2. To enhance communication skills for future career aspirations
3. To gain critical communication skills in writing and public speaking

Course Outcomes:

1. Write effective sentences using appropriate grammar and vocabulary
2. Express clearly in everyday conversations with lucid pronunciation
3. Analyse the given listening inputs for effective comprehension
4. Apply different reading strategies to various texts and use them appropriately

Indicative Experiments	
1.	**Fundamentals of Grammar:** Parts of Speech, Articles, Tenses, Sentence Structure, Types of Sentences, Subject-Verb Agreement **Activity:** Exercises and worksheets
2.	**Speaking for Self-Expression:** Formal Self-Introduction, Expressing Oneself **Activity:** Self-Introduction, Just a Minute (JAM)
3.	**Basic Listening:** Listening to Simple Conversations, Short Speeches/Stories **Activity:** Gap fill exercises
4.	**Reading Skills:** Reading Strategies, Skimming and Scanning **Activity:** Glaze reading, Reading comprehension, Reading newspaper articles
5.	**Drafting Paragraphs:** Keywords Development, Writing Paragraphs using Connectives **Activity:** Picture and poster interpretation
6.	**Vocabulary Enrichment:** Synonyms and Antonyms, Prefixes and Suffixes, Word Formation, One Word Substitution, Frequently used Idioms and Phrases, Homophones and Homonyms **Activity:** Crossword puzzles and worksheets
7.	**Listening for Pronunciation:** Introduction to Phonemes, Listening to Native Speakers, Listening to Various Accents **Activity:** Listening and imitating, Spell Bee
8.	**Interactive Speaking:** Everyday Conversations, Team Interactions, Simulations **Activity:** Situational role plays
9.	**Email and Letter Writing:** Types and Format of Emails and Letters **Activity:** Official e-mails and letters, personal letters
10.	**Reading for Comprehension:** Short Stories by Indian Writers **Activity:** Summarising, loud reading

Total Laboratory Hours I **60 hours**

Mode of Evaluation: Continuous assessment/ FAT/ Written assignments/ Quiz/ Oral examination / Group activity

Recommended by Board of Studies	I 2s.06.2021		
Approved by Academic Council	I No. 63	Date	23.09.2021

BSTS101P	Quantitative Skills Practice I	IL TT Tp IC
		T 0 I0 I 3 11.S
Pre-requisite	**Nil**	**Syllabus version**
		1.0

Course Objectives:

1. To enhance the logical reasoning skills of the students and help them improve problem-solving abilities
2. To acquire skills required to solve quantitative aptitude problems
3. To boost the verbal ability of the students for academic and professional purposes

Course Outcomes:

1. Exhibit sound knowledge to solve problems of Quantitative Aptitude
2. Demonstrate ability to solve problems of Logical Reasoning
3. Display the ability to tackle questions of Verbal Ability

Module:1	**Logical Reasoning**	**5 hours**

Word group categorization questions
Puzzle type class involving students grouping words into right group orders of logical sense
Cryptarithmetic

Module:2	**Data arrangements and Blood relations**	**6 hours**

Linear Arrangement - Circular Arrangement - Multi-dimensional Arrangement - Blood Relations

Module:3	**Ratio and Proportion**	**6 hours**

Ratio - Proportion - Variation - Simple equations - Problems on Ages - Mixtures and alligations

Module:4	**Percentages, Simple and Compound Interest**	**6 hours**

Percentages as Fractions and Decimals - Percentage Increase/ Decrease - Simple Interest - Compound Interest - Relation Between Simple and Compound Interest

Module:5	**Number System**	**6 hours**

Number system- Power cycle - Remainder cycle - Factors, Multiples - HCF and LCM

Module:6	**Essential grammar for Placement**	**7 hours**

- Prepositions
- Adjectives and Adverbs
- Tense
- Speech and Voice
- Idioms and Phrasal Verbs
- Collocations, Gerunds and Infinitives
- Definite and Indefinite Articles
- Omission of Articles
- Prepositions
- Compound Prepositions and Prepositional Phrases
- Interrogatives

Module:7	**Reading Comprehension for Placement**	**3 hours**

Types of questions - Comprehension strategies - Practice exercises

Module:8	**Vocabulary for Placement**	**6 hours**

Exposure to questions related to Synonyms -Antonyms -Analogy - Confusing words - Spelling correctness

	Total Lecture hours:	**45 hours**

Text Book(s)

SMART. (2018). *Place Mentor* 1st (Ed.). Chennai: Oxford University Press.

Aggarwal R.S. (2017). *Quantitative Aptitude for Competitive Examinations* 3rd (Ed.). New Delhi: S. Chand Publishing.

3. FACE. (2016). *Aptipedia Aptitude Encyclopedia* 1st (Ed.). New Delhi: Wiley Publications.			
4. ETHNUS. (2016). *Aptimithra,* 1st (Ed.) Bangalore: McGraw-Hill Education Pvt. Ltd.			
Reference Books			
1. Sharma Arun. (2016). *Quantitative Aptitude,* ?1\Ed.). Naida: McGraw Hill Education Pvt. Ltd.			
Mode of evaluation: CAT, Assessments and FAT (Computer Based Test)			
Recommended by Board of Studies	I 28.06.2021		
Approved by Academic Council	I No. 63	Date	23.09.2021

BSTS102P	Quantitative Skills Practice II	ILTTP IC
		T 0 I0 I 3 11.S
Pre-requisite	**Nil**	**Syllabus version**
		1.0

Course Objectives:

1. Help to trigger the students' logical thinking skills and apply it in real-life scenarios
2. Learn to deploy the strategies of solving quantitative ability problems
3. To expand the verbal ability of students
4. Assist to run the gamut of employability skills

Course Outcomes:

1. Become proficient in interacting and using decision making models effectively
2. Help to understand the given concepts expressly to deliver an impactful presentation
3. Acquire knowledge of solving quantitative aptitude and verbal ability questions effortlessly

Module:1	**Logical Reasoning puzzles -Advanced**	**2 hours**

Advanced puzzles:

- Sudoku
- Mind-bender style word statement puzzles
- Anagrams
- Rebus puzzles

Module:2	**Logical connectives, Syllogism and Venn diagrams**	**2 hours**

Logical Connectives - Advanced Syllogisms - 4, 5, 6 and other multiple statement problems - Challenging Venn Diagram questions: Set theory

Module:3	**Permutation, Combination and Probability -Advanced**	**4 hours**

Fundamental Counting Principle- Permutation and Combination - Computation of Permutation - Advanced problems - Circular Permutations - Computation of Combination - Advanced problems -Advanced probability

Module:4	**Quantitative Aptitude**	**6 hours**

Logarithms, Progressions, Geometry and Quadratic equations - Advanced

- Logarithm
- Arithmetic Progression
- Geometric Progression
- Geometry
- Mensuration
- Coded inequalities
- Quadratic Equations

Concepts followed by advanced questions of CAT level

Module:5	**Image interpretation**	**2 hours**

Image interpretation: Methods - Exposure to image interpretation questions through brainstorming and practice

Module:6	**Critical Reasoning - Advanced**	**3 hours**

Concepts of Critical Reasoning - Exposure to advanced questions of GMAT level

Module:7	**Recruitment Essentials**	**8 hours**

Mock interviews

Cracking other kinds of interviews

Skype/ Telephonic interviews
Panel interviews
Stress interviews

Guesstimation

1. Best methods to approach Guesstimation questions
2. Practice with impromptu interview on Guesstimation questions

Case studies/ situational interview

1. Scientific strategies to answer case study and situational interview questions
2. Best ways to present cases
3. Practice on presenting cases and answering situational interviews asked in recruitment rounds

Module:8	**Problem solving and Algorithmic skills**	**18 hours**

Logical methods to solve problem statements in Programming - Basic algorithms introduced

	Total Lecture hours:	**45 hours**

Text Book(s)

1. SMART. (2018). *Place Mentor* 1st (Ed.). Chennai: Oxford University Press.
2. Aggarwal R.S. (2017). *Quantitative Aptitude for Competitive Examinations* 3rd (Ed.). New Delhi: S. Chand Publishing.
3. FACE. (2016). *Aptipedia Aptitude Encyclopedia* 1st (Ed.). New Delhi: Wiley Publications.
4. ETHNUS. (2016). *Aptimithra,* 1st (Ed.) Bangalore: McGraw-Hill Education Pvt.Ltd.

Reference Books

1. Sharma Arun. (2016). *Quantitative Aptitude,* ?1\Ed.). Naida: McGraw Hill Education Pvt. Ltd.

Mode of evaluation: CAT, Assessments and FAT (Computer Based Test)

Recommended by Board of Studies	I 2a.06.2021		
Approved by Academic Council	I No. 63	Date	23.09.2021

BMEE101N	Introduction to Engineering	L	T	P	C
		0	0	0	1
Pre-requisite	Nil	**Syllabus version**			
		1.0			

Course Objective:

- To make the student comfortable and get familiarized with the facilities available on campus
- To make the student aware of the exciting opportunities and usefulness of engineering to society
- To make the student understand the philosophy of engineering

Course Outcome:

- To know the infrastructure facilities available on campus
- To rationally utilize the facilities during their term for their professional growth
- To appreciate the engineering principles, involve in life-long learning and take up engineering practice as a service to society

General Guidelines

1. Student should observe and involve in the activities during the induction programme. Both general activities and those which are discipline-specific should be included here.
2. Student should get familiarized with the infrastructure facilities available on campus during the general induction, school induction programme and also from the institutional website.
3. Student should attend the lecture by industries, including those on career opportunities, organized by the School and probably involve in 'Do-it-yourself' projects or projects involving reverse-engineering.
4. Activities under 'Do-it-Yourself' will be detailed by the School.
5. Student should prepare a report on the activities and observations, as per the specified format, and submit the same in institutional LMS, VTOP for further evaluation

   General instruction on formatting: Document to be prepared with the titles given in the template; Arial type with font size of 12 to be used; photographs can be included in the document as per the requirement; 1.5 line spacing to be used.

Mode of Evaluation: Evaluation of the submitted report and interaction with the students

Recommended by Board of Studies	02.07.2021		
Approved by Academic Council	No. 63	Date	23.09.2021

BSSC101N	Essence of Traditional Knowledge	L	T	P	C
		0	0	0	2
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives:

1. To impart the knowledge on Indian tradition and Culture.
2. To enable the students to acquire the traditional knowledge in different sectors.
3. To analyze and understand the Science, Management and Indian Knowledge System.

Course Outcomes:

1. Familiarize the concept of Traditional Indian Culture and Knowledge.
2. Explore the Indian religion, philosophy and practices.
3. Analyze and understand the Indian Languages, Culture, Literature and Arts.
4. Gives a clear understanding on the Indian perspective of modern scientific world and basic principles of Yoga and holistic health care system of India.
5. Enable knowledge on Legal framework and traditional knowledge.

Module:1	**Introduction to Traditional Knowledge**

Traditional knowledge: Definition, nature and characteristics, scope and importance, kinds of traditional knowledge, Indigenous Knowledge, characteristics, Traditional knowledge vis-a-vis Indigenous knowledge, Traditional knowledge Vs Western Knowledge.

Module:2	**Culture and Civilization**

Introduction to Culture and Civilization, Culture and Heritage, Characteristics features of Indian Culture, Importance of Culture, Cultural practices in Ancient India, Medieval India and Modern India.

Module:3	**Languages and Literature**

Indian Languages and Literature: the role of Sanskrit, significance of scriptures to current society, Indian philosophies, other Sanskrit literature and literatures of South India.

Module:4	**Religion and Philosophy**

Religion and Philosophy: Religion and Philosophy in ancient India, Religion and Philosophy in Medieval India, Religious Reform Movements in Modern India (selected movements only).

Module:5	**Fine Arts in India**

Indian Painting, Indian handicrafts, Music, divisions of Indian classic music, modern Indian music, Dance and Drama. Science and Technology in India, Development of science in ancient, medieval and modern India. Traditional Medicine - Herbal Healing - Yoga and Pranayama practices.

Module:6	**Traditional Knowledge in different sectors**

Traditional knowledge and engineering, Traditional medicine system, Traditional knowledge in agriculture, Dependence of Traditional Societies on food and healthcare needs; Importance of conservation and sustainable development of environment, Management of biodiversity and Protection of Traditional knowledge.

Module:7 Legal framework and Traditional Knowledge

Introduction on Legal framework and Traditional Knowledge: The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006, Plant Varieties Protection and Farmer's Rights Act, 2001 (PPVFR Act); The Biological Diversity Act 2002 and Rules 2004, The protection of traditional knowledge bill, 2016.

Total Lecture Hours:	**60 hours**

Text Books:

1.	Shikha Jain, Parul G Munjal And Somya Joshi,(2020) Traditional Knowledge Systems And Cultural Heritage, Aryan Books International, India.
2.	Anindya Bhukta(2020), Legal Protection for Traditional Knowledge: Towards A New

	Law for Indigenous Intellectual Property, Emerald Publishing Limited, United Kingdom.
Reference Books :	
–1	Traditional Knowledge System in India, by Amit Jha, 2009.
2.	Basant Kumar Mohanta & Vipin Kumar Singh (2012), "Traditional Knowledge System & Technology in India", Pratibha Prakashan, India.
3–	S. Baliyan, Indian Art and Culture, Oxford University Press, India.
4	http://indiafacts.org/author/michel-danino/
5.	GN Jha (Eng. Trans.) Ed. R N Jha, Yoga-darshanam with Vyasa Bhashya, Vidyanidhi Prakasham, Delhi,2016.

Mode of Evaluation: Quiz and Term End - Quiz			
Recommended by Board of Studies	16-11-2021		
Approved by Academic Council	No. 64	Date	16-12-2021

BCHY102N	Environmental Sciences	L	T	P	C
		0	0	0	2
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives:

The course is aimed at students to

1. Understand and appreciate the unity of life in all its forms and their implications of life style on the environment.
2. Identify the different causes for environmental degradation.
3. Analyze individual's contribution to environmental pollution.
4. Evaluate the impact of pollution at the global/local level and find solutions for remediation.

Course Outcomes

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

1. Recognize the environmental issues in a problem-oriented, interdisciplinary perspective.
2. Classify the key environmental issues, the science behind those problems and potential solutions.
3. Demonstrate the significance of biodiversity and its preservation.
4. Identify various environmental hazards.
5. Design various methods for the conservation of resources.
6. Formulate action plans for sustainable alternatives that incorporate science, humanity, and social aspects.

Module: 1	**Environment and Ecosystem**	**5 hours**

Environment: definition; Earth–life support system. Ecosystem definition, components and types. Key environmental problems, their basic causes and sustainable solutions. Food chain, food web and their significance, Energy flow in ecosystem; Ecological succession-stages involved, primary and secondary succession - hydrarch, mesarch, xerarch.

Module: 2	**Biodiversity**	**4 hours**

Biodiversity-definition, levels and importance. Species: roles: types: extinct, endemic, endangered and rare species. Hot-spots –Significance, Mega-biodiversity. Threats to biodiversity due to natural and anthropogenic activities, Conservation methods. GM crops-advantages and disadvantages.

Module: 3	**Sustaining Environmental Quality**	**4 hours**

Environmental hazards: definition, types, causes and solutions: Biological (Malaria, COVID-19), Chemical (BPA, heavy metals), and Nuclear (Chernobyl); Air, water and soil quality management and conservation; Solid waste management methods.

Module: 4	**Clean and Green Energy**	**5 hours**

Renewable energy resources: Solar energy-thermal and photovoltaic; Hydroelectric energy. Wind energy, Ocean thermal energy; Geothermal energy; Energy from biomass; Hydrogen energy; Solar-hydrogen revolution. Electric and CNG vehicles.

Module: 5	**Environmental Protection Policies**	**4 hours**

Environmental Protection (EPA) objectives; Air Act, water Act, Forest conservation Act and Wild life protection Act. Environmental Impact Analysis: guidelines, core values. Impact assessment methodologies.

Module: 6	**Sustainable development**	**4 hours**

Effect of population-urban environmental problems; Population age structure; Sustainable human societies: tools in economics, sustainable development goals SDGs and promoting awareness. Women and child welfare, Women empowerment.

Module: 7	**Global Climate Change**	**4 hours**
Global climate change and green-house effect. Kyoto Protocol-carbon credits, The Paris Agreement, carbon sequestration: definition, types and methodologies. Ozone layer depletion: causes and impacts. Mitigation of ozone layer depletion- Montreal Protocol. Role of Information Technology in environment.		
Total Lecture hours:		**30 hours**
Assessment: Seminars, Quiz, Case Studies, Final Assessment Test.		
Text Books		
1. G. Tyler Miller and Scott E. Spoolman (2016), Environmental Science, 15th Edition, Cengagelearning. 2. Benny Joseph, (2012), Environmental Science and Engineering, 5th Edition, Tata McGraw Hill Education Private Limited, New Delhi, India.		
Reference Book(s)		
1. David M. Hassenzahl, Mary Catherine Hager, Linda. R. Berg (2011), Visualizing Environmental Science, 4th Edition, John Wiley & Sons, USA. 2. Raj Kumar Singh, (2012), Environmental Studies, Tata McGraw Hill Education Private Limited, New Delhi, India. 3. George Tyler Miller, Jr. and Scott Spoolman (2012), Living in the Environment – Principles, Connections and Solutions, 17th Edition, Brooks/Cole, USA.		

Recommended by Board of Studies	14-02-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BHUM101N	Ethics and Values	L	T	p	C
		0	0	0	2
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives:

1. To understand and appreciate the ethical issues faced by an individual in profession, society and polity.
2. To understand the negative health impacts of certain unhealthy behavior.
3. To appreciate the need and importance of physical, emotional health and social health.

Expected Course Outcomes:

1. Students will be able to:
2. Follow sound morals and ethical values scrupulously to prove as good citizens.
3. Understand various social problems and learn to act ethically.
4. Understand the concept of addiction and how it will affect the physical and mental health.
5. Identify ethical concerns in research and intellectual contexts, including academic integrity, use and citation of sources, the objective presentation of data, and the treatment of human subjects.
6. Identify the main typologies, characteristics, activities, actors and forms of cybercrime.

Module:1	**Being Good and Responsible**

Gandhian values such as truth and non-violence - Comparative analysis on leaders of past and present - Society's interests versus self-interests - Personal Social Responsibility: Helping the needy, charity and serving the society.

Module:2	**Social Issues 1**

Harassment - Types - Prevention of harassment, Violence and Terrorism.

Module:3	**Social Issues 2**

Corruption: Ethical values, causes, impact, laws, prevention - Electoral malpractices;
White collar crimes - Tax evasions - Unfair trade practices.

Module:4	**Addiction and Health**

Peer pressure - Alcoholism: Ethical values, causes, impact, laws, prevention - Ill effects of smoking - Prevention of Suicides;
Sexual Health: Prevention and impact of pre-marital pregnancy and Sexually Transmitted Diseases.

Module:5	**Drug Abuse**

Abuse of different types of legal and illegal drugs: Ethical values, causes, impact, laws and prevention.

Module:6	**Personal and Professional Ethics**

Dishonesty - Stealing - Malpractices in Examinations - Plagiarism.

Module:7	**Abuse of Technologies**

Hacking and other cyber crimes, Addiction to mobile phone usage, Video games and Social networking websites.

Total Lecture Hours:	**60 hours**

Text Books:

1.	R R Gaur, R Asthana, G P Bagaria, "A Foundation Course in Human Values and Professional Ethics", 2019, 2nd Revised Edition, Excel Books, New Delhi.
2.	Hartmann, N., "Moral Values", 2017, United Kingdom: Taylor & Francis.

Reference Books :

1.	Rachels, James & Stuart Rachels, "The Elements of Moral Philosophy", 9th edition, 2019, New York: McGraw-Hill Education.

2.	Blackburn, S. "Ethics: A Very Short Introduction", 2001, Oxford University Press.
3.	Dhaliwal, K.K, "Gandhian Philosophy of Ethics: A Study of Relationship between his Presupposition and Precepts", 2016, Writers Choice, New Delhi, India.
4	Ministry of Social Justice and Empowerment, "Magnitude of Substance Use in India", 2019, Government of India.
5.	Ministry of Home Affairs, "Accidental Deaths and Suicides in India", 2019, Government of India.
6.	Ministry of Home Affairs, "A Handbook for Adolescents/ Students on Cyber Safety", 2018, Government of India.

Mode of Evaluation: Poster making, Quiz and Term End - Quiz			
Recommended by Board of Studies	27-10-2021		
Approved by Academic Council	No. 64	Date	16-12-2021

BMEE209L	Materials Science and Engineering	L	T	P	C
		3	0	0	3
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives

1. To impart knowledge on the correlation between structure-property of materials.
2. To provide knowledge on mechanical properties of materials and strengthening mechanisms.
3. To give insight into advanced materials such as polymers, ceramics and composites and their applications.

Course Outcomes

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

1. Compare different structures based on the atomic arrangement.
2. Examine various phases of metals and alloys using phase diagrams.
3. Assess the mechanical behaviour of materials according to the standards.
4. Recommend suitable heat treatment and surface hardening processes.
5. Propose the suitable material based on the structure-property relationships.

Module:1	**Fundamentals to Materials engineering**	**3 hours**

Historical perspective of materials, materials science, Materials engineering, Materials classification, Materials tetrahedron, Engineering requirement of advanced materials and smart materials – Diversified applications.

Module:2	**Crystallography and Defects**	**6 hours**

Fundamental Concepts, Crystal geometry, Unit Cell, Classification of Lattices – Bravais Lattice - Point coordinates, Crystallographic Directions and Planes, Weiss zone law applications - Single and Poly crystalline materials, Non-crystalline/Amorphous Materials. Crystal Structure of Metals, Ceramics and Polymers, Defects in crystals – point defects, line defects (dislocations), Characteristics of Dislocations, Slip Systems, Slip in Single Crystal, Deformation by Twining, surface defects and volume defects, Microscopic examination.

Module:3	**Solidification, Diffusion and Phase Transformation**	**8 hours**

Nucleation - Homogeneous and Heterogeneous Nucleation- Growth of crystals- Planar growth – dendritic growth. Diffusion: Introduction – Fick's Law of Diffusion - Diffusion Mechanisms, Steady state and non-steady state diffusion. Basics of phase diagram, Gibb's phase rule, Lever rule, Unary phase Diagrams, Binary Isomorphous and Eutectic Systems, Interpretation of Phase Diagram, Iron – iron carbide phase diagram – Slow cooling of hypo and hyper eutectoid steels, Phase transformations in steels and cast iron.

Module:4	**Mechanical behaviour of Materials**	**7 hours**

Hardness Testing of Materials, Tensile properties of the materials, Effect of strain rate, Impact Testing, Fracture of Metals – Ductile Fracture, Brittle Fracture, Ductile to Brittle Transition Temperature (DBTT), Fatigue – Endurance limit, Fatigue test, S-N curves, factors affecting fatigue, structural changes accompanying fatigue; Creep and stress rupture– mechanism of creep – stages of creep and creep test, Mechanisms of Strengthening in Metals and alloys.

Module:5	**Heat Treatment**	**7 hours**

Isothermal Transformation diagrams and Continuous Cooing Transformation diagram. Principles of heat treatment, Annealing, Concept of Recovery, Recrystallization and Grain Growth, Normalizing, Hardening, Tempering, Solutionizing, Ageing, Special heat treatment processes: Austemepering, Martempering, Ausforming, Hardenability of steel, Microstructure changes during heat treatment.

Surface hardening processes - Carburizing – Nitriding – Cyaniding and carbo-nitriding, Induction and flame hardening, Laser and Electron beam hardening.

Module:6	**Metallic Materials**	**6 hours**

Steels – Types of Steels, Effect of alloying elements on structure and properties of steels,

Alloy Steel – Tool and Die Steel, Stainless steel, Speciality steel, Cast iron- White, Grey, Malleable and Nodular - Properties and application of cast irons. Non-ferrous Alloys, Aluminium, copper, Nickel, Magnesium and Titanium.		
Module:7	**Non-metallic and Composite Materials & Economic, Environmental, and societal issues in materials Science and Engineering**	**6 hours**
Ceramics: types, properties and application of ceramics; Glass: classification of glass, properties and application of glass; Polymer: classification of polymers - properties and application of polymers; Fibers: Natural Fibers/Synthetic Fibers; Composites: Classification of Composite Materials, Properties and Application of Composite Materials.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Books	
1.	William D. Callister Jr., David G. Rethwisch, Callister's Materials Science and Engineering, 2018, 10th edition, John Wiley & Sons, Inc., United states.
2.	William F Smith, Javad Hasemi and Ravi Prakash, Materials science and Engineering, 2017, 5th edition, McGraw Hill Publications.
Reference Books	
1.	Michael F. Ashby, Materials Selection in Mechanical Design, 2016, 5th edition, Elsevier Butterworth-Heinemann.
2	Donald R. Askeland, Science and Engineering of Materials, SI Edition, 2015, 7th edition, Springer, Boston, MA.
3	Raghavan V, Materials Science and Engineering, 2015, 6th edition, Prentice Hall India Learning Private Limited, United Kingdom.
4	Sidney Avner, Introduction to Physical Metallurgy, 2017, 2nd edition, McGraw Hill Education

Mode of Evaluation: CAT / Written assignment / Quiz / FAT			
Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE209P	Materials Science and Engineering Lab	L	T	P	C
		0	0	2	1
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objective

1. To impart practical exposure on optical microscopy, furnace, and mechanical testing equipment.
2. To provide hands-on experience on image analysis software.

Course Outcome

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

1. Investigate the phases in the microstructure of samples.
2. Assess the mechanical properties as per the ASTM standards.
3. Develop and propose the industrial heat treatments.

Indicative Experiments	
1.	Thermal analysis of Pb-Sn alloy (To produce cooling curve and report the eutectic temperature.
2.	Metallographic sample preparation.
3.	To study the microstructure of Ferrous Materials a) Steel b) Stainless Steel c) Cast Iron.
4.	To study the microstructure of Non- Ferrous Materials.
5.	Cold work and annealed microstructure of alloys (Ferrous/Non-ferrous).
6.	Heat Treatment of Steel (Annealing, Normalising, Quenching and Tempering).
7.	Age hardening studies of Aluminium alloys.
8.	Study of surface hardened Steel – Case Depth, hardness and microstructure.
9.	Hardness measurement of ferrous and non-ferrous alloys.
10.	Hardenability of Steels by Jominy end quench test according to ASTM standards.
11.	Tensile property evaluation of ductile and brittle materials according to ASTM standards.
12.	Quantitative metallography and image analysis
	Total Laboratory Hours **30 hours**

Text Book(s)

1.	William D. Callister Jr., David G. Rethwisch, Callister's Materials Science and Engineering, 2018, 10th edition, John Wiley & Sons, Inc., United states
2.	William F Smith, Javad Hasemi and Ravi Prakash, Materials science and Engineering, 2017, McGraw Hill Publications, 5th edition.
3.	Lab Manual prepared by course faculty member

Reference Books

1.	Michael F. Ashby, Materials Selection in Mechanical Design, Elsevier Butterworth-Heinemann, 2016, 5th edition.
2	Donald R. Askeland, Science and Engineering of Materials, SI Edition, 2015, 7th edition, Springer, Boston, MA
3	V. Raghavan, Materials Science and Engineering, 2015, 6th edition, Prentice Hall India Learning Private Limited, United Kingdom
4	Michael F. Ashby, Materials Selection in Mechanical Design, Elsevier Butterworth-Heinemann, 2016, 5th edition.

Mode of assessment: Continuous assessment / FAT / Oral examination			
Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE211L	Engineering Optimization	L	T	P	C
		2	1	0	3
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives

1. To impart knowledge on linear, non-linear optimization problems and techniques to solve them.
2. To develop modelling skills and to solve engineering optimization problems.
3. To demonstrate the use of software to solve optimization problems.
4. To develop the skills of using modern heuristic search algorithms.

Course Outcomes

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

1. Formulate the engineering problems as optimization problems.
2. Identify optimality conditions for unconstrained and constrained optimization problems.
3. Solve linear programming problems.
4. Apply suitable algorithm and solve constraint & unconstraint optimization problems.
5. Justify modern heuristic search algorithms for solving optimization problems.

Module:1	**Optimum Problem Formulation**	**6 hours**

Introduction to Optimization – Statement of an Optimization Problem – Classifications of Optimization problem – Optimum Problem Formulation: Problem Formulation Process, Application problems related Engineering Design and Manufacturing.

Module:2	**Optimality Criterion**	**6 hours**

Introduction – Optimality Criterion: Single variable problems – Optimality criterions for unconstraint problems. Multivariable Optimization problems – Optimality criterion for constrained optimization problems: Lagrangian Multiplier, Kuhn-Tucker Conditions – Exercise problems to identify optimality conditions for unconstrained and constrained problems (Hand Calculation).

Module:3	**Linear Programming**	**8 hours**

Introduction – Standard form of a LPP problem - Graphical solution for LPP – Simplex Method – Revised Simplex method – Duality in LPP – Modelling of Transportation problem as an Optimization problem – Exercise problems (limited to simplex method – Demonstration: Solving LPP problems using software tool (MATLAB).

Module:4	**Non-Linear Programming – Unconstrained Optimization I**	**5 hours**

Introduction – Standard form of an unconstrained problem – Unimodal and Multimodal functions – Introduction to One Dimensional minimization methods: Elimination method: Fibonacci Method. Interpolation methods: Newton Method Exercise problems (hand calculation – Newton and Secant method) – Solving 1D problems using software tool (MATLAB).

Module:5	**Non-Linear Programming – Unconstrained Optimization II**	**6 hours**

Multi variable unconstraint optimization algorithms: Univariate Method – Pattern directions – Conjugate Direction method (Powell's method) - Steepest Descent method – Exercise problems (hand calculation – Univariate and Steepest Descent method) Demonstration: Solving unconstraint problems using software tool (MATLAB).

Module:6	**Non-Linear Programming – Constrained Optimization**	**5 hours**

Introduction - Standard form of a constrained problem – Transformation methods- Penalty function method: Interior and Exterior methods - Exercise problems: Converting constrained problem into unconstrained problems using various penalty function – Demonstration: Solving Constraint problems using software tool (MATLAB).

Module:7	**Modern Methods of Optimization**	**7 hours**

Introduction: Heuristics, Meta-Heuristics, Combinatorial Optimization problems – Examples of P, NP, NP-complete and NP-Hard problems – Introduction to Genetic Algorithm, Simulated Annealing – Particle Swarm Optimization - Demonstration: Working of GA, SA,

PSO using Software tools (MATLAB).				
Module:8	**Contemporary Issues**			**2 hours**
	Total Lecture hours:			**45 hours**
Text Book(s)				
1.	Rao S.S, Engineering optimization: theory and practice, 2020, 5th Edition, John Wiley & Sons, Inc., USA.			
2.	Deb K, Optimization for engineering design: Algorithms and examples, 2012, PHI Learning Pvt. Ltd., India.			
Reference Books				
1.	Arora J.S, Introduction to Optimum Design, 2016, 4th Edition, Academic Press.			
2.	Igor Griva, Stephen G. Nash, Ariela Sofer, Linear and Non-Linear Optimizaton, 2009, 2nd Edition, Society of Industrial and Applied Mathematics.			
Mode of Evaluation: CAT / written assignment / Quiz / FAT				
Recommended by Board of Studies	09-03-2022			
Approved by Academic Council	No. 65	Date	17-03-2022	

BMEE308L	Control Systems	L	T	P	C
		2	0	0	2
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives

1. To expose the students to classical methods of control engineering, physical system modelling and control.
2. To enable the students to design control system for various applications.
3. To enrich the ability of the students to analyse the performance of dynamic control systems.

Course Outcome

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

1. Apply the concepts of control systems and modelling techniques.
2. Develop various representations of system based on the first principles approach.
3. Infer the domain specifications from the time and frequency response.
4. Analyse the stability of closed-loop systems using different techniques.
5. Demonstrate the state-space representation and modern control theory.
6. Design appropriate control systems for different applications.

Module:1	**Introduction**	**2 hours**
Concept of control system, Classification of control systems – Open-loop and closed-loop control systems, Examples of control systems- Effects of feedback, Feedback Characteristics.		
Module:2	**Model Representations**	**4 hours**
Transfer Functions of LTI Systems, Concepts of Poles and Zeros, Block diagram, Determining the Transfer function from Block Diagrams, Signal flow graphs – Reduction using Mason's gain formula.		
Module:3	**Modelling of Physical Systems**	**5 hours**
Development of mathematical models: mechanical, electrical, electromechanical, Thermal, Hydraulic and Pneumatic systems.		
Module:4	**Time Response Analysis**	**6 hours**
Standard test signals, Time response of first order systems and second order systems, Transient response of second order systems – Time domain specifications, Steady state errors and error constants, General Controllers – P, PI, PD and PID controllers.		
Module:5	**Stability Analysis**	**4 hours**
The concept of stability – Routh-Hurwitz's stability criterion – qualitative stability and conditional stability – Root Locus Technique: Concept of root locus – Construction of root locus.		
Module:6	**Frequency Response Analysis**	**4 hours**
Frequency domain specifications, Bode plot, Phase margin and Gain margin, Polar plots, Nyquist Criteria.		
Module:7	**Introduction to State Space Analysis**	**3 hours**
Concepts of state, state variables and state model, Modelling system in state space, Solving the time invariant state equations, State Transition Matrix, Concepts of Controllability and Observability.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)

1.	Nagrath I.J, and Gopal M, Control Systems Engineering, 2017, 6th edition, New Age International Publishers.
2.	Ogata K, Modern Control Engineering, 2015, 5th Edition, Prentice Hall of India Pvt. Ltd.

Reference Books			
1.	Norman S Nise, Control Systems Engineering, 2018, 7th edition, John Wiley and Sons, Inc.		
2.	Benjamin C. Ku, Farid Golnaraghi, Automatic Control Systems, 2017, 10th edition, McGraw-Hill Education.		
Mode of Evaluation: CAT / Written assignment / Quiz / FAT / Seminar / Case studies			
Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE308P	Microcontrollers and Interfacing Lab	L	T	P	C
		0	0	2	1
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives

1. To expose the students to fundamentals of Microcontrollers.
2. To understand the functions of microcontroller programming and interfacing.
3. To enable the students to design appropriate microcontroller-based systems.

Course Outcomes

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

1. Demonstrate and interface microcontroller with sensors and actuators.
2. Develop speed control techniques using microcontroller.
3. Construct the simulation model using control system tool box.

Indicative List of Experiments	
1	Study of embedded systems using microcontrollers and its architectural features.
2	Push button, Keypad and Display Interfacing with microcontroller.
3	Programming Traffic Light Control using microcontroller.
4	Interfacing Ultrasonic Sensor with microcontroller.
5	Open loop Speed and direction control of a DC motor using microcontroller.
6	Closed loop Speed control of a DC motor based on PID Controller using microcontroller.
7	Interfacing Stepper motor with microcontroller.
8	Microcontroller Interfacing and Data transmission using RF/Bluetooth/WIFI.
9	Development of a line following robot.
10	Development of IoT enabled data transmission from sensors.
11	Creating linear models of your control system using transfer function, state-space, and other representations using MATLab Control System toolbox.
12	Interface and visualize system behaviour in the time domain and frequency domain using MATLab control system toolbox.
	Total Laboratory Hours: 30 hours

Text Book(s)

1. Nagrath I.J., and Gopal M., Control Systems Engineering, 2017, 6th edition New Age International Publishers.
2. K. Ogata, Modern Control Engineering, 2015, 5th Edition, Prentice Hall of India Pvt. Ltd.
3. Lab Manual prepared by course faculty members.

Reference Books

1. Norman S Nise, Control Systems Engineering, 2018, 7th edition John Wiley and Sons, Inc
2. Benjamin C. Ku and Farid Golnaraghi, “Automatic Control Systems”, 2017, 10th edition McGraw-Hill Education.

Mode of assessment: Viva-voce examination, Lab performance & FAT

Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE407L	Artificial Intelligence	L	T	P	C
		2	1	0	3
Pre-requisite	**BMAT202L, BMAT202P**	**Syllabus version**			
		1.0			

Course Objectives

1. To provide basic understanding on Artificial Intelligence with its sub-sets.
2. To impart knowledge of search algorithm, logics, reasoning and uncertainty.
3. To introduce the basic concepts of machine learning and its application in mechanical engineering.

Course Outcome

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

1. Translate the characteristics of artificial intelligence and its sub-sets.
2. Implement appropriate algorithm for problem solving by searching.
3. Construct the logical agents and familiar in the application of fuzzy in AI.
4. Design the decision making algorithm with the reasoning of uncertainties.
5. Develop machine learning programs based on supervised, unsupervised and reinforcement learning.
6. Experiment the benefit of neural network in deep learning.
7. Apply machine learning approach to solve problems related to mechanical engineering.

Module:1	**Foundation of AI**	**4 hours**
Introduction – Foundations of AI – Evolution of AI – Intelligent Agents: Agents and environments, Concept of rationality, structure of agents – Structure of Knowledge based system - Risks and Benefits of AI.		
Module:2	**Problem-solving by searching**	**6 hours**
Uninformed search: Breath first search, Depth first search, iterative deepening – Heuristic search: Greedy search, A*search – Adversarial search: Minimax search, alpha-beta-pruning.		
Module:3	**Logic (Knowledge, reasoning and planning)**	**8 hours**
Propositional Logic – First Order Logic – Inference in First Order Logic – Knowledge representations – automated planning. Fuzzy: Fuzzy sets, operation and properties, Feature of membership functions, fuzzification and defuzzification, Fuzzy logic rules based system.		
Module:4	**Reasoning with uncertainty**	**6 hours**
Quantifying uncertainty – Probabilistic reasoning – Making Simple Decisions – Making Complex Decisions – Multiagent decision making.		
Module:5	**Machine Learning**	**6 hours**
Supervised learning: Decision trees, linear regressing and classification, and support vector machine – Unsupervised: Clustering, dimensionality reduction, Principal component analysis – Reinforcement: Passive and active reinforcement learning.		
Module:6	**Deep Learning**	**7 hours**
Simple feedforward networks – Computation graph for deep learning – Convolution neural networks – Learning algorithms – generalization – Recurrent Neural Networks - Deep reinforcement learning.		
Module:7	**Use cases**	**6 hours**
AI in manufacturing process: Materials characterization and machine process – AI in logistics and supply chain management – Prediction of mechanical system failure – diagnostic system – Human-in-loop for Machine human collaborative task.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Books

1.	Russell S, Norvig P, Artificial Intelligence - A Modern Approach, 2021, 4th edition, Prentice Hall.

2.	Ivan Vasilev, Advanced Deep Learning with Python: Design and implement advanced next-generation AI solutions using TensorFlow and PyTorch, 2019, 1st edition, Packt Publishing Ltd.		
Reference Books			
1.	Bishop C. M, Pattern Recognition and Machine Learning, 2011, 2nd edition, Springer.		
2.	Nilsson N.J, Artificial Intelligence: A New Synthesis, 1998, 1st edition, Morgan Kaufmann.		
Mode of Evaluation: CAT / Written assignment / Quiz / FAT /			
Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE202L	Mechanics of Solids	L	T	P	C
		3	0	0	3
Pre-requisite	**BMEE201L**	**Syllabus version**			
		1.0			

Course Objectives

1. To understand the fundamental concepts of mechanics of deformable solids; including static equilibrium, geometry of deformation, and material constitutive behaviour.
2. To provide students with exposure on systematic methods for solving engineering problems in solid mechanics.
3. To discuss the basic mechanical principles underlying modern approaches for design of various structural members subjected to axial load, torsion, bending, buckling, transverse shear, and combined loading.
4. To build the necessary theoretical background for structural analysis and design courses.

Course Outcomes

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

1. Analyse stresses and strains in simple and compound bars
2. Illustrate the relationship among load, shear force and bending moment for various beams
3. Evaluate the bending and shear stresses for beams with varying cross sections
4. Calculate the slope and deflection of various beams
5. Apply torsion equation for shafts and helical springs
6. Analyse the failure of columns, thin and thick shells

Module:1	**Simple stresses and strains**	**9 hours**

Definition/derivation of normal stress, shear stress, and normal strain and shear strain – Stress-strain diagram for brittle and ductile materials - Poisson's ratio & volumetric strain – Elastic constants – relationship between elastic constants and Poisson's ratio – Generalised Hook's law – Deformation of simple and compound bars – Creep – Strain energy – Resilience – Gradual, sudden, impact and shock loadings – thermal stresses.

Module:2	**Bi-axial stress system**	**6 hours**

Introduction – Stresses on an inclined section of a bar under axial loading – compound stresses – Normal and tangential stresses on an inclined plane for biaxial stresses – Two perpendicular normal stresses accompanied by a state of simple shear – Mohr's circle of stresses and strain, Strain rosette – Principal stresses and strains – Analytical and graphical solutions. Theories of failures.

Module:3	**Shear Force and Bending Moment**	**6 hours**

Definition of beam – Types of beams – Concept of shear force and bending moment – S.F and B.M diagrams for cantilever, simply supported and overhanging beams subjected to point loads, uniformly distributed loads, uniformly varying loads and combination of these loads – Point of contra flexure – Relation between S.F., B.M and rate of loading at a section of a beam.

Module:4	**Stresses in beams**	**6 hours**

Theory of simple bending – Assumptions – Derivation of bending equation - Neutral axis – Determination of bending stresses – section modulus of rectangular and circular sections (Solid and Hollow), I, T, Angle and Channel sections – Design of simple beam sections, Shear Stresses: Derivation of formula – Shear stress distribution across various beams sections like rectangular, circular, triangular, I, T sections.

Module:5	**Deflection of beams**	**5 hours**

Deflection of beams by Double integration method – Macaulay's method – Area moment theorems for computation of slopes and deflections in beams – Conjugate beam method.

Module:6	**Torsion**	**5 hours**

Introduction to Torsion – derivation of shear strain – Torsion formula – stresses and deformations in circular and hollow shafts – Stepped shafts – shafts fixed at the both ends, stresses in helical springs.

Module:7	**Thin and Thick Cylinders, Columns**	**6 hours**
Thin cylinders and shells – deformation of thin cylinders and shells; Thick Cylinders, Shrink fits, Compounding. Theory of columns – Long column and short column - Euler's formula – Rankine's formula.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Textbooks	
1.	Ferdinand P. Beer, E. Russell Johnston, John T. DeWolf, David F. Mazurek, Sanjeev Sangh, Mechanics of Materials, 2020, 8th Edition, McGraw Hill Education, India.
2.	Russell C. Hibbeler, Mechanics of Materials in SI Units, 9th Edition; 2018, Pearson Education, India.
Reference Books	
1.	James M. Gere, Barry J. Goodno, Mechanics of Materials, 2019, 9th Edition, Cengage Learning India Pvt. Ltd.
2.	Rattan S. S., Strength of Materials, 2017, 3rd edition, McGraw Hill Education, India.
3.	Ramamrutham S, Narayanan R, Strength of Materials, 2020, 20th Edition, Dhanpat Rai Publishing Company, India.
4.	Popov E. P, Nagarajan S, Lu Z. A; Mechanics of materials, SI version, 2015, Prentice-Hall of India.
5.	James M. Gere, and Stephen Timoshenko, Mechanics of Materials; 2004, 2nd edition, CBS publishers and distributors.

Mode of Evaluation: CAT, Written assignment, Quiz , FAT			
Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE202P	Mechanics of Solids Lab	L	T	P	C
		0	0	2	1
Pre-requisite	**BMEE201L**	**Syllabus version**			
		1.0			

Course Objectives

1. To impart practical skills in investigating the mechanical behavior of materials.
2. To demonstrate the importance of testing standards in the determination of mechanical properties.

Course Outcome

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

1. Evaluate elastic constants of engineering materials as per the ASTM standards.
2. Develop stress-strain diagram of engineering materials as per the ASTM standards.
3. Examine the impact behavior of ductile materials as per the ASTM standards.

Indicative Experiments		
1.	Tensile and compression tests on the given specimens for determining Young's modulus of materials using Universal Testing Machine.	
2.	Determination of the Poisson's ratio of a metallic specimen in the linear elastic range of loading.	
3.	Estimation of Notch Toughness of the metallic bar using Charpy/Izod Impact Testing Machines.	
4.	Determination of the ultimate shear strength of mild steel specimen by double shear test.	
5.	Determination of Young's modulus of the metallic/non-metallic beam using the deflection test method.	
6.	Verification of the Maxwell's Reciprocal Theorem.	
7.	Determination of the Maximum bending stress of a mild steel beam using deflection test method.	
8.	Hardness tests using Brinell and Rockwell test rigs.	
9.	Estimation of the stiffness and the rigidity modulus of the given helical spring under axial loading.	
10.	Torsion test on mild steel or cast-iron specimens to find out modulus of rigidity.	
11.	Verification of the Euler buckling equations using steel columns subjected to different end conditions.	
12.	Strain measurement of the given beam using the Rosette Strain Gauge.	
	Total Laboratory Hours	**30 hours**

Text Book(s)

1.	Ferdinand P. Beer, E. Russell Johnston, John T. DeWolf, David F. Mazurek, Sanjeev Sangh, Mechanics of Materials, 2020, 8th Edition, McGraw Hill Education, India.
2.	Russell C. Hibbeler, Mechanics of Materials in SI Units, 2018, 9th Edition, Pearson Education, India.
3.	Lab Manual prepared by course faculty members

Reference Books

1.	James M. Gere, Barry J. Goodno, Mechanics of Materials, 2019, 9th Edition, Cengage Learning India Pvt. Ltd.
2.	Rattan S. S, Strength of Materials, 2017, 3rd edition, McGraw Hill Education, India.
3.	Ramamrutham S, Narayanan R, Strength of Materials, 2020, 20th Edition, Dhanpat Rai Publishing Company, India.
4.	Popov E. P, Nagarajan S, Lu Z. A; Mechanics of materials, SI version, 2015,

	Prentice-Hall of India.			
5.	James M. Gere, and Stephen Timoshenko, Mechanics of Materials; 2004, 2nd edition, CBS publishers and distributors.			
Mode of assessment: Viva-voce examination, Lab performance & FAT				
Recommended by Board of Studies	09-03-2022			
Approved by Academic Council	No. 65	Date	17-03-2022	

BMEE203L	Engineering Thermodynamics	L	T	P	C
		2	1	0	3
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives

1. To apply the laws of thermodynamics and describe their significance.
2. To provide fundamental knowledge of ideal and real gases.
3. To analyse vapour, gas power cycles and determining properties of gas mixtures.
4. To establish the relationship between commonly measurable properties and the properties that cannot be measured directly.

Course Outcome

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

1. Demonstrate the understanding of basic thermodynamics concepts such as systems, forms of energy - work and heat, temperature.
2. Analyse the properties of pure substances, ideal and real gases.
3. Apply the first law of thermodynamics for closed and open systems.
4. Apply the second law of thermodynamics and entropy principles for engineering systems.
5. Analyse the performance of vapour and gas power cycles.
6. Evaluate the mixture properties using gas laws.
7. Assess the substance properties using thermodynamic relations.

Module:1	**Introduction and basic concepts of thermodynamics**	**4 hours**

Systems and control volume, properties of a system, state and equilibrium, quasi-static equilibrium, processes and cycles, forms of energy, pressure, work and heat transfer, temperature and the Zeroth law of thermodynamics.

Module:2	**Properties of pure substances**	**6 hours**

Phases of a pure substance, phase change process of pure substances, property diagrams for phase change processes, vapour property tables, Ideal gas equation of state, real gases-Van der Waals equation of state, compressibility factor, Benedict-Webb Rubin equation.

Module:3	**The first law of thermodynamics**	**8 hours**

Energy analysis of closed and open systems, energy analysis of steady flow devices-boiler, turbine, heat exchangers, pumps and nozzles, energy analysis of unsteady flow processes, limitations of the first law of thermodynamics.

Module:4	**The second law of thermodynamics**	**8 hours**

Thermal energy reservoirs, heat engines, heat pumps and refrigerators, Kelvin-Planck and Clausius statement and their equivalence, reversible and irreversible processes, Carnot cycle, Carnot principles, thermodynamic temperature scale, Entropy, Clausius-inequality, TdS equations, entropy change, entropy balance, the increase of entropy principles, Exergy-availability and irreversibility.

Module:5	**Vapour and gas power cycles**	**9 hours**

Carnot vapour power cycle, Ideal Rankine cycle, ideal re-heat Rankine cycle, ideal regenerative Rankine cycle, the effect of isentropic efficiencies, Air standard assumptions, Otto, Diesel cycle, Brayton, Stirling cycle and Ericsson cycles.

Module:6	**Gas mixtures**	**4 hours**

Composition of the gas mixture, mole and mass fractions, Dalton's law, Amagat's law, properties of gas mixtures.

Module:7	**Thermodynamic property relations**	**4 hours**

Maxwell relations, Clapeyron equation, General equations for du, dh, ds, Cv and Cp, Joule-Thomson coefficient.

Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Books

1.	Yunus A. Cengel, Michael A. Boles and Mehmet Kanoglu, Thermodynamics: An Engineering Approach, 2019, 9th Edition, McGraw Hill Education.		
Reference Books			
1.	Michael J Moran, Howard N Shapiro, Daisie D. Boettner and Margaret B. Bailey Fundamentals of Engineering Thermodynamics, 2015, 8th Edition, Wiley.		
2.	Nag P. K., Engineering Thermodynamics, 2017, 6th Edition, McGraw Hill Education.		
Mode of Evaluation: CAT, Written assignment, Quiz, FAT.			
Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE204L	Fluid Mechanics and Machines	L	T	P	C
		3	0	0	3
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives

1. To apply hydrostatic law, principle of mass and momentum in fluid flows, concepts in Euler's and Bernoulli equations.
2. To provide fundamental knowledge of fluids, its properties and behaviour under various conditions of internal and external flows.
3. To determine the losses in a flow system, flow through pipes, boundary layer concepts.
4. To familiarize the student with the various pumps and turbines.

Course Outcomes

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

1. Demonstrate the significance of fluid properties and laws of fluid statics to engineering systems.
2. Describe the flow fields using Lagrangian and Eulerian approaches.
3. Formulate suitable governing equations to solve fluid flow problems.
4. Analyse the viscous flow through pipes and determine various losses.
5. Perform dimensional analysis of various flow problems.
6. Apply the boundary layer concept and predict the flow separation.
7. Analyse the performance of hydraulic pumps and turbines.

Module:1	**Fluid Statics and Buoyancy**	**8 hours**

Definition of fluid, Concept of continuum, Fluid properties, Rheological classification, Pascal's Law and Hydrostatic pressure and its measurement -Manometry.
Hydrostatic forces on Plane, Inclined and Curved surfaces, Buoyancy, Condition of Equilibrium for Submerged and Floating Bodies, Centre of Buoyancy.

Module:2	**Fluid Kinematics**	**5 hours**

Description of fluid motion – Lagrangian and Eulerian approach, Types of flows, Control volume, Material derivative and acceleration, Streamlines, Pathlines and Streaklines, Stream function and velocity potential function, The Reynolds transport theorem.

Module:3	**Fluid Dynamics**	**5 hours**

The continuity equation, The Euler and Bernoulli equations – venturimeter, orificemeter, Pitot tube, Momentum equation and its application – forces on pipe bends, moment of momentum, The Navier–Stokes Equations.

Module:4	**Viscous Flow in pipes**	**6 hours**

General Characteristics of pipe flow, Fully-developed laminar flow, Hagen Poiseuille equation, Turbulent flow, Darcy–Weisbach equation, Moody chart, major and minor losses, Multiple pipe systems.

Module:5	**Dimensional Analysis**	**5 hours**

Dimensional homogeneity, Rayleigh's method, Buckingham π theorem, Non-dimensional numbers, Model laws and distorted models, Modelling and similitude.

Module:6	**Boundary layer flow**	**5 hours**

Boundary layers, Laminar flow and turbulent flow, Boundary layer thickness, Momentum integral equation, Drag and lift, Separation of boundary layer, Methods of preventing the boundary layer separation.

Module:7	**Hydraulic Machines**	**9 hours**

Introduction - Centrifugal pumps – Work done - Head developed - Pump output and Efficiencies - priming - minimum starting speed - performance of multistage pumps - Cavitation - methods of prevention - Pump characteristics – Classification of hydraulic turbines - Pelton wheel - Francis turbine - Kaplan and Propeller turbines - - Specific speed - Theory of draft tube - Governing - Performance characteristics - Selection of turbines.

Module:8	**Contemporary issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Books				
1.	Som S K, Gautam Biswas, Chakraborty S, Introduction to Fluid Mechanics and Fluid Machines, 2017, McGraw Hill.			
2.	Fox and McDonald, Introduction to Fluid Mechanics, 2020, 10th Edition, Wiley.			
Reference Books				
1.	Yunus A. Cengel and John. M. Cimbala, Fluid Mechanics: Fundamentals and Applications, 2019, 4th Edition, McGraw Hill.			
Mode of Evaluation: CAT, Written assignment, Quiz, FAT				
Recommended by Board of Studies		09-03-2022		
Approved by Academic Council		No. 65	Date	17-03-2022

BMEE204P	Fluid Mechanics and Machines Lab	L	T	P	C
		0	0	2	1
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives

1. To train students practically with the procedures for measuring the co-efficient of discharge of orifice, mouthpiece, notches, orifice meter and venturi meter.
2. To train the students to determine the friction factor and minor losses in pipe components.
3. To equip the students to perform experiments in hydraulic machines and analyse the results.

Course Outcomes

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

1. Perform experiments on various flow measuring devices to calibrate them.
2. Perform experiments to determine friction factor and minor losses in pipe components.
3. Conduct experiments on hydraulic machines to assess their performance.

List of Experiments

1	Determination of coefficient of discharge of an orifice.
2	Determination of coefficient of discharge of a mouthpiece.
3	Determination of coefficient of discharge of a rectangular/ triangular notch.
4	Determination of coefficient of discharge of a venturi meter / orifice meter.
5	Estimation of friction factor of a pipe.
6	Estimation of minor losses in pipe fittings.
7	Verification of the Bernoulli Theorem.
8	Study and calibration of a pitot static tube.
9	To study the performance of a centrifugal pump.
10	Study the performance of a Pelton Turbine.
11	Determination of static pressure distribution around an air foil.
	Total Laboratory Hours **30 hours**

Text Books

1	Som S K, Gautam Biswas, Chakraborty S, Introduction to Fluid Mechanics and Fluid Machines, 2017, McGraw Hill
2	Lab Manual prepared by course faculty

Mode of assessment: Continuous assessment, FAT, Oral examination

Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE206P	Machine Drawing Lab	L	T	P	C
		0	0	4	2
Pre-requisite	**BMEE102P**	**Syllabus version**			
		1.0			

Course Objectives

1. To provide the knowledge of design practices for common machine elements.
2. To train students to excel in part and assembly drawing of mechanical components.
3. To impart skills in applying CAD tools for conceptualizing product.

Course Outcome

At the end of the course, the student will be able to
1. Use CAD tools efficiently to design machine elements.
2. Demonstrate the use of ISO/BIS standards in machine drawing.
3. Apply the concepts of conventional tolerancing and GD&T principles.
4. Illustrate the relative motion among parts in mechanical assembly.

Indicative Experiments	
1.	**Introduction to Machine Drawing:** Study of Drawing Sheet Layout and Drawing Standards. Use of software packages for machine drawing and drafting.
2.	**Basics of Machine Drawing:** Study of basic specifications and conventional representation of standard components i.e.Bolts, Screw, Rivets, Keys, Pins, Washers; Surface Roughness and Welding symbols in machine drawing.
3.	**Basic of Limits, Fits and Tolerances:** Study of fundamental of Deviations, Shaft and Hole Terminology, Method of placing limit dimensions. Study of different types of Fits and Tolerances. Reading of machining grade. Use of tolerance tables.
4.	**Introduction to Limits, Fits and Tolerances in Machine Drawing:** Incorporating Geometrical Tolerance and Dimensioning, GD&T Symbols, LMC, MMC, concept in engineering drawing.
5.	**Part Modeling of machine components:** 3D Modeling of standard machine components i.e. Shaft, Pulley, Springs, Plummer-Block, Bracket.
6.	**Detailed Drawing of Part:** Drafting of standard machine part components into production drawing-Orthographic Projection and Isometric Projection.
7.	**Modeling and Assembly of machine elements:** 3D Modeling of standard machine elements i.e.Universal Coupling, Bench Vice, Radial Engine.
8.	**Detailed Drawing of Assembly:** Drafting of standard assembly elements into Orthographic, Isometric and Section view. Applying Bill of Material concept.
9.	**Exploded Assembly Drawing:** Understanding step of assembly of components.
10.	**Motion Study of Assembly:** Applying motion among components in assembly. Understanding Constraints Relations and Degree of Freedom.
	Total Laboratory Hours **60 hours**

Text Books	
1.	Bhatt N. D, Machine Drawing, 2008, Charotar Publishing House Pvt. Limited, India.
2.	French, T. E, Vierch, C. J, and Foster, R. J., Engineering Drawing and Graphic Technology.
3.	Lab Manual prepared by course faculty members.
Reference Books	
1.	Narayana K.L., Kannaiah, P., and Venkata Reddy K, Machine Drawing, 2016, 5th Ed., New Age International Publishers, India.
2.	John K. C., Text Book of Machine Drawing, 2009, PHI Learning Pvt. Ltd.
3.	Lockhart, S., Giesecke, F. E., Dygdon, J., Spencer, H., Mitchell, A., Johnson, C., Good man, M., Technical Drawing with Engineering Graphics, 2016, Prentice Hall, United Kingdom.
4.	Lakshminarayanan, V., and Mathur, M. L., Text Book of Machine Drawing (with

	Computer Graphics), 2007, 12th Ed, Jain Brothers, India.			
5.	SP 46: 1988 Engineering Drawing Practice for Schools and Colleges, 1988, Bureau of Indian Standards.			
6.	Design Data: Data Book of Engineers by PSG College, 2019, 4th Ed., Kalaikathir Achagham Coimbatore publication, India**.**			
Mode of assessment: Viva-voce examination, Lab performance & FAT				
Recommended by Board of Studies		09-03-2022		
Approved by Academic Council		No. 65	Date	17-03-2022

BMEE207L	Kinematics & Dynamics of Machines	L	T	P	C
		3	0	0	3
Pre-requisite	**BMEE201L**	**Syllabus version**			
		1.0			

Course Objectives

1. To enable students to understand the fundamental concepts of mechanisms.
2. To facilitate students to understand the functions of cams, gears, and flywheel.
3. To impart knowledge on design of mechanisms and dynamic loads acting on the mechanism.
4. To give an insight on the concepts of balancing, vibration and speed governing devices.

Course Outcome

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

1. Examine the kinematic behaviour of various planar mechanisms.
2. Construct velocity and acceleration diagrams for various planar mechanisms.
3. Analyse kinematics of cam and gear-train mechanisms.
4. Investigate the dynamic forces acting on planar mechanisms.
5. Analyse the balancing of masses and vibrations of mechanical systems.
6. Assess the characteristics of governors and gyroscopic effects.

Module:1	**Mechanisms and kinematics**	**6 hours**

Introduction, mechanisms and machines, terminology, planar mechanism - Kinematic diagram and inversion, Mobility, Coincident joints, Grubbler and Grashoff's law, Four bar, single and double slider mechanisms and their inversions.

Module:2	**Velocity and Accelerations in Mechanisms**	**8 hours**

Velocity and acceleration in planar mechanisms - Relative velocity method, Coriolis component of acceleration, Kennedy's Theorem, Instantaneous Centre method.

Module:3	**Kinematic analysis of Cams and Gears**	**7 hours**

Cams: Types of cams – Types of followers – Definitions – Motions of the followers – Layout of cam profiles. Gear: terminology, fundamental of gearing, involute profile, interference and undercutting, minimum number of teeth, contact ratio - Gear trains: simple, compound and epicyclic.

Module:4	**Synthesis of planar mechanism**	**4 hours**

Two position and Three position synthesis of planar mechanism - Graphical and analytical methods - Freudenstein equation.

Module:5	**Dynamic Force Analysis**	**6 hours**

Introduction-D' Alembert's principle-static and inertial force analysis of reciprocating engine-Equivalent dynamic system. Turning moment diagram-four stroke engine-multicylinder engine-design of flywheel of IC engine-design of flywheel rim- design of flywheel of punching press.

Module:6	**Balancing and Vibration**	**8 hours**

Static and Dynamic Balancing of Rotating Masses, Balancing of Reciprocating Masses. Introduction to vibration - Terminologies - Single degree of freedom- damped and undamped- free and forced vibration – Vibration isolation and Transmissibility. Transverse vibrations of shafts – Whirling of shaft -Torsional vibration of single rotor and two rotors' systems.

Module:7	**Governors and Gyroscope**	**4 hours**

Governors: Centrifugal Governors- types and its characteristics - Working principle of electronic governor. Gyroscope – Gyroscopic Effects on the Movement of airplanes and Ships – Gyroscope Stabilization.

Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1. Rattan S. S, Theory of Machines, Tata McGraw Hill, 2019

Reference Books				
1.	Joseph Edward Shigley and John Joseph Uicker Jr., Theory of Machines and Mechanisms SI Edition, 2014, Oxford University Press			
2	Norton R. L, Kinematics and Dynamics of Machinery, , 2017, McGraw-Hill Education			
3	Norton R. L., Design of Machinery, An Introduction to the Synthesis and Analysis of Mechanisms and Machines, 2019McGraw-Hill Higher Education			
Mode of Evaluation: CAT, Written assignment, Quiz, FAT				
Recommended by Board of Studies		09-03-2022		
Approved by Academic Council		No. 65	Date	17-03-2022

BMEE207P	Kinematics & Dynamics of Machines Lab	L	T	P	C
		0	0	2	1
Pre-requisite	**BMEE201L**	**Syllabus version**			
		1.0			

Course Objective

1. To impart practical skills in analyzing different mechanism.
2. To familiarize the use of cams and gears.
3. To demonstrate the importance of governors and gyroscopes.

Course Outcomes

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

1. Determine the kinematic behaviour of various planar mechanisms.
2. Analyse the free, forced, and damped vibration of different systems.
3. Investigate the performance of various governors and the gyroscope.

Indicative Experiments	
1.	Study of different planar mechanisms
2.	Determination of the Coriolis component of acceleration
3.	Kinematic analysis of gear and gear train
4.	Cam synthesis and jump phenomenon
5.	Determination of the natural vibration of the spring mass system
6.	Determination of the free torsional vibration of two rotor system
7.	Determination of the radius of gyration of bifilar & trifilar system
8.	Determination of the critical speed of the whirling shafts with different fixings
9.	Determination of equilibrium speeds of Watt governor
10	Determination of equilibrium speeds of Porter governor
11	Determination of equilibrium speeds of Hartnell governor
12	Determination of gyroscopic couple acting on a rotating disc
	Total Laboratory Hours **30 hours**

Text Book(s)

1.	Rattan S. S, Theory of Machines, Tata McGraw Hill, 2019.
2.	Lab Manual prepared by course faculty members.

Reference Books

1.	Joseph Edward Shigley and John Joseph Uicker Jr., Theory of Machines and Mechanisms SI Edition, 2014, Oxford University Press
2	Norton R. L, Kinematics and Dynamics of Machinery, 2017, McGraw-Hill Education
3	Norton R. L, Design of Machinery, An Introduction to the Synthesis and Analysis of Mechanisms and Machines, 2019, McGraw-Hill Higher Education

Mode of assessment: Viva-voce examination, Lab performance & FAT

Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE210L	Mechatronics and Measurement Systems	L	T	P	C
		3	0	0	3
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives

1. To familiarize key elements of mechatronics system, impart knowledge of the elements and techniques involved in mechatronics systems for industrial automation.
2. To impart the theoretical and practical aspects of measurement system design.
3. To give insight to the principles of sensors & actuators, and their interfacing with DAQ.

Course Outcomes

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

1. Demonstrate the basic concepts, applications and elements of mechatronic systems.
2. Analyze various measuring instruments for different applications.
3. Compare various types of sensors and actuators used in mechatronics systems.
4. Apply the concept of signal processing and use of interfacing systems.

Module: 1	**Basics of Mechatronics Systems**	**6 hours**

Basic concepts in mechatronics, Mechatronics systems design approach, Key elements of mechatronics system, Role of sensors, actuators and measurements-Feedback in mechatronics systems- Emerging application areas of mechatronics.

Module: 2	**Measurement System**	**6 hours**

Introduction to measurement, Standards of measurement, Modes of measurement, generalized measurement system, Applications of Measurement System, Errors in measurement, sources of errors. Specifications: Sensitivity, resolution, bias, dead space- Static and dynamic characteristics- System response.

Module: 3	**Basic Sensors**	**7 hours**

Position and Speed Measurement- Proximity Sensors and Switches, Potentiometer, Linear Variable Differential Transformer, Digital Optical Encoder; Stress and Strain Measurement - Electrical Resistance Strain Gauge, Measuring Resistance Changes with a Wheatstone Bridge, Measuring Different States of Stress with Strain Gauges.

Module: 4	**Advanced Sensors**	**7 hours**

Force Measurement with Load Cells; Temperature Measurement- Liquid-in-Glass Thermometer, Bimetallic Strip, Electrical Resistance Thermometer, Thermocouple; Vibration and Acceleration Measurement - Piezoelectric Accelerometer; Pressure and Flow Measurement; Capative sensors- Fiber optic sensors-Semiconductor Sensors and Microelectromechanical Devices:IMU,Gyroscope.

Module: 5	**Actuators**	**6 hours**

Electromagnetic Principles-Solenoids and Relays-Electric Motors- DC Motors-Stepper Motors-Hydraulics- Hydraulic Valves, Hydraulic Actuators; Pneumatics.

Module:6	**Data Acquisition**	**6 hours**

Introduction to Data Acquisition-Quantizing Theory-Analog-to-Digital Conversion- Digital-to-Analog Conversion-Signal Conditioning-Computer Based Instrumentation Systems-Software Design and Development-Data Recording and Logging-The Intelligent Multivariable Measurement System.

Module:7	**Measurement Systems**	**5 hours**

Linear and angular measurements – taper measurement, threads, surface finish, inspection of straightness, flatness and alignment- Comparators - Gear testing-Coordinate measuring machines, Optical Tool Maker's Microscope, Profile Projector.

Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1	Alciatore, D.G. and Histand, M.B. Introduction to mechatronics and measurement systems. 2019, New York, Ny: Mcgraw-Hill Education.
2	Bewoor, A.K. and Kulkarni, V.A., Metrology & Measurement, 2009, McGraw-Hill Education.
Reference Books	
1.	DeSilva, C.W., Farbod Khoshnoud, Li, M. and Halgamuge, S.K, Mechatronics : Fundamentals and Applications. Boca Raton: 2016, CRC Press, Taylor & Francis Group.
2	William Charles Bolton, Mechatronics: electronic control systems in mechanical and electrical engineering. 2019, Harlow, England: Pearson.
3.	Thomas G. Beckwith, Roy D. Marangoni, John H. Lienhard, Mechanical Measurements, 2009, Pearson Education.
4	Cesare Onwubolu Godfrey C Fantuzzi, Mechatronics: Principles and applications, 2020, S.L.: Butterworth-Heinemann Ltd.
5	Bentley, J.P. (2008). Principles of measurement systems. Harlow Pearson Prentice Hall.

Mode of Evaluation: CAT, Written assignment, Quiz, FAT.			
Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE210P	Mechatronics and Measurement Systems Lab	L	T	P	C
		0	0	2	1
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives

1. To integrate the mechanical systems with electrical, electronics and computer systems for providing multidisciplinary approach.
2. To familiarize the use of transducers, sensors and actuators.
3. To use of software tools for measurement, perception and signal conditioning.

Course Outcome

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

1. Practice the various fluid power systems.
2. Implement different sensors for various industrial applications.
3. Caliberate measuring instruments and measure various geometrical features.

Indicative Experiments

1.	Design and analysis of hydraulic, pneumatic and electro-pneumatic circuits using automation software and hardware.
2.	Stepper motor, Traffic light, HMI Programming interface using a PLC.
3.	Force and Torque measurement using strain gauge.
4.	Measurement of speed and displacement using linear and rotary sensors.
5.	Pressure measurement systems using sensors.
6.	Temperature measurement using RTD and thermocouple.
7.	Vibration and acceleration measurements using Piezo electric sensor.
8.	Development of data logging using virtual instrument software.
9.	Calibration and dimensional measurement using Micrometer, Mechanical Comparator, Vernier Caliper and Dial Gauge.
10.	Measurement of flatness of the object using dial gauge and taper angle using Bevel Protractor, Dial Gauge and Sine-Bar. Measurement of bores by using Micrometer and Dial bore indicator.
11.	Measurement of Gear tooth thickness by using Gear tooth Vernier.
12.	Surface roughness measurement of machined component.
	Total Laboratory Hours **30 hours**

Text Books

1.	Autor: Anthony Esposito (2014). Fluid power with applications. Editorial: Harlow: Pearson Education Limited.
2.	Rabiee, M. (2018). Programmable logic controllers : hardware and programming. Tinley Park, Il: The Goodheart-Willcox Company, Inc.
3.	National Instruments (Firm (2003). LabVIEW : measurements manual. Austin, Tex.: National Instruments.
4.	Lab Manual of prepared by course faculty members.

Reference Books

1.	Fluid Power: Hydraulics and Pneumatics, 3rd Edition, Lab Manual.
2.	LabVIEW TM User Manual LabVIEW User Manual. (2003).

Mode of assessment: Viva-voce examination, Lab performance & FAT

Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE301L	Design of Machine Elements	L	T	P	C
		3	1	0	4
Pre-requisite	**BMEE202L, BMEE202P**	**Syllabus version**			
		1.0			

Course Objectives

1. To impart the knowledge on materials selection in design
2. To familiarize the effects of various types of loading on machine parts.
3. To develop the design methodology for mechanical components used in industries.
4. To adopt various standards in the design process.

Course Outcomes

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

1. Evaluate the design of machine components using theories of failure.
2. Analyse machine components subjected to dynamic loads against fatigue failure.
3. Recommend suitable mechanical springs for various applications.
4. Design shafts, keys and couplings as per the international standards.
5. Investigate the design aspects of temporary and permanent joints.
6. Design and develop the engine components.

Module:1	**Introduction to Design**	**8 hours**
Design Process – Factors Considered in Design – Selection of Materials – Use of Standards in Design – Direct, Bending and Torsional Stresses in Machine Elements - Factor of Safety – Design Stress – Theories of Failures.		
Module:2	**Fatigue Strength**	**8 hours**
Stress Concentration – Theoretical Stress Concentration Factor – Size Factor – Surface Finish Factor – Fatigue Stress Concentration Factor – Notch Sensitivity – Variable and Cyclic Loads – Fatigue Strength – S-N Curve – Gerber, Soderberg and Goodman Equations – Combined Cyclic Stresses – Minor's rule – Basquin's equation.		
Module:3	**Design of Mechanical Springs**	**8 hours**
Stresses and Deflections of Helical Springs – Extension Springs – Compression Springs – Springs for Fatigue Loading, Energy Storage Capacity – Leaf Springs – Helical Torsion Springs – Flat Spiral Springs.		
Module:4	**Design of Shafts, Keys and Couplings**	**9 hours**
Design of Solid and Hollow Shafts for Strength and Rigidity – Design of Shafts for Combined Bending, Torsion and Axial Loads – Design of Keys-Stresses in Keys – Design of Rigid and Flexible couplings.		
Module:5	**Design of Permanent Joints and Threaded Fasteners**	**9 hours**
Design of Riveted Joints – Design of Welded Joints – Design of Bolted Assembly – Direct Loading and Eccentric Loading.		
Module:6	**Design of Cotter and Knuckle Joints**	**8 hours**
Introduction to Cotter and Knuckle Joints - Design of Cotter Joints – Spigot and Socket, Sleeve and Cotter, Gib and Cotter – Design of Knuckle Joint.		
Module:7	**Design of Engine Components**	**8 hours**
Introduction to IC engine components – Classification - Design of Flywheel – Design of Connecting Rod – Design of Crankshaft – Design of Piston.		
Module:8	**Contemporary Issues**	**2 hours**
	Total lecture hours:	**60 hours**

Text Book(s)

1. V. B. Bhandari, Design of Machine Elements, 2020, 5th Edition, Tata McGraw Hill.

Reference Books

1. Richard G. Budynas and Keith Nisbett J, Shigley Mechanical Engineering Design, 2020,

	11th Edition (in SI Units), McGraw Hill		
2.	Harsha, A. P., Hornberger, L. E., Shoup, T. E., Spotts, M. F., Design of Machine Elements, 2019, Pearson India Education Services Pvt. Limited.		
3.	Robert L. Norton, Machine Design, 2018, 5th Edition, Pearson.		
4.	Juvinal, R.C and Kurt M.Marshek, Machine Component Design, 2016, Wiley.		
5.	PSG Design Data: Data Book of Engineers, 2020, Kalaikathir Achchagam.		
Mode of Evaluation: CAT, Written assignment, Quiz, FAT			
Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE302L	Metal Casting and Welding	L	T	P	C
		3	0	0	3
Pre-requisite	**BMEE209L, BMEE209P**	**Syllabus version**			
		1.0			

Course Objectives

1. To provide an insight on the casting fundamentals and processes.
2. To impart knowledge on the welding processes for developing various joints.

Course Outcomes

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

1. Interpret the solidification characteristics for designing gating system.
2. Demonstrate working principle of various casting processes.
3. Use various melting practices and explore casting defects.
4. Apply suitable welding process for different functional requirements.
5. Examine weld defects and suggest suitable methods to assess weld quality.

Module:1	**Casting Fundamentals**	**7 hours**

Solidification of pure metals and alloys. Mechanism of columnar and dendritic growth. Concept of progressive and directional solidifications. Solidification time and Chvorinov's rule. Principles of fluid flow: Bernoulli's theorem and law of mass continuity. Gating system-components and functions. Design of the gating System. Different types of gates. Gating ratio and its functions. Definition and functions of the riser. Types of risers and their application. Design of riser. Aspiration effect. Use of insulating material and exothermic compounds in risers.

Module:2	**Expendable Mould Casting**	**6 hours**

Sand casting – Types and properties of sand – Types, features and steps involved in sand mould – Pattern making, pattern allowances – Mould and Core materials – Core making, chaplets – Sand-moulding machines – Procedural steps and applications of Shell mould casting, Plaster and Ceramic mould casting, Lost-foam Casting, Investment mould casting.

Module:3	**Permanent Mould Casting**	**5 hours**

Procedural steps and applications of Vacuum casting, Slush casting, Low-pressure casting, Die-casting – hot chamber and cold chamber, Centrifugal casting, Squeeze casting, Thixomolding and Rheocasting, Casting Techniques for single-crystal components.

Module:4	**Melting Technology and Casting Defects**	**6 hours**

Melting furnaces for ferrous and non-ferrous foundries. Electric and fuel fired furnaces. Induction Furnaces; Types of Furnaces, Electromagnetic Stirring, power supplies; Recent developments in energy considerations. Melting practice – ferrous, non-ferrous metals and alloys and composites. Melting practices; Fluxing, inoculation, degassing and grain refinement treatments. Control of pouring temperature Heat treatments of castings, Shop floor melt quality tests.

Residual stresses and Casting defects and factors responsible for them. Different inspection and testing methods to evaluate the casting.

Module:5	**Joining Processes**	**8 hours**

Classification of welding processes **–Fusion welding:** Oxy-fuel gas welding - types of flames and uses, Arc welding: power sources -methods of arc initiation and maintenance, arc stability, duty cycle, metal transfer. Non-consumable electrode - GTAW, PAW, AHW. Consumable electrode - SMAW, SAW, GMAW, FCAW, EGW, ESW. Electrodes and its coatings. Beam welding (EBW & LBW).

Solid State welding: Cold welding and roll bonding, Ultrasonic welding, Friction welding, Friction stir welding, Resistance welding, Explosion welding, Diffusion welding, Thermit welding.

Brazing, Soldering and adhesive bonding: Principle of Operation, advantages, Limitations and application.

Module:5	**Fundamentals of welding**	**5 hours**

Solidification of the weld metal, Heat flow in welding, Metallurgical transformation in and around weldment, Implication of cooling rates, Heat affected zone (HAZ), Shielding gases, Classification of Filler metals and Fluxes, Weldability of plain carbon steels, Low Carbon Steels, Stainless steels and Aluminium Alloys.		
Module:7	**Welding Defects and Testing**	**6 hours**
Spatter, Under-cutting, and over lapping Crack- Initiation and Propagation - Incomplete Penetration, Inclusions, Porosity and blowholes, Lack of fusion, Distortion (Distortion and residual stresses, Concept of distortion, Types of distortion, Control of welding distortion) causes and remedies for weld defects. Testing and Inspection of welding: Visual Inspection, Weldability, Destructive testing of welds, Non-destructive testing of welds and Hot Cracking Tests.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Books	
1.	John K.C, Metal casting and Joining, 2015, PHI publications.
2.	P. L. Jain, Principles of Foundry Technology, 2009, 5th edition, TMH Publications.
3.	Parmar R.S, Welding Engineering and Technology, 2013, Khanna Publishers.
Reference Books	
1.	Serope Kalpakjian, and Steven Schmid, Manufacturing Engineering and Technology, 2020, 8th edition, Pearson education.
2.	P.N. Rao, Manufacturing Technology Foundry, Forming and Welding, 2003, 2nd Edition.

Mode of Evaluation: CAT, Written assignment, Quiz, FAT			
Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE302P	**Metal Casting and Welding Lab**	**L**	**T**	**P**	**C**
		0	**0**	**2**	**1**
Pre-requisite	**BMEE209L, BMEE209P**	**Syllabus version**			
		1.0			

Course Objectives

1. To provide an insight on foundry practices.
2. To impart practical exposure on the effect of welding parameters on joint characteristics.

Course Outcome

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

1. Assess the properties of moulding sand and demonstrate the melting practices.
2. Evaluate the effect of welding parameters on microstructure and weld quality.
3. Investigate the weldability of various materials.

Indicative Experiments	
1.	Determination of permeability, shear strength and compression strength of the given foundry sand.
2.	Determination of the grain fineness of the given foundry sand.
3.	Determination of clay content for the given moulding sand sample and to study the variation of compression strength for various moisture contents.
4.	Determination of flowability for the given foundry sand.
5.	Prepare the mould for the given pattern with the core using two boxes and three – box moulding process.
6.	Foundry melting practice – demonstration.
7.	To study the effect of heat input on microstructure of weld metal and HAZ of Al / Ni alloys performed under GTAW process.
8.	To study the effect of FSW process parameters (tool rotational speed, axial load, and travel speed) on the butt welding of Al alloy.
9.	Study the bead on plate experiment (bead profile, penetration, and its dilution) on Austenitic stainless steel by using GMAW process.
10.	To study the weldability of plastic material using ultrasonic welding machine.
11	To study the residual stress measurement of the friction stir welded specimen (Demonstration).
12.	Effect of shielding gases on the weld performance of GMAW process. (Case study)
	Total Laboratory Hours **30 hours**

Text Books	
1.	John K.C, Metal Casting and Joining, 2015, PHI publications.
2.	P. L. Jain, Principles of Foundry Technology, 2009, 5th edition, TMH Publications.
3.	Parmar R.S, Welding Engineering and Technology, 2013, Khanna Publishers.
3.	Lab Manual prepared by course faculty

Reference Books	
1.	Srinivasan N. K., 'Foundry Technology', 1986, Khanna Publications
2.	Richard L Little, Welding and welding technology, 2020, Mc Graw Hill

Mode of assessment: Continuous assessment, FAT, Oral examination			
Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE303L	Thermal Engineering Systems	L	T	P	C
		3	0	0	3
Pre-requisite	**BMEE203L**	**Syllabus version**			
		1.0			

Course Objectives

1. To guide the students to apply the laws of thermodynamics in applications of thermal systems.
2. To help students gain essential and basic knowledge of various types of internal and external combustion engines and train them with the procedures for the testing of engines and fuels.
3. To equip the students to analyse steam turbine, gas turbine cycles, refrigeration and air – conditioning systems.

Course Outcome

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

1. Apply the thermodynamics laws to the working of IC engines.
2. Analyze performance parameters of IC engines.
3. Design a steam nozzle for thermal power plant and analyze the performance of reciprocating air compressors.
4. Analyze the performance parameters of steam and gas power cycles.
5. Compare various refrigeration systems based on their performance.
6. Evaluate the cooling load requirements for conditioned space.

Module:1	**IC Engines**	**7 hours**

Working principle of 2-stroke and 4-stroke SI and CI engines - Valve and port timing diagrams, Wankel engine, simple carburettor - Ignition system - Combustion stages in SI and CI engine **-** Knocking and detonation - Fuel injection system - MPFI, CRDI, GDI – Rating of fuels - Cooling system, Lubrication system - super charging and Turbo charging.

Module:2	**IC Engines Performance**	**6 hours**

Performance test - Measurement of Brake power, Indicated power and Frictional power, Fuel consumption, Air consumption - Heat balance test - Morse test and Retardation test on IC engine.

Module:3	**Air Compressor**	**6 hours**

Reciprocating compressors - Construction - Working - Effect of clearance volume – Multi-staging – Volumetric efficiency – Isothermal efficiency.

Module:4	**Steam nozzle**	**6 hours**

Steam Nozzles – One-dimensional steady flow of steam through a convergent and divergent nozzle – Metastable flow.

Module:5	**Steam turbine and Gas turbine**	**6 hours**

Steam turbine – Impulse and Reaction turbine – Performance
Gas turbine - Open and Closed cycle gas turbine, Reheating, Regeneration and Intercooling.

Module:6	**Refrigeration**	**6 hours**

Air refrigeration system - Vapour compression refrigeration system - Components - Working - P-H and T-S diagrams - Calculation of COP - Effect of sub-cooling and super-heating – Selection and properties of refrigerant - Vapour absorption system - NH_3 - water system, Vapour adsorption system. Cryogenic engineering **-** Introduction, Application, Cryo-coolers.

Module:7	**Air-conditioning**	**6 hours**

Types of air-conditioning system and its working principle – Psychrometry - Psychrometric properties, processes and chart – heating and cooling load calculations.

Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book				
1.	Rajput R.K., Thermal Engineering, 2017, 10th Edition, Laxmi Publications (P) Ltd.			
Reference Books				
1.	Ganesan, V., Internal combustion engines. 2012, McGraw Hill Education (India) Pvt Ltd.			
2.	Manohar Prasad., Refrigeration and Air Conditioning, 2015, 3rd Edition, New Age International.			
3.	Soman, K., Thermal Engineering. 2011, PHI Learning Pvt. Ltd.			
Mode of Evaluation: CAT, Written assignment, Quiz, FAT.				
Recommended by Board of Studies		09-03-2022		
Approved by Academic Council		No. 65	Date	17-03-2022

BMEE303P	Thermal Engineering Systems Lab	L	T	P	C
		0	0	2	1
Pre-requisite	**BMEE203L**	**Syllabus version**			
		1.0			

Course Objectives

1. To apply theoretical knowledge gained in theory and get hands-on experience of the topic.
2. To train students practically with the procedures for testing of engines, air compressor, refrigeration and air conditioning.
3. To equip the students to analyse the experimental data of IC engines, air compressor, refrigeration and air conditioning.

Course Outcomes

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

1. Conduct the experiments on IC engines to assess their performance.
2. Perform experiments on refrigeration and air conditioning systems to predict their COP.
3. Conduct the experiments on air compressor and air blower to assess their performance.

Indicative Experiments	
1.	Draw the valve timing and port timing diagram for the given engines and compare with the theoretical value and give your comments.
2.	Compare the properties of different fuels by performing flash point, fire point, viscosity and calorific value tests and find out which is suitable for the better performance of the given engine.
3.	Compare the performance of a single-cylinder CI engine connected with different dynamometers and suggest a suitable dynamometer for better accuracy of the results.
4.	Compare the energy distribution of a single-cylinder CI engine connected with different dynamometers and suggest a suitable dynamometer for better accuracy of the results.
5.	Do the performance test on a single-cylinder SI engine and compare your results with the engine specifications. Suggest a suitable method to improve the accuracy of your results.
6.	Determine the friction power of a given four-cylinder petrol engine by performing Morse test and compare the results with Willan's line method.
7.	Determine the friction power of a given single-cylinder diesel engine by performing retardation test and compare the results with Willan's line method.
8.	Determine the actual index of compression and compare with the isentropic compression for a given reciprocating air compressor.
9.	Compare the performance of air blower with different vane profiles.
10.	Calculate the COP of the given vapor compression refrigeration system and air-conditioning system and compare with the theoretical calculation.
11.	Compare the power output for the steam turbine at different load conditions.
12.	Compare the boiler efficiency for different load levels for the given boiler.
	Total Laboratory Hours | 30 hours

Text Book

1.	Lab manual prepared by the faculty.

Mode of assessment: Continuous assessment, FAT, Oral examination

Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE304L	Metal Forming and Machining	L	T	P	C
		3	0	0	3
Pre-requisite	**BMEE209L, BMEE209P**	**Syllabus version**			
		1.0			

Course Objectives

1. To impart knowledge on the basic principles of metal forming theories and processes.
2. To give an insight on metal cutting theories, machine tools, and machining processes.

Course Outcomes

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

1. Develop the yield criterion and workability behaviors of materials.
2. Evaluate various bulk and sheet metal forming processes for different functional requirements.
3. Demonstrate various machine tools and machining operations.
4. Analyse the mechanics of metal cutting processes.
5. Investigate the heat flow, tool life and tool wear during metal cutting process.

Module:1	**Fundamentals of Metal Forming**	**6 hours**

Stress-Strain relations in elastic and plastic deformation, stress tensor, yield criteria, yield locus, octahedral shear stress and shear strains, invariants of stress strain, slip line field theory plastic deformations of crystals temperature and strain rate dependence, determination of flow stress- Slab analysis - Upper bound analysis - Slip line field analysis, recrystallization, Deformation zone geometry - Numerical problems.

Module:2	**Bulk Forming of Metals**	**7 hours**

Forging: Classification of forging processes – Forging machines & equipment's – Forging pressure & load in open die forging and closed die forging – Friction hill – Die-design parameters – Metal flowlines in forging – Forging defects – Residual stresses in forging - Powder metallurgy forging.

Rolling: Classification of rolling processes – Types of rolling mills – Expression for rolling load – Forces and geometrical relationships in rolling – Effect of front & back tension – Friction hill – Defects in rolled product.

Extrusion: Classification of extrusion processes – Extrusion equipment's – Deformation, lubrication & defects – Extrusion of tubes & seamless pipes – Hydrostatic extrusion.

Drawing: Drawing equipment's & Dies – Determination of drawing force & power – Estimation of redundant work – Optimal cone angle & dead zone formation – Drawing variables – Tube drawing processes.

Module:3	**Sheet Metal Forming**	**5 hours**

Conventional processes, Forces in circular cup drawing, Redrawing, drawing of tubes from annular sheet dies, forming limit diagram, forming with hydrostatic pressure, explosive forming, electrohydraulic forming, magnetic pulse forming, HERF, electromagnetic forming. Forming limit criteria, defect in formed parts, principles and process parameters- Advantages -Limitations and Applications.

Module:4	**Machine Tools and Operations**	**6 hours**

Generating motions of machine tools, Machines using single-point tools, operations and process parameters – work and tool holding in engine lathe, horizontal-boring machine, shaping machine, planning machine.

Machines using multipoint tools, operations and process parameters – drilling machine, horizontal-milling machine, vertical-milling machine, broaching machine, taps and dies.

Machines using abrasive wheels, operations and process parameters – horizontal-spindle surface-grinding machine, vertical-spindle surface-grinding machine, cylindrical-grinding machine, internal-grinding machine, centerless grinding machines.

Cutting tool nomenclatures. Numerical expressions and simple problems on machining time and material removal rate.

Module:5	**Mechanics of Metal Cutting**	**7 hours**

Orthogonal & oblique cutting, shear plane angle, shear stress and strain, principal chip

types, theoretical determination of cutting forces – Ernst and Merchant's theory, Lee and Shaffer's theory, Oxley's theory. shear angle relation, friction in metal cutting, energy in cutting process, Kronenberg relation and velocity relation, chip deviation and other effects on cutting forces, stress on tool, stress distribution, Dynamometers for measuring forces in turning, milling and drilling, numerical problems.		
Module:6	**Heat Flow in Metal Cutting and Tool Life**	**7 hours**
Heat generation in metal cutting, heat at tool-work interface, heat at tool-chip interface, heat in absence of flow zone, Temperature distribution in metal cutting, Measurement of cutting temperature – Work-tool Thermocouple, direct thermocouple measurements, radiation methods, evaluation of machinability. Tool life, Taylor's equation, tool failure, variables affecting the tool life causes of tool failures, forms of wear in metal cutting, cutting tool materials, cutting Fluids, action of coolants and lubricants, application of cutting fluids, surface roughness in machining and its measurement, tool geometries for improved surface finish, economics of metal-cutting operations.		
Module:7	**Gear generation and Unconventional machining methods**	**5 hours**
Gear generating principles - Gear Hobber - Gear finishing methods - Bevel gear generator. Classification of unconventional machining process – Principle of AJM, WJM, USM, EDM, ECM, LBM – Process characteristics – Applications.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Books	
1.	B.L. Juneja, Fundamentals of Metal Forming Processes, 2010, 2nd edition, New Age International.
2.	K.C. Jain, A.K. Chitale, Textbook of Production Engineering, 2014, PHI Learning Pvt. Ltd.
Reference Books	
1.	George E Dieter, Mechanical Metallurgy, Tata McGraw Hill, 1988
2.	Helmi A. Youssef, Hassan A. El-Hofy, Mahmoud H. Ahmed, Manufacturing Technology: Materials, Processes, and Equipment, 2011, CRC Press, Taylor & Francis Group
3.	Heinz Tschaetsch, Metal Forming Practise, 2005, Springer Berlin Heidelberg New York
4.	Hosford W.F. Caddell R.M., Metal Forming – Mechanics and Metallurgy, 2011, 4th edition, Cambridge University Press.
5.	Geoffrey Boothroyd and Winston. A. Knight, Fundamentals of Machining and Machine Tools, 2005, CRC Press, 3rd edition
6.	Amitabha Battacharyya, Metal Cutting: Theory and Practice, 2011, New Central Book Agency
7.	Amitabha Ghosh and A.K. Mallik, Manufacturing Science, 2010, 2nd edition, East-West Press.
8.	Dixit U.S. and Ganesh Narayanan R, Metal Forming: Technology and Process Modelling, 2013, McGraw-Hill Education, Noida
9.	P.N. Rao, Manufacturing Technology: Metal Cutting and Machine Tools, 2018, Volume 2, 4th Edition, McGraw Hill Education.
10.	Serope Kalpakjian, and Steven Schmid, Manufacturing Engineering and Technology, 2020, 8th edition, Pearson education.
11.	P. L. B. Oxley, "The Mechanics of Machining", 1989, Ellis Horwood Ltd.

Mode of Evaluation: CAT, Written assignment, Quiz, FAT.			
Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE304P	Metal Forming and Machining Lab	L	T	P	C
		0	0	2	1
Pre-requisite	**BMEE209L, BMEE209P**	**Syllabus version**			
		1.0			

Course Objectives

1. To provide practical exposure on deformation behavior of ferrous and non-ferrous metals.
2. To impart hands-on experience on machine tools and machining processes.

Course Outcomes

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

1. Investigate the deformation characteristics of ferrous and non-ferrous metals as per ASTM standard.
2. Evaluate the effect of cutting parameters in machining operations.
3. Generate various features on components through machining operations.

Indicative Experiments

1.	Erichsen cupping test to determine the formability of ferrous metals and nonferrous metals.
2.	Rolling of ferrous metals and non-ferrous metals.
3.	Compression test for flow stress analysis.
4.	Deformation and recrystallization in copper.
5.	Cold work-annealing cycle for deformation of low carbon steel.
6.	Study the effect of cutting parameters on temperature generation in machining.
7.	Measurement and analysis of cutting forces in turning operation.
8.	Measurement of surface finish in grinding operation.
9.	Grinding of single point cutting tool using tool and cutter grinder.
10.	Gear manufacturing in milling machine.
11.	Helical gear cutting using gear hobbing and gear shaping.
12.	Programing and profile cutting in wire-EDM.
	Total Laboratory Hours **30 hours**

Text Books

1.	B.L.Juneja, Fundamentals of Metal Forming Processes, 2010, New Age International, 2nd edition.
2.	Geoffrey Boothroyd and Winston. A. Knight, Fundamentals of Machining and Machine Tools, 2005, CRC Press, 3rd edition.
3.	K. C. Jain, A. K. Chitale, Textbook of Production Engineering, 2014, PHI Learning Pvt.
4.	Lab Manual prepared by course faculty.

Reference Books

1.	Amitabha Ghosh and Asok Kumar Mallik, Manufacturing Science, 2010, 2nd edition, East-West Press.
2.	Dixit U.S. and Ganesh Narayanan R, Metal Forming: Technology and Process Modelling, 2013, McGraw-Hill Education, Noida.
3.	Dieter G.E., Mechanical Metallurgy, 1995, McGraw-Hill.

4.	Hosford W.F. Caddell R.M., Metal Forming – Mechanics and Metallurgy, 2011, 4th edition, Cambridge University Press.		
5.	Amitabha Battacharyya, “Metal Cutting, Theory and Practice”, 1984, New Central Book Agency.		
6.	Hassan Abdel-Gawad ElHofy, Fundamentals of Machining Processes (Conventional and Nonconventional Processes), 2018, CRC press, 3rd Edition.		
7.	Rao P.N., Manufacturing Technology: Metal Cutting and Machine Tools, 2018, Volume 2, 4th Edition, McGraw Hill Education.		
Mode of assessment: Continuous assessment, FAT, Oral examination			
Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE306L	Computer Aided Design and Finite Element Analysis	L	T	P	C
		3	0	0	3
Pre-requisite	**BMEE202L, BMEE202P**	**Syllabus version**			
		1.0			

Course Objectives

1. To impart knowledge on the design of engineering products and processes at continuum scale.
2. To give insight to convert the physical problem into an engineering problem through geometrical and numerical modelling capabilities.
3. To familiarize the application of finite element methods on structural, thermal and dynamic problems.
4. To develop the knowledge and skills needed to evaluate design solutions.

Course Outcome

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

1. Develop concept model into CAD model using geometric modelling techniques.
2. Apply suitable product data exchange techniques to convert geometric model into numerical model.
3. Generate mathematical representation of curves, surfaces and solids using interpolation and approximation concepts.
4. Formulate 1D and 2D finite element equations at element and assembly level for static structural, thermal and dynamic applications.
5. Apply finite element formulations using linear and quadratic shape functions to compute desired results.
6. Solve complex engineering problem using the first principles and commercial CAD/FEM tools.

Module:1	**Introduction to CAD**	**4 hours**
Raster-scan graphics-Coordinate systems-Database structures for graphic modelling-Engineering Data Management system- Transformation of geometry-3D Transformations-Clipping-Hidden line/surface removal-Colour-Shading		
Module:2	**Geometric modelling – Analytical and Synthetic curves**	**4 hours**
Requirements of geometric modelling-Wireframe modelling-analytical curves-Cubic spline-Bezier spline-B-spline-NURBS- Solving analytical and synthetic curve problems		
Module:3	**Geometric modelling – Surface and solid modelling-CAD Standards**	**5 hours**
Surface representation-Analytical and Synthetic surfaces-Solid representation methods-constrained based modelling-parametric modelling- Standardisation in graphics-Exchange of modelling data-software modules-software development-Efficient use of CAD software		
Module:4	**Introduction to approximation methods**	**4 hours**
Introduction to Finite Element Method - Direct formulation - Minimum total potential energy formulation - Variational approach - Weighted Residual formulation – Weak Formulation		
Module:5	**Interpolation Functions**	**8 hours**
Polynomial form of interpolation functions - Simplex, Complex, Multiplex elements, Selection of order of interpolation functions, Convergence requirements, Global local and natural coordinates system. Derivation of shape function equation for various elements: One dimensional element (linear, quadratic and cubic), Two dimensional elements – linear, bilinear and quadratic - Beam element.		
Module:6	**Analysis of One Dimensional and Two-dimensional problems**	**14 hours**
Generic form of 1D finite element equations –Bar, Truss, Beam -1D thermal – Isoparametric elements-Numerical Integration-Problem solving Generic form of 2D finite element equations - Triangular element - Rectangular elements- - Applications in solid mechanics (plane stress, plane strain and axisymmetric) and heat transfer		
Module:7	**Dynamic Problems**	**4 hours**
Dynamic analysis using finite element method -Eigen value and Eigen vectors- 1D Bar and Beam-vibration problems –Problem solving		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Books

1	Ibrahim Zeid, “Mastering CAD/CAM”, 2013, McGraw Hill Education (India) P Ltd., SIE.

2	Rao S. S., Finite Element Method in Engineering, 2010, 5th edition, Butterworth-Heinemann.			
Reference Books				
1.	Saeed Moaveni, Finite Element Analysis, Theory and Application with ANSYS, 2021, Pearson Fifth Edition.			
2.	Tirupathi R. Chandrupatla and Ashok D. Belugundu, Introduction to Finite Elements in Engineering, 2011, 4th Edition, Prentice Hall.			
3.	Seshu. P, Finite Element Analysis, 2013, Prentice Hall of India.			
4.	J.N.Reddy, Introduction to Finite Element Method, 2019, McGraw -Hill International Edition.			
Mode of Evaluation: CAT, Written assignment, Quiz, FAT				
Recommended by Board of Studies		09-03-2022		
Approved by Academic Council		No. 65	Date	17-03-2022

BMEE306P	**Computer Aided Design and Finite Element Analysis Lab**	**L**	**T**	**P**	**C**
		0	**0**	**2**	**1**
Pre-requisite	**BMEE202L, BMEE202P**	**Syllabus version**			
		1.0			

Course Objectives

1. To enable the student's skills in CAD and FEM software that can be used and implemented for various engineering applications.
2. To develop proficiency in the application of the finite element method (modelling, analysis, and interpretation of results) to realistic engineering problems.

Course Outcomes

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

1. Create CAD and FE models for trusses, frames, plate structures, machine parts, and engineering components using general-purpose CAD and FE software.
2. Evaluate and interpret the results of FEA analysis of engineering problems.

Indicative Experiments		
1.	Parametric modelling – Curves, solids and surfaces	6 hours
2.	Importing and exporting the CAD models to analysis software	2 hours
3.	Analysis of loading and stress distribution in a simple & stepped bar with different cross section area and analysis of a 2D Truss structure	6 hours
4.	Analysis of beam deflection under different types of loading	4 hours
5.	Analysis of stress on a flat plate with a hole at its centre	2 hours
6.	Heat transfer analysis using pure conduction and heat generation.	2 hours
7.	Axis-symmetric analysis	2 hours
8.	Determining the natural frequencies and mode shapes for simple structure	2 hours
9.	Perform harmonic analysis on simple structure and plot the frequency response function.	2 hours
10	Analysis of a 3D model	2 hours
	Total Laboratory Hours	**30 hours**

Text Books	
1	Ibrahim Zeid, "Mastering CAD/CAM", 2013, McGraw Hill Education (India) P Ltd., SIE.
2	Rao S. S., Finite Element Method in Engineering, 2010, 5th edition, Butterworth-Heinemann.
3	Lab Manual of prepared by course faculty members

Reference Books	
1.	Saeed Moaveni, Finite Element Analysis, Theory and Application with ANSYS, 2021, Pearson Fifth Edition.
2.	Tirupathi R. Chandrupatla and Ashok D. Belugundu, Introduction to Finite Elements in Engineering, 2011, 4th Edition, Prentice Hall.
3.	Seshu. P, Finite Element Analysis, 2013, Prentice Hall of India.
4.	Reddy J.N, Introduction to Finite Element Method, 2019, McGraw -Hill International Edition.

Mode of assessment: Continuous assessment, FAT, Oral examination			
Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE401L	Computer Integrated Manufacturing	L	T	P	C
		3	0	0	3
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives

1. To impart knowledge of CIM, various concepts of automation and applications.
2. To provide in-depth knowledge on digital manufacturing, IoT and Industry 4.0.

Course Outcomes

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

1. Differentiate the concepts of automation, CIM, CAD, and CAM.
2. Develop CNC part programs.
3. Interface real-time simulation with intelligent CNC machine tools using Digital Twins.
4. Apply CAM software tools for solving real time component machining.
5. Analyze the automated flow lines through FMS.
6. Visualize the concepts of future automated factory environments to digital transformation.

Module:1	**Basics of CIM and Automation**	**6 hours**

Introduction to Automation, Basic elements of automated systems- levels of automation, Advanced automation functions, Automation to Autonomy. Introduction to Computer Integrated Manufacturing, computerized elements of a CIM system, Evolution of Computer Integrated Manufacturing, Nature and role of the elements of CIM System, Product life cycle Management and Collaborative Product Development.

Module:2	**Computer Numerical Control**	**6 hours**

Principles elements of CNC system, Typical CNC Machine Tools, Designation of Axis and Motion of CNC Machines, Practical design considerations for CNC machined parts, CNC Controllers-Open architecture, PC based, Look ahead functions, Parallel kinematic Machine Tools, Multitasking CNC machines.

Module:3	**CAM Programming**	**7 hours**

Manual part programming, Computer assisted part programming, Automated programming of CNC-machine tools, Machining of Free form surfaces, Tolerance based Machining, Automatic Feature Recognition in CAM Programming, Knowledge based machining,

Module:4	**Intelligent Manufacturing systems**	**6 hours**

Artificial Intelligence and Machine Learning impact on CNC Machining, Intelligent fully autonomous CNC Machine tool, **Real-Time Machine Monitoring**, Real-time CAM simulation for Digital Manufacturing and Digital Twins.

Module:5	**Computerized Manufacture Planning and Control System**	**6 hours**

Computer Aided Process Planning, Retrieval and Generative Systems, benefits of CAPP, computer integrated production management system, Integration CAD/CAPP/CAM/CNC based on STEP Standards, ISO14649 STEPNC in Machining, Computer Aided Quality Control, Shop floor control.

Module:6	**Group Technology and Flexible Manufacturing Systems**	**6 hours**

Fundamentals of Group Technology-types of part families and Flexible Manufacturing Systems, types of FMS, FMS components, Material handling and storage system, applications, benefits, computer control systems.

Module:7	**Future of Automated Factory**	**6 hours**

Digital Transformation in manufacturing-Trends and Challenges, Industry 4.0, functions, applications and benefits. Internet of Things (IOT), IOT applications in manufacturing, Big-Data and Data Analytics in manufacturing, Blockchain in Manufacturing, cyber-physical manufacturing systems.

Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Books	
1.	Mikell P Groover, Automation, Production Systems and Computer-Integrated Manufacturing, 2019, 5th edition, Pearson.
2.	Xun Xu, Integrating Advanced Computer-Aided Design, Manufacturing, and Numerical Control: Principles and Implementations, 2015, IGI Global.
3.	Radhakrishnan P, CADC/CAM/CIM, 2018, New Age International (P) Ltd.
Reference Books	
1.	Kant Vajpayee S, Principles of Computer Integrated Manufacturing, 1999, Prentice Hall of India, New Delhi.
2.	Rao P.N, Tewari N. K. Computer Aided Manufacturing Tata McGraw Hill Pub, 2017, New Delhi.
3.	Ercan Oztemel, Intelligent Manufacturing Systems, Smart Factories and Industry 4.0: A General Overview, 2019, 1st Edition.
4.	Yáñez, Fran, and Brea, Francisco Yáñez. The 20 Key Technologies of Industry 4. 0 and Smart Factories: The Road to the Digital Factory of the Future. 2017, Independently Published.

Mode of Evaluation: CAT, Written assignment, Quiz, FAT			
Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE401P	**Computer Integrated Manufacturing Lab**	**L**	**T**	**P**	**C**
		0	**0**	**2**	**1**
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives

1. To impart knowledge on CAM & CIM software for various engineering applications.
2. To develop proficiency in the application of CIM to the realistic engineering problems.

Course Outcome

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

1. Develop CNC programs for various geometries using CAM and CIM software.
2. Evaluate and interpret flexible integrated digital factory systems.

Indicative Experiments

1.	Manual Programming for CNC Tuning / Milling Machine.
2.	Offline verification of CNC program using CNC controller simulator.
3.	CAD/CAM based Part Programming and operation of a 3 axis CNC Milling Machine.
4.	Demonstrate automatic feature recognition using CAM software.
5.	CNC tool path verification and optimization using digital manufacturing software.
6.	Simulation to predict and optimize performance of CNC machining operations.
7.	Demonstrate factory shop floor data collection methods.
8.	Modeling and Simulation of CIM system using software.
9.	Simulation on flexible manufacturing systems.
10	Virtual Reality simulation of digital manufacturing machinery and factory.
	Total Laboratory Hours **30 hours**

Text Books

1.	Xun Xu, Integrating Advanced Computer-Aided Design, Manufacturing, and Numerical Control: Principles and Implementations, 2015, IGI Global.
2.	Hans Bernhard Kief, Helmut A. Roschiwal, Karsten Schwarz, The CNC Handbook: Digital Manufacturing and Automation from CNC to Industry 4.0, 2021, Industrial Press.
3.	Lab Manual prepared by course faculty.

Reference Books

1.	Mikell P. Grover, Automation, Production Systems and Computer-Integrated Manufacturing, 2019, Pearson Education, New Delhi.
2.	Radhakrishnan P, Computer Numerical Control Machines and Computer Aided Manufacture, 2018, New Age International (P) Ltd.

Mode of assessment: Continuous assessment, FAT, Oral examination

Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE402L	Heat and Mass Transfer	L	T	P	C
		3	0	0	3
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives

1. To impart a comprehensive knowledge of various modes of heat and mass transfer.
2. To empower the students for solving heat transfer problems in the industry.
3. To equip the student in the design of heat exchangers.

Course Outcomes

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

1. Solve the steady and unsteady heat conduction problems for simple geometries
2. Analyse the natural and forced convective heat transfer processes
3. Design the heat exchangers using the LMTD and effectiveness-NTU methods
4. Solve the radiation heat transfer problems
5. Analyse the various mass transfer processes

Module:1	**Conduction – I**	**8 hours**

Fundamental laws; Identification of significant modes of heat transfer in practical applications. General equation of heat conduction in cartesian, cylindrical and spherical coordinates; One Dimensional steady state conduction in simple geometries - plane wall, cylindrical and spherical shells; Electrical analogy; Conduction in composite walls and shells; Critical thickness of insulation; Thermal contact resistance; Overall heat transfer coefficient; One dimensional steady conduction heat transfer with internal heat generation in plane walls, cylinders and spheres.

Module:2	**Conduction – II**	**7 hours**

Extended surfaces (Fins). Conduction shape factor; Unsteady state heat transfer - Systems with negligible internal resistance - Lumped heat capacity analysis; Infinite bodies - flat plate, cylinder and sphere; Semi-Infinite bodies - Chart solutions.

Module:3	**Forced Convection**	**7 hours**

Equations of conservation of mass, momentum and energy. Boundary layers for flow over a flat plate, curved objects and flow through circular pipes. External flow over flat plate, cylinder, sphere and bank of tubes; Internal flow through circular and non - circular pipes.

Module:4	**Natural Convection**	**5 hours**

Flow over vertical, horizontal and inclined plates; Flow over cylinders and spheres; Combined free and forced Convection; Introductory concepts of boiling and condensation.

Module:5	**Heat Exchangers**	**6 hours**

Classification of heat exchanger, LMTD, AMTD, Design of heat exchanger; Concentric pipe heat exchanger, shell and tube heat exchanger, cross - flow heat exchanger; Analysis epsilon - NTU method; Introduction to compact heat exchanger.

Module:6	**Radiation**	**6 hours**

Terminology and laws; black body, gray body; Radiation from real surfaces; Effect of orientation - view factor; Equivalent emissivity method, electrical analogy - surface and space resistances. Radiation shields.

Module:7	**Mass Transfer**	**4 hours**

Basic concepts - diffusion mass transfer - Fick's law of diffusion - steady state molecular diffusion - convective mass transfer - momentum, heat and mass transfer analogy - convective mass transfer correlations.

Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Books

1. Yunus A Cengel and Afshin J Ghajar, Heat and Mass Transfer: Fundamentals and Applications, 2015, 5th edition, McGraw-Hill.
2. Sachdeva R C, Fundamentals of Engineering Heat and Mass Transfer, 2017, 5th edition, New Age International.

3.	Necati Ozisik M, Heat Transfer –A Basic Approach, 2016, McGraw Hill, New York.			
Reference Books				
1.	Theodore L. Bergman, Adrienne S. Lavine, Frank P. Incropera, David P. DeWitt, Fundamentals of Heat and Mass Transfer, 2018, 8th edition, Wiley.			
2.	J P Holman and Souvik Bhattacharyya, Heat Transfer, 2016, 10th edition, McGraw-Hill.			
3.	Kothandaraman, C.P, "Fundamentals of Heat and Mass Transfer", 2015, New Age International, New Delhi.			
Mode of Evaluation: CAT, Written assignment, Quiz, FAT				
Recommended by Board of Studies		09-03-2022		
Approved by Academic Council		No. 65	Date	17-03-2022

BMEE402P	Heat and Mass Transfer Lab	L	T	P	C
		0	0	2	1
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives

1. To impart a comprehensive knowledge of various modes of heat and mass transfer.
2. To empower the students for solving heat transfer problems in the industry.
3. To equip the student in the design of heat exchangers.

Course Outcomes

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

1. Conduct the experiments on different heat transfer modes
2. Conduct the experiments on pin fin to assess its performance
3. Understand the various pool boiling regimes
4. Demonstrate the mass transfer mechanism

Indicative Experiments

1.	Determination of the thermal conductivity of a given metal sample and comparison with tabulated values.
2.	Determination of the thermal conductivity of a given liquid and comparison with tabulated values.
3.	Heat conduction in spherical coordinate system.
4.	Study of heat conduction by electrical analogy: experiment on a composite wall.
5.	Determination of rate of heat transfer in natural convection from a cylinder 2 hours and comparison with theoretical calculations.
6.	Determination of rate of heat transfer in forced convection from a heated pipe and comparison with theoretical calculations.
7.	Prediction of temperature distribution and efficiency of a pin fin under forced and free convection and comparison with theoretical calculations.
8.	Study of the regimes of pool boiling and determination of critical heat flux.
9.	Determination of emissivity of a given surface.
10.	Determination of Stefan-Boltzmann constant and comparison with reference value.
11.	Demonstration of condenser, heat pipe and mass transfer apparatus.
	Laboratory examinations (model and final)
	Total Laboratory Hours **30 hours**

Text Books

1.	Yunus A Cengel and Afshin J Ghajar, Heat and Mass Transfer: Fundamentals and Applications, 2015, 5th edition, McGraw-Hill.
2.	Sachdeva R C, Fundamentals of Engineering Heat and Mass Transfer, 2017, 5th edition, New Age International.
3.	Necati Ozisik M, Heat Transfer –A Basic Approach, 2016, McGraw Hill, New York.
4.	Lab Manual prepared by course faculty

Reference Books

1.	Theodore L. Bergman, Adrienne S. Lavine, Frank P. Incropera, David P. DeWitt, Fundamentals of Heat and Mass Transfer, 2018, 8th edition, Wiley.
2.	J P Holman and Souvik Bhattacharyya, Heat Transfer, 2016, 10th edition, McGraw-Hill.
3.	Kothandaraman, C.P, “Fundamentals of Heat and Mass Transfer”, 2015, New Age International, New Delhi.

Mode of assessment: Continuous assessment, FAT, Oral examination

Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE205E	Renewable Energy Systems	L	T	P	C
		2	0	2	3
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives

1. To help students gain essential knowledge on the importance of various renewable energy sources.
2. To familiarize the students with principles of energy conversion for various renewable energy sources.
3. To understand the method for assessment of various input energy resources for meeting specific requirements.
4. To know limitations in renewable energy conversion techniques.
5. To do practical experiments for energy resource performance under different operating conditions.

Course Outcomes

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

1. Outline the current energy scenario and its needs towards the renewable energy sector.
2. Demonstrate the various components of solar thermal energy systems.
3. Analyse the nuances of solar PV systems to assess their performance.
4. Analyse the wind, hydel, ocean and geothermal energy systems to assess their performance.
5. Perform the design and analysis of various bio-energy systems.
6. Summarize various hybrid energy systems to solve real world problems.
7. Conduct experiments, interpret the data, and analyse the performance of various renewable energy systems.

Module:1	**Energy Source and its Scenario**	**3 hours**

Energy chain and common forms of usable energy - Present energy scenario - World and Indian energy status - Introduction to renewable energy resources – Need for Renewable energy sources – Renewable energy potentials – Indian and global renewable energy scenario. Energy Trilemma index of the World Energy Council.

Module:2	**Solar Thermal Energy Systems**	**5 hours**

Introduction to thermal systems and applications - Solar thermal collectors - Flat plate collectors - Evacuated tube collectors - Compound parabolic collectors - Solar air heaters - Solar dryers -solar cookers - solar stills - Solar ponds - Concentrating collectors – Thermal energy storage – Phase change materials.

Module:3	**Solar Photovoltaic Systems**	**5 hours**

Introduction to Solar Energy - Spectral distribution of Solar radiation – Resource assessments -Instruments for measurement of solar radiation - Solar radiation data analysis - Physics of solar cells - Cell and module – third generation solar cells - Manufacturing and fabrication Process– Characteristics of cells and module - Performance parameters – Balance of systems- PV System applications - Stand-alone - Grid connected systems – integrated PV systems – High performance solar cells – Energy storage systems – Battery Analysis.

Module:4	**Wind Energy Systems**	**4 hours**

Fundamentals of wind energy – Resource assessment - measurement of wind energy parameters – types of wind turbines - selection of components - blade materials - power regulation - various methods of control - wind farms - site selection - offshore wind farms - Solar Wind Hybrid energy systems.

Module:5	**Hydel, Ocean, Geothermal Energy Systems**	**4 hours**

Small hydro systems – Introduction – Resource Assessment – Estimation of Power potential – Types – Components – Performance.

Ocean Energy Systems - Introduction - Resource Assessment - Power generation through

OTEC systems - Energy through waves and tides – Geothermal energy systems.		
Module:6	**Bio Energy Systems**	**4 hours**
Need of Bio Energy - Resource Assessment - Fermentation - Gasification - Pyrolysis – Power generation technique - Biofuels Production.		
Module:7	**Hybrid Energy Systems**	**3 hours**
Energy systems for processes and power applications – solar – wind – Biomass hybrid technologies, Solar – Fuel cell hybrid systems – Hydrogen generation technologies.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	Fang Lin You, Hong ye, Renewable Energy Systems, 2017, 3rd Edition, Advanced conversion technologies and applications, CRC Press, ISBN: 978-1138077584.
2.	BH Khan, Non-conventional Energy Sources, 2017, 3rd Edition, Tata- Mc. Graw Hill Publications. ISBN-13:978-0070142763.
Reference Books	
1.	John Andrews, Nick Jelley Energy Science: Principles, technologies and impacts, 2017, Oxford Universities press. ISBN: 978-0198755814.
2.	Ziyad Salameh, Renewable Energy Systems Design, 2014, 1st Edition, Academic Press, ISBN: 978-0123749918.
Mode of Evaluation: CAT, Written assignment, Quiz, FAT.	
Indicative Experiments	
1.	Solar Radiation measurement by Pyranometer, Pyrheliometer, Albedo meter
2.	I-V curves of a solar PV module for different operating conditions using PV training Kit.
3.	Performance characteristics of a Solar liquid flat plate collector
4.	Determination of power curve using Wind Energy Experimental Set up
5.	Performance Variation of Tip speed ratio v/s Cp of Wind Energy Generator using Wind Energy Generator Experimental Set up.
6.	Performance of Proton Exchange Fuel Cell by Experimental simulation
7.	Performance estimation of a household Biomass stove using briquette
8.	Evaluation of Property measurements of different biofuels.
9.	Simulation of hybrid energy systems using software tools
10.	Performance characteristics of a Solar Air heating systems
11.	Performance characteristics of a Solar stills
12.	Study experiment based on renewable energy sources.
Total Laboratory Hours	**30 hours**
Textbook	
Lab Manual prepared by the Faculty member	
Mode of assessment: Continuous assessment, FAT, Oral Examination	

Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE208L	Industrial Engineering	L	T	P	C
		3	0	0	3
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives

1. To analyse different planning activities needed during the operations stage of a manufacturing or a service industry.
2. To apply productivity techniques for achieving continuous improvement.
3. To analyse the various project alternatives based on time and cost.

Course Outcome

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

1. Define productivity and reasons for poor productivity and ways of improving it.
2. Analyse the demand for a product and predict demand using suitable forecasting techniques.
3. Identify the various elements of cost in production and estimate the unit cost.
4. Apply the knowledge of work study and ergonomics for work standardization.
5. Identify key factors influencing facility location and layout decision.
6. Apply the project management techniques for evaluation and scheduling.
7. Analyse and evaluate engineering projects alternatives.

Module:1	**Competitiveness and Strategy**	**5 hours**
Competitiveness – Operations Strategy - Productivity – Factors affecting Productivity - Increasing productivity of resources - Kinds of productivity measures - Case study.		
Module:2	**Demand Analysis**	**6 hours**
Demand and Supply – Elasticity of Demand – Demand Forecasting – Forecasting Techniques – Time Series Models – Causal Regression – Forecast Error.		
Module:3	**Cost of Production**	**6 hours**
Cost concepts – Classification of costs - Materials – Labour – Overheads – Prime cost – Unit selling price; Production cost- Fixed and variable cost- Break-even analysis – Margin of safety – Angle of incidence – CVP analysis - Applications.		
Module:4	**Work Design and Measurement**	**7 hours**
Work Study – Method study – Recording techniques – Methods analysis – Motion study – Work measurement – Introduction to Ergonomics and its industrial applications.		
Module:5	**Facilities Design**	**7 hours**
Plant Location – Factors influencing location decision – Evaluating location alternatives – Facilities Layout – Types – Computer aided layout design techniques – CRAFT-ALDEP – CORELAP.		
Module:6	**Project Scheduling**	**6 hours**
Project Life Cycle – Work Breakdown structure – Planning and Scheduling with Gantt Charts – PERT and CPM – Time- Cost Trade off – Comparison of PERT and CPM.		
Module:7	**Investment Analysis**	**6 hours**
Time value of money, present and future worth, Cash flow analysis - Economic evaluation of alternatives – Capital budgeting – methods - Pay-back period – Net present value – Rate of return – .profitability index.		
Module:8	**Contemporary Issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Books

1. William J Stevenson, “Operations Management”, 2020, 14th Edition, McGraw-Hill Education, New Delhi.
2. Martand T Telsang, “Industrial Engineering and Production Management”, 2018, 3rd Revised Edition, S Chand and Company Ltd., New Delhi.

3.	Yates J K, “Engineering Economics’, 2017, CRC Press, Taylor & Francis Group.		
Reference Books			
1.	Dan Reid R and Nada R. Sanders, “Operations Management”, 2012, 5th Edition, John Wiley and Sons.		
2.	Panneerselvam R, “Production and Operations Management”, 2012, 3rd Edition, Prentice Hall of India Publications.		
3.	Zahid A.Khan, et al., “Principles of Engineering Economics with Applications”, 2018, 2nd Edition, Cambridge University Press, India.		
Mode of Evaluation: CAT, Written assignment, Quiz, FAT			
Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE212L	Quality Control and Improvement	L	T	P	C
		3	0	0	3
Pre-requisite	BMAT202L, BMAT202P	Syllabus version			
		1.0			

Course Objectives

1. Develop the understanding of process variability and quality control.
2. Present a problem oriented in depth knowledge, underlying concepts, tools, and application of quality control.
3. Demonstrate the ability to design and implement acceptance sampling and reliability principles.

Course Outcome

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

1. Evaluate the basic statistical concepts and quality tools an industrial case.
2. Demonstrate the ability to design, use, and interpret control charts for variables and attributes
3. Determine the process capability indices for real time processes and demonstrate Six-Sigma
4. Design a sampling plan to construct OC curve and evaluate its effectiveness for a given process.
5. Implement the philosophy of Taguchi's DOE and other process improvement methods
6. Apply the reliability concepts to solve real time industry problem.

Module:1	Introduction to Statistical Quality Control	5 hours

History of Quality Control - Statistical Quality Control and Statistical Process Control – Need for Statistical Concepts – Important Quality Control Tools - Quality costs and Quality loss – Quality Assurance – Taguchi's Quality Loss Function - limitation of SQC - Service Quality

Module:2	Control Charts For Variables	7 hours

Control Charts for Variables - Control Charts for $\bar{X}$ and R - process capability – interpretation- Control Charts for $\bar{X}$ and S - Control Chart for Individual Measurements - Applications of Control Charts for Variables

Module:3	Control Charts for Attributes	6 hours

Control Chart for Fraction-Nonconforming (OC curve of the control chart, variable sample size, nonmanufacturing application, the OC function and ARL calculation); Control Charts for Nonconformities or Defects; Choices Between Attribute and Variable Control Charts, Guideline for Implementing Control charts.

Module:4	Process Capability Analysis and six sigma	5 hours

PCA analysis using a histogram and probability plot, process capability ratios, Performance index calculation, PCA using a control chart, estimating natural tolerance limits of a process. Six sigma - Concept of six sigma, methods of six sigma, DMAIC methodology, DFSS methodology, six sigma control chart, case studies.

Module:5	CUSUM Control Charts	6 hours

Cumulative-Sum (CUSUM) Control Charts - CUSUM Control Chart basic principles for monitoring the shift in process mean, CUSUM design parameters, CUSUM for large shifts - Exponentially Weighted Moving Average (EWMA) control chart (EWMA control chart for monitoring process mean, design of an EWMA control chart.

Module:6	Acceptance Sampling	7 hours

The Acceptance-Sampling - Definition of a Single-Sampling - Advantages and Disadvantages of Sampling - Types of Sampling Plan - OC Curve - Designing a Single-Sampling Plan - Double, Multiple, and Sequential - The Dodge–Romig Sampling Plans – Producers risk Consumers risk - AOQL LTPD calculation.

Module:7	Reliability Engineering	7 hours

Definition of Reliability – Relationship between MTTF and MTBF - Hazard rate, Reliability

Distributions, System reliability, Reliability block diagrams: series, parallel and mixed configuration - Achieving Product reliability – Maintainability and availability - Simple problems			
Module:8	**Contemporary Issues:**		**2 hours**
	Total Lecture hours:		**45 hours**
Text Books			
1.	Amitava Mitra - Fundamentals of Quality Control and Improvement, 4th Edition, Wiley		
2.	Eugene L. Grant and Richard S. Leaven Worth, Statistical Quality Control, 2017, 7th edition, TMH.		
3.	Charles Ebeling, An Introduction To Reliability And Maintainability Engineering. 2017, Mc Graw Hill.		
Reference Books			
1.	Douglus C. Montgomery. Introduction to Statistical Quality Control, 2013, 7th Edition, John Wiley &Sons.		
2.	Statistical Quality Control. M. Mahajan, 2016, Dhanpat Rai & Sons January.		
3.	L.S.Srinath, Reliability Engineering, 2005, Affiliated East west press.		
Mode of Evaluation: CAT, Written assignment, Quiz and FAT.			
Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMAT206L	Numerical Analysis	L	T	P	C
		3	0	0	3
Pre-requisite	BMAT101L, BMAT102L, BMAT102P	Syllabus version			
		1.0			

Course Objectives

1. To familiarize theory and application of numerical methods for most common mathematical problems.
2. Clearly bring out role of approximation theory in the process of developing a numerical method for solving an engineering problem.
3. To provide the approximation techniques work with emphasis on accuracy and efficiency of the developed methods.

Course Outcome

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

1. Examine errors in numerical procedures and assess the accuracy of the calculated results.
2. Solve system of nonlinear equations numerically using direct and iterative methods.
3. Compute approximations of functions and data using elementary functions.
4. Apply iterative techniques to solve linear systems and Eigenvalue problems.
5. Use numerical techniques to estimate derivatives and integrals of functions.
6. Apply numerical methods to solve initial value problems and boundary value problems.

Module:1	Preliminaries on computing	6 hours

Basic concepts: Numerical algorithms and errors, round-off errors, floating point arithmetic, rounding, error analysis, conditioning, measuring efficiency of numerical procedures - consistency, stability and convergence analysis;

Module:2	Numerical solution of nonlinear equations	6 hours

Solutions of equations in one variable – Bisection method, Secant method, Fixed-point iteration, Newton's method and its variations for simple and multiple roots; Polynomial roots; System of nonlinear equations – Fixed-Point iteration, Newton's method and its variations for system; Steepest Descent method, Convergence analysis and order of convergence;

Module:3	Interpolation and Approximation	6 hours

Interpolating polynomials; Finite differences, Newton's forward and Backward interpolation, Divided differences – Lagrange and Newton's divided difference interpolations and error analysis; Interpolation by Spline functions; Orthogonal polynomials and Least squares approximation, Chebyshev polynomials; Rational function approximation; Trigonometric polynomial approximation, Fourier series;

Module:4	Numerical solutions of linear system of equations	6 hours

Linear systems of equations, Solution by direct methods – Gauss elimination, Gauss-Jordan method and pivoting strategies, Matrix decompositions – LU and Cholesky factorizations; Matrix conditioning - Ill and well-conditioned systems, Condition numbers and norms; Norms of vectors and Matrices, Solution by Iterative methods – Jacobi, Gauss-Siedel, SOR methods; Error bounds and iterative refinement;

Module:5	Eigenvalues and Eigenvectors	6 hours

The Matrix Eigenvalue Problem, Characteristic polynomial, Gerschgorin's theorems, Reduction of matrices to simpler form - Diagonalization; Tridiagonalization and QR-Factorization, Methods for determination of Eigenvalues and Eigen vectors – Power method, Householder's method, QR method; Singular value decomposition; Applications of Eigenvalue Problems;

Module:6	Numerical differentiation and Integration	6 hours

Approximating derivatives by difference equations, error and instability; Richardson extrapolation; Derivatives of unequally spaced data; Partial derivatives; Elements of numerical integration, Newton-Cotes quadrature formulae; Romberg integration, Adaptive

integration, Gaussian quadrature, Error estimation, Multiple integrals;		
Module:7	**Numerical methods for differential equations**	**7 hours**
Existence of solutions for ordinary differential equations, uniqueness; Solving IVPs by Taylor-Series method, Euler's method and its modifications, Runga-Kutta methods, Multistep Methods; Higher-order equations and systems; Stability; Solving BVPs by Shooting methods, Difference methods, Variational methods; Introduction to numerical solutions for partial differential equations;		
Module: 8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Books	
1.	Gerald C.F, Wheatley P.O, Applied Numerical Analysis, 2004, 7th Edition, Pearson Education.
2.	Burden R.L, Faires J.D, Numerical Analysis, 2011, 9th Edition, Cengage Learning.
3.	Chapra S.C, Canale R.P, Numerical methods for Engineers, 2010, 6th Edition, McGraw-Hill Education.
4.	Stoer J, Bulirsch R, Introduction to Numerical Analysis, 2009, Springer (India).
Reference Books	
1.	Hildebrand F.B, Introduction to Numerical Analysis, 2003, 2nd Edition, Dover Publications.
2.	Endre Suli, Mayers D.F, An Introduction to Numerical Analysis, 2003, Cambridge University Press.
3.	Atkinson K.E, Han W, Elementary Numerical Analysis, 2006, 3rd Edition, Wiley International.
4.	Conte S.D, De Boor C, Elementary Numerical Analysis, 2010, TATA McGraw-Hill.

Mode of Evaluation: CAT, Written assignment, Quiz, FAT.			
Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE305L	Manufacturing Planning and Control	L	T	P	C
		3	0	0	3
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives

1. To impart knowledge on operations strategy, product planning and forecasting.
2. To develop skills to estimate and use appropriate process planning, layouts location and facility location.
3. To understand the importance of capacity planning, management, production scheduling and controlling systems.

Course Outcome

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

1. Take the decisions in conversion process, manufacturing strategy, product planning and forecasting product demand
2. Take the decisions in process planning and design, performance measures, capacity planning
3. Take the decisions in selection of facilities location and design the facilities layout
4. Generate the aggregate plans, master schedules, short-term schedules
5. Generate material requirements planning and strategies for manufacturing excellence.

Module:1	**Operations Strategy**	**5 hours**

Operations and Productivity: Operations / manufacturing, Operations for goods and services, Operations for Goods and Services, The Productivity Challenge, Decision making in an organization / conversion process.

Operations Strategy: A global view of operations, Developing missions and strategies, Competitive priorities, Issues in operations strategy, Strategy development and implementation, Strategic planning, Core competencies and outsourcing, Global operations strategy options.

Module:2	**Product planning and Forecasting**	**7 hours**

Design of Goods and Services: Goods and services selection, Generating new products, Product development, Issues for product design, Product development continuum, Defining a product, Documents for production - product life-cycle, Service design, Transition to production.

Forecasting: Types, Strategic importance, Steps, Approaches, Time-Series, Forecasting methods, Monitoring and controlling forecasts.

Module:3	**Process planning**	**5 hours**

Process Strategy: Process Strategies, Selection of equipment, Process analysis and design, Special considerations for service process design, Production technology, Technology in services, Process redesign.

Module:4	**Facilities location**	**6 hours**

Location Strategies: The Strategic importance of location - supply chain considerations, Factors affecting location decisions, Methods of evaluating location alternatives - costing alternative locations - scoring models - geometric models, Locating multiple facilities, Service location strategy, Location of facilities on networks, Geographic information systems.

Module:5	**Layout of facilities**	**7 hours**

Layout Strategies: Strategic importance of layout decisions - Types of layout – product layouts, process layouts, fixed-position layouts, hybrid/combination layouts, cellular Layouts, service layouts, Designing product layouts and line-balancing, Designing process layouts – measure of effectiveness.

Module:6	**Capacity planning and Constraint management**	**6 hours**

Capacity planning and Constraint Management: Defining and measuring capacity, Determinants of effective capacity, Design of effective capacity, Bottleneck analysis and the theory of constraints, Break-even analysis, Reducing risk with incremental changes, Applying expected monetary value, Applying investment analysis to strategy-driven investments, Forecasting capacity requirements, Developing capacity strategies, Evaluating Alternatives.				
Module:7	**Production planning, Scheduling, MRP and Inventory Control**			**7 hours**
Hierarchy of planning decision, Planning process, Approaches for aggregate planning, Master schedule, Short-term schedules, Control of schedules. MRP process and extensions to MRP. Inventory control, JIT systems, Lean operations, Toyota Production System				
Module:8	**Contemporary Issues**			**2 hours**
	Total Lecture hours:			**45 hours**
Text Book				
1.	Jay Heizer, Barry Render, Munson Chuck, and Sachan Amit, Operations Management, 2017, 12th Edition, Pearson.			
Reference Books				
1.	Stevenson William J,Operations Management, 2018, 13th Edition, McGraw-Hill.			
2.	Mahadevan B, Operations Management: Theory and Practice, 2010, 2nd Edition, Pearson India.			
Mode of Evaluation: CAT, Written assignment, Quiz, FAT				
Recommended by Board of Studies	09-03-2022			
Approved by Academic Council	No. 65	Date	17-03-2022	

BMEE307L	Product Design and Development	L	T	P	C
		3	0	0	3
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives

1. To discuss about Product requirement analysis, concept generation, detailed design verification by quick design techniques.
2. To provide students with technical and practical knowledge and skills required to engage in Product development projects and intellectual property rights.

Course Outcome

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

1. Illustrate the basics of product design and development processes and organisation policies.
2. Infer the workplace management, health and safety management.
3. Apply the methods of generating, evaluating and testing to select the best product concept.
4. Demonstrate the methods of design problem solving and concept generation to testing.
5. Practice the industrial design and Design for X.
6. Infer the process of intellectual property rights.

Module:1	**Introduction**	**7 hours**

The design process –product life cycle –product development process – Collaborative product development – concurrent engineering - Strategic Planning and Opportunity Identification for new products – Identifying Market Opportunities – Communication with Stake holders in line with organizational policy and requirements

Module:2	**Organizational Competency Management**	**6 hours**

Organization's policies and procedures for working with colleagues, Competency, skills and knowledge requirements for working effectively; health and safety management – OSHA; Competency development, Training need analysis; skills need analysis

Module:3	**Product Specifications**	**5 hours**

Voice of Customer – customer survey – need gathering methods – Explore systematically - Establishing product specification -competitive benchmarking; House of Quality, Lean Thinking

Module:4	**Problem Solving**	**5 hours**

Need for design creativity - Creative thinking – creativity and problem solving – TRIZ- Morphological approach

Module:5	**Concept Generation**	**5 hours**

Concept Generation - Concept Screening- Concept Scoring – Concept Testing methods - Case Studies

Module:6	**Embodiment Design and Industrial design**	**6 hours**

Introduction to embodiment design – product architecture – Configuration Design – Parametric Design - Test and Validation – Detail design - Industrial design – human factors design

Module:7	**Design for X, Prototype and IP**	**9 hours**

Design for Manufacture - Design for Assembly - Design for serviceability – design for environment –- Design for Quality - Reliability – Sustainability. Failure Mode and Effect Analysis - Test and Inspection –Warranty; Cost evaluation –categories of cost – overhead costs – activity based costing Prototyping and Testing; Product Testing- Standards, Certification and Documentation. – Intellectual Property Rights - Patents, Design Patents, Trade Marks, Trade Secrets and copyrights

Module:8	**Contemporary issues**	**2 hours**

	Total Lecture hours:	**45 hours**
Text Book		
1.	Karl T. Ulrich, Steven D. Eppinger, Product Design and Development, 2015, 6th Edition, McGraw-Hill.	
Reference Books		
1.	George E. Dieter, Linda C. Schmidt, Engineering design, 2017, 4th Edition, McGraw-Hill.	
2.	Kevin Otto, Kristin Wood, Product Design, 2004, Pearson Education.	
3.	Armstrong S, Engineering and Product Development Management: The Holistic Approach, 2001, Cambridge University Press.	
Mode of Evaluation: CAT, written assignment, Quiz, FAT.		
Recommended by Board of Studies	09-03-2022	
Approved by Academic Council	No. 65	Date 17-03-2022

BMEE309L	Lean Manufacturing	L	T	P	C
		3	0	0	3
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives

1. To provide practical level understanding of the key elements of lean production systems.
2. To impart knowledge on systematic approach for implementing value stream mapping.
3. To inculcate the practice of operational excellence through Toyoto's way.

Course Outcomes

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

1. Identify key requirements and concepts in lean production system.
2. Apply the stability and standardized work systems.
3. Demonstrate the JIT and Jidoka and implement Lean culture.
4. Map the value chain, predict the value addition and apply the value stream.
5. Implement the 14 principles of Toyoto's operational excellence.

Module:1	**Lean Production System**	**5 hours**

Birth of lean production: Types of production systems-Craft Production-Mass Production-Ford System, Growing Dysfunction, Birth of lean production, Virtue of necessity, Lean revolution at Toyota.

Lean production system: Why lean production? Systems and Systems thinking, Basic image of lean production, Customer focus, Muda, Mura, Muri.

Module:2	**Stability and Standardized work**	**7 hours**

Stability: Standards in lean system, 5S system, Total Productive Maintenance.

Standardized work: Lean thinking, Why standardized work? Elements of standardized work, Charts Used to Defne Standardized Work, Manpower reduction, Overall efficiency versus Individual efficiency, Standardized Work and Kaizen, Common layouts.

Module:3	**Just-in-Time Production**	**7 hours**

Why JIT, Principles of JIT, JIT system, Kanban, Kanban rules, Expanded role of conveyance, Production levelling, Three types of pull systems, Value stream mapping.

Jidoka Concept: Development of Jidoka concept, Why Jidoka, Poka-Yoke, Inspection systems and zone control, using Poka-Yokes and Implementing Jidoka

Module:4	**Involvement, Hoshin planning, and Culture**	**6 hours**

Involvement: Why involvement? Terrible waste of humanity, Activities supporting involvement, Kaizen circle activity, Practical kaizen training, Suggestion programs.

Hoshin planning: What is planning? Why plan? Problems with planning, Hoshin planning, Hoshin planning system, Four phases of hoshin planning.

The culture of Lean Production: What is lean culture? How does lean culture feel?

Module:5	**Value Stream Management Process**	**6 hours**

Why Use Value Stream Management? Attributes of Value Stream Management,

Commit to Lean: Management Push or Worker Pull? Key Management Activities, Invest in Your People, Short-Term Pains and Long-Term Gains, Implementing Lean Transforms a Business Culture, Commitment checklist.

Choose the Value Stream: What Is a Value Stream? Selecting Value Streams for Improvement, Additional Considerations for Value Stream Selection.

Learn about Lean: Training and Doing, Key Concepts of Lean, Three Stages of Lean Application, Identify Non-Lean Conditions

Module:6	**Value Stream Mapping**	**6 hours**

Map the Current State: Value Stream Mapping, How to Map the Current State, Case Study.

Identify Lean Metrics: Fundamentals, Steps for Identifying Lean Metrics, Premiere Manufacturing Case Study, Help Identify Wastes, Lean Manufacturing Assessment.

Map the Future State: Focus on three stages - Customer demand - Continuous flow - Leveling.

Create and Implement Kaizen Plans: Value Stream "Kaizen" Events, Planning Recap, Prepare for Implementation, Recommendations.		
Module:7	**The world-class power of the Toyota way**	**6 hours**
The Toyota Way: using operational excellence as a Strategic Weapon, A storied history: How Toyota became the World's Best Manufacturer, 14 principles of Toyota way (Part 1 Philosophy: long-term systems thinking; Part 2 Process: struggle to flow value to each customer; Part 3 People: respect, challenge, and grow your people and partners toward a vision of excellence; Part 4 Problem Solving: think and act scientifically to improve toward a desired future, Part 5 Conclusion: Be thoughtful and evolve your enterprise).		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Books	
1.	Pascal Dennis, Lean Production Simplified: A Plain-Language Guide to the World's Most Powerful Production System, 2015, Third Edition, CRC Press-Taylor & Francis, UK.
2.	Don Tapping, Tom Luyster and Tom Shuker, Value Stream Management: Eight Steps to Planning, Mapping, and Sustaining Lean Improvements, Productivity Press, New York, 2002
3.	Jeffrey K. Liker, The Toyota Way: 14 management principles from the world's greatest manufacturer, 2021, Second edition, MaGraw-Hill Edition.
Reference Books	
1.	Masaaki Imai, Gemba Kaizen: A Commonsense, Low-Cost Approach to Management, 1997, MaGraw-Hill.
2.	James P. Womack and Daniel T. Jones, Lean Thinking: Banish Waste & Create Wealth in Your Corporation, 2001, Revised Edition, Simon & Shuster.
3.	Mike Rother, Learning to See: Value Stream Mapping to Create Value & Eliminate MUDA, 2003, Lean Enterprise Institute.
4.	Jeffrey K Liker and Divid Meier, The Toyota Way Field Book: A Practical Guide for Implementing Toyota's 4Ps, 2006, Tata MaGraw-Hill Edition.
5.	John Allen, Charles Robinson and David Stewart, Lean Manufacturing: A Plant Floor Guide, 2001, Society of Manufacturing Engineers, Michigan.
6.	Mike Rother, "Toyota Kata: Managing People for Improvement, Adaptiveness, and Superior Results", 2010, Tata MaGraw-Hill Edition.

Mode of Evaluation: CAT, Written assignment, Quiz, FAT			
Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE310L	Supply Chain Management	L	T	P	C
		3	0	0	3
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives

1. Provide an overview and conceptual understanding of Supply Chain Management.
2. Introduce theoretical models and applications in the area of Supply Chain Management.
3. Equip the students with tools and concepts to manage and improve Supply Chain for operational excellence.

Course Outcome

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

1. Understand supply chain need, and analyze the strategies, and drivers of performance of the supply chain.
2. Evaluate different distribution and network design options.
3. Analyze the impact of information in achieving coordination.
4. Optimize inventory level in a Supply Chain.
5. Evaluate different transportation modes and pricing strategies.
6. Analyze the challenges in the global Supply Chain network as well as in maintaining sustainability of the Supply Chain.

Module:1	**Introduction to Supply Chain Management**	**5 hours**

Definition – Stages – Objective - Importance of SC Decisions - Decision Phases - Process views of a SC

Module:2	**Strategic Fit and Drivers of Performance**	**6 hours**

SC Strategies - Achieving strategic fit - Uncertainty and Capabilities of SC - Steps and Challenges in achieving the fit – Scope - Measures of performance - Drivers of SC performance - roles and impact on financial performance

Module:3	**Distribution Systems and Networks**	**6 hours**

Role of distribution – Influence of drivers on distribution systems - Distribution Network Options – Impact of online sales on distribution

Factors influencing network design decisions – phases in design decisions - models – facility location – capacity allocation

Module:4	**Coordination and Technology in Supply Chain**	**6 hours**

Lack of coordination and Bullwhip Effect – Vendor Managed Inventory and Collaborative Planning, Forecasting and Replenishment - Role of IT in the supply chain – Macro processes - Customer Relationship Management –Internal supply chain management – Supplier Relationship Management - Supply chain IT in practice – Future of IT in supply chain.

Module:5	**Planning & Managing Inventories in a Supply Chain**	**7 hours**

The role of cycle inventory in a supply chain –Managing multi echelon cycle inventory – Estimating cycle inventory – related costs in practice – the role of safety inventory in a supply chain – managing safety inventory in a multi echelon supply chain – estimating and managing safety inventory in practice.

Module:6	**Sourcing, Transporting and Pricing of Products**	**7 hours**

Sourcing decisions in supply chain – transportation in the supply chain – transportation infrastructure – suppliers of transport services – transportation modes and trade-offs – pricing and revenue management in the supply chain.

Module:7	**Global and Sustainable Supply Chains**	**6 hours**

Trend towards globalization - Challenges – Off shoring Decisions – Risk and Uncertainty in Global SCM – Sources – Sustainability in Supply Chain – Role and importance – sustainability pillars and drivers – best practices.

Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Chopra, S. and Meindl, P., Supply Chain Management: Strategy, Planning & Operations, 2018, 7th edition, Pearson India Education Services Pvt. Ltd., India.
Reference Books	
1.	Simchi-Levi, D. Simchi-Levi, E. Ravi Shankar, and Kaminsky, P., Designing & Managing the Supply Chain: Concepts, Strategies & Case Studies, 2019, 3rd Edition, McGraw-Hill, New York.
2.	Janat Shah, Supply Chain Management, Text and Cases, 2016, 2nd edition, Pearson India Education Services Pvt. Ltd., India.
3.	Martin Christopher, Logistics and Supply Chain Management, 2016, 5th edition, Pearson Education Limited, UK.

Mode of Evaluation: CAT, Digital Assignment, Quiz, FAT			
Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE311L	Welding Engineering	L	T	P	C
		3	0	0	3
Pre-requisite	**BMEE302L, BMEE302P**	**Syllabus version**			
		1.0			

Course Objectives

1. Select their profession as an Engineer in Industries and expand areas of materials, power, and energy-related fields.
2. Practice effectively in the emerging Industrial environment with the lead role and make timely development toward establishing newer technology in welding-related fields or business.
3. Pursue their careers in academia and develop entrepreneur skills.

Course Outcome

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

1. Select a suitable process for producing quality weldments based on materials and applications.
2. Design weld joints that serve under different loading and servicing.
3. Test and evaluate the weldments in various environments.
4. Assess the quality of weldments and suggest methods of producing quality joints.
5. Apply suitable consumables for welding involving different types of materials.
6. Develop and adopt energy-saving and eco-friendly techniques in the welding industry.

Module:1	**Fundamentals and Principles of Arc Welding**	**5 hours**

Classification of welding processes: heat sources, power sources, arc phenomena, arc blow, power source characteristics, V-I, relationship, flux covering, different types of electrodes and their applications, gas welding and cutting, flame characteristics.

Module:2	**Electrical aspects of welding**	**6 hours**

Basic principles, different methods of control of volt-ampere characteristics, operation, volt control, slope control, dual control, resistance welding transformers, welding rectifiers, choice of diode material; use of thyristors, inverters - Measurements of welding current, voltage, temperature, load and displacement.

Module:3	**Welding metallurgy**	**7 hours**

Heat flow in welding: temperature distribution in welding, heat flow equations, simple problems, metallurgical effects of heat flow in welding. Solidification of Metals, - welding of stainless steels (austenitic, ferritic, martensitic, duplex and PH stainless steels), use of Schaffler and Delong diagrams, Welding of Cu, Al, Ti and Ni alloys – microstructures, defects and remedial measures. Preheating and post-heating.

Module:4	**Design of Weldments**	**7 hours**

Joint design based on stresses in the structure; Joint design for structural elements such as bars, beams, plates, slabs, columns, trusses, plate girders, cylindrical shells and pressure vessels and pipe lines. Design for flanged connections, structural hollow sections and branch connections; Welded joint design to control distortion and shrinkage, residual stresses and cracking.

Module:5	**Welding codes and standards**	**6 hours**

Structural Welding Codes: Design requirements, allowable stress values, workmanship and inspection. Petroleum Piping Fabrication: Process and product standards for manufacturing of pipe - welding procedure and welder qualification, field welding and inspection. Pressure Vessel Fabrication: Design requirements, fabrication methods, joint categories, welding and inspection, post weld heat treatment and hydro testing.

Module:6	**Repair welding and Reclamation**	**6 hours**

Engineering aspects of repair, aspects to be considered for repair welding, techno-economics, repair welding procedures for components made of steel casting and cast iron, half bead, temper bead techniques, usage of Ni-base filler metals - Damaged bends in gas

transmission pipeline, heat exchanger repair techniques-explosive expansion, plugging, etc.,		
Module:7	**Welding applications**	**6 hours**
Materials, processes, fabrication and construction, use of automatic welding and systems in the automobile industry - Oil and gas industry - nuclear industry, materials, processes, fabrication, inspection and testing, case studies, recent trends and developments - Materials, processes, fabrication, inspection and testing.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Books	
1.	Nadkarni S.V., Modern Arc Welding Technology, 2010, Oxford and IBH Publishing.
2.	Khanna O. P., A Textbook of Welding Technology, 2009, Dhanpat Rai Publishers.
3.	Radhakrishnan V. M. Welding Technology and Design 2005, Revised Second Ed., New Age International Publishers.
Reference Books	
1.	Kou S., Welding Metallurgy, 2002, John Wiley, 2002.
2.	John Norrish. Advanced welding processes Technologies and process control, 2006, Wood head Publishing and Maney Publishing. Cambridge, England.
3.	Bhattacharya M. Weldment Design, Association of Engineers, 1991.

Mode of Evaluation: CAT, Written assignment, Quiz, FAT			
Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE312L	Engineering Tribology	L	T	P	C
		3	0	0	3
Pre-requisite	**BMEE201L, BMEE204L, BMEE204P**	**Syllabus version**			
		1.0			

Course Objectives

1. To introduce tribology as an important design consideration that affects the performance of various machine components in relative motion and in contact.
2. To understand the importance of friction and wear while designing components for functional applications.
3. To recognize the importance of lubrication in machine components and in the design of various types of bearings.
4. To provide exposure latest developments and applications in the field of Tribology.

Course Outcomes

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

1. Apply the principles of tribology in design of machine components.
2. Estimate the friction and wear characteristics in interacting surfaces.
3. Use the principles of lubrication in designing various types of bearings.
4. Analyze the pressure and estimate the load carrying capacity of a journal bearing.
5. Examine components and characterize tribological failures.
6. Apply the knowledge on surface modification/treatment techniques in designing components for various applications.

Module:1	**Introduction to Tribology**	**6 hours**

Introduction – Tribology in design – Tribology in Industry – Economic aspects – Topography of engineering surfaces – Surface parameters – Geometric – Statistical parameters – Measurements – Surface contact – Types of contact – Hertz's theory of elastic contact

Module:2	**Friction and Wear**	**6 hours**

Laws of friction – Stick-slip phenomenon – Friction characteristics of metals and non-metals – Ploughing theory of friction – Measurement of friction. Wear – Wear mechanisms – Interfacial wear and Chemical wear – Wear measurements – Ferrography and oil analysis.

Module:3	**Lubrication and Bearings**	**7 hours**

Lubrication types – Regimes – Basic Modes of Lubrication – Properties of Lubricants – Lubricant Additives – Bearing Terminology – Sliding contact and Rolling contact bearings

Module:4	**Hydrodynamic Lubrication**	**11 hours**

Mechanism of pressure development – Reynolds equation – Plane slider bearing – Journal bearing – Long bearing and Short Bearing approximations – Load carrying capacity – Friction – Sommerfeld Number – Petroff's equation – Oil flow and Thermal equilibrium – Squeeze film lubrication

Module:5	**Tribological testing and Instrumentation**	**5 hours**

Diagnosing Tribological problems – Atomic Force Microscope (AFM) – Challenges of Tribological Testing at Small Scales – Methods and Instrumentation used for Tribological Testing – Influences of Test Parameters

Module:6	**Wear resistant coatings and surface treatments**	**4 hours**

Coating techniques dependent on vacuum or gas at very low pressure (Physical vapour, Chemical vapour and Physical-chemical vapour deposition techniques) – Coating processes requiring localized sources of intense heat (Surface welding, Thermal spraying and Laser surface hardening/alloying techniques)

Module:7	**Applications and case studies in Tribology**	**4 hours**

Tribology in Automotive, Aerospace, Marine, Manufacturing, Biomedical and other applications

Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

TextBooks	
1.	Gwidon Stachowiak and Andrew W Batchelor, Engineering Tribology, 2016, Fourth Edition, Butterworth Heinemann, Oxfordshire UK.
Reference Books	
1.	Harish Hirani, Fundamentals of Engineering Tribology with Applications, 2016, First Edition, Cambridge University Press, England.
2.	Bharat Bhusan, Modern Tribology Handbook Volume 1, 2000, First Edition, CRC Press, Florida US.
3.	Prasanta Sahoo, Engineering Tribology, 2005, Prentice Hall of India, New Delhi, India.
4.	Majumdar B.C., Introduction to Tribology of Bearings, 2018, Second Edition, S.Chand Publisher, India.
5.	Ian Hutchings and Philip Shipway, Tribology: Friction and Wear of Engineering Materials, 2017, Second Edition, Butterworth Heinemann, Oxfordshire UK.
6.	Kenneth C. Ludema and Layo Ajayi, Friction, Wear, Lubrication, A Textbook in Tribology, 2018, Second Edition, CRC Press, Florida US.
7.	Yukio Hori, 2006, Hydrodynamic Lubrication, Springer Japan.
8.	N.P. Suh, Tribophysics, 1986, Prentice-Hall, Englewood Cliffs, New Jersey.

Mode of Evaluation: CAT, Written assignment, Quiz, FAT			
Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE313E	Non- destructive Testing	L	T	P	C
		3	0	2	4
Pre-requisite	**BMEE302L, BMEE302P, BMEE304L, BMEE304P**	**Syllabus version**			
		1.0			

Course Objectives

1. To provide a basic understanding with case studies on different NDT & E techniques.
2. Impart knowledge on inspecting materials with industry specifications and standards.
3. To get knowledge about the advanced NDT techniques.

Course Outcome

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

1. Infer the knowledge of various NDT techniques.
2. Apply the NDT techniques to identify surface defects of engineering components.
3. Use the subsurface NDT techniques to identify the defects.
4. Examine and quantify closed discontinuities to assess the structural integrity of engineering components.
5. Analyse the outputs of the acquired data from NDT techniques.
6. Evaluate the output results in the different modality.

Module:1	**Introduction NDT**	**6 hours**

Fundamentals of characterisation studies, Codes, Standards and Specifications, Defects in Materials due to various processing, Visual Testing – vision certification, lighting, material attributes, environmental factors, visual perception, direct and indirect methods – mirrors, magnifiers, boroscopes and fibroscopes– light sources and special lighting–calibration.

Module:2	**Surface inspection Techniques**	**5 hours**

Dye penetrant testing – visible, fluorescent method, Selection of penetrant method - Theory of magnetism and Principle of Magnetic Particle Testing - Wet Magnetic Particle Testing (WMPT) and Dry Magnetic Particle Testing (DMPT).

Module:3	**Ultrasonic Testing**	**8 hours**

Introduction, Elastic wave propagation in solids, Bulk waves, Particle motion and Wave fronts, Reflection and refraction at interfaces, Attenuation and scattering, Ultrasonic transducers, Inspection techniques, Flaw characterization, Material properties characterization, Immersion testing, Applications.

Module:4	**Acoustic emission testing**	**4 hours**

AE sources, Wave propagation in metals and alloys, AE signal intensity in attenuation media, AE equipments, Signal features, Data collection and analysis, source location, Applications.

Module:5	**Eddy current testing**	**7 hours**

Generation of eddy currents – effect of change of impedance on instrumentation – properties of eddy currents – eddy current sensing elements, probes, type of coil arrangement – absolute, differential, lift off, operation–Through encircling coils, type of arrangements – absolute, differential fill factor, operation - Factors affecting sensing elements and coil impedance - test part and test system– Applicable codes and standards.

Module:6	**Radiography Testing**	**7 hours**

Introduction to Radiography – radiography sources - Film Radiography - Film handling and storage - Effect of film processing on film characteristics - Radiographic Image Quality and Radiographic Techniques - Special Radiographic Techniques and Interpretation of radiographs - Radiation hazards evaluation and control - Applicable codes and standards of Radiography techniques.

Module:7	**Advanced NDT**	**6 hours**

Leak testing, Hydro testing, Holography, Thermography, Magnetic Barkhausen Effect, and In-situ metallography. Industrial applications of flaw detection probability, Wave propagation in guided wave modes in isotropic and composite plate structures, Mode conversion, diffraction and scattering of ultrasonic waves in isotropic and anisotropic media, Pulsed eddy

current NDT, Electromagnetic acoustic technique (EMAT). Scanning Acoustic Microscopy (SAM) and Scanning Laser Acoustic Microscopy.		
Module:8	**Contemporary ISsues**	**2 hours**
	Total Lecture hours:	**45 hours**
Text Book(s)		
1.	Wong B. Stephen, Non-Destructive Testing - Theory, Practice and Industrial Applications, 2015, 1st edition, Lambert Academic Publishing, USA.	
Reference Books		
1.	Prasad, J C. G. Krishnadas Nair, Non-Destructive Test and Evaluation of Materials, 2017, 2nd edition, McGraw Hill Education (India) Private Limited.	
2.	Raviprakash, Non-Destructive Testing Techniques, 2010, 1st edition, New Age International Private Limited Published.	
3.	Baldev Raj, M. Thavasimuthu, and Jayakumar T, Practical Non-Destructive Testing, 2009, 3rd edition , Narosa publications.	
Mode of Evaluation: CAT / written assignment / Quiz / FAT		
Indicative Experiments		
1.	Inspection of welds/samples using solvent removable visible dye penetrant	
2.	Inspection of welds using solvent removable fluorescent dye penetrant.	
3.	Inspection of welds/samples by Magnetic Particle Testing – Dry method	
4.	Inspection of welds/samples by Magnetic Particle Testing – Wet method	
5.	Detection of surface flaws in non- ferrous material using eddy current testing.	
6.	Non- conductive coating dimensional variations measurement using eddy current testing.	
7.	Calibration and detection of sub / deep surface flaws using Ultrasonic testing.	
8.	Evaluate the location of sub / deep surface flaws using Ultrasonic testing.	
9	Detection of sub / deep surface flaws using Ultrasonic testing.	
10	Evaluate the location of sub / deep surface flaws using Ultrasonic testing.	
Total Laboratory Hours		**30 hours**
Text Book		
Lab manual prepared by the faculty member.		
Mode of assessment: Continuous assessment, FAT, Oral examination		
Recommended by Board of Studies	09-03-2022	
Approved by Academic Council	No. 65	Date 17-03-2022

BMEE314E	Mechanical Vibrations and Acoustics	L	T	P	C
		3	0	2	4

Pre-requisite	BMEE207L, BMEE207P	Syllabus version
		1.0

Course Objectives

1. To enable students to understand the fundamental concepts of mechanical vibrations and acoustics.
2. To impart knowledge on the concept of vibration for single, two and multi degree of freedom systems.
3. To formulate mathematical models and complete solution of mechanical vibration and acoustic problems.
4. Obtain linear vibratory models of dynamic systems with changing complexities (SDOF, MDOF).

Course Outcomes

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

1. Formulate the equations of motion for the given vibratory systems.
2. Examine the free and forced vibration response of a single degree of freedom system under damped or un-damped condition.
3. Investigate dynamic characteristics of two degree of freedom systems.
4. Investigate the vibration response of multi-degree of freedom systems by performing modal analysis.
5. Examine the vibration response for continuous systems.
6. Demonstrate the fundamentals concepts of acoustics and its control methods.

Module:1	Fundamentals of Vibration	6 hours

Introduction, Degree-of-freedom, Classification of vibration, Vibration terminology, Harmonic Motion, Periodic Motion, Modelling of vibratory system, Equations of motion, Force and moment balance, energy methods.

Module:2	Single degree of freedom System	6 hours

Free vibration of undamped and damped SDOF systems, Harmonically excited vibration response of undamped and damped SDOF systems, Transmissibility, Estimation of damping, Logarithmic decrement, Quality factor, Introduction to Transient vibration.

Module:3	Two Degree of Freedom System	6 hours

Introduction to two degrees of freedom system, Equation of motion, Coordinate coupling and principal coordinates, Normal mode analysis, Properties of mode shapes, Forced vibration, Vibration absorber, Vibration isolation.

Module:4	Multi Degree of Freedom System	7 hours

Derivation of equation of motion, Free and forced vibration systems, Eigen value and Eigen vector, Orthogonal properties, Modal matrix, Modal analysis, Influence Coefficients, Approximate Numerical Methods.

Module:5	Vibration of Continuous Systems	6 hours

Systems governed by wave equations, Transverse Vibration of strings, Longitudinal Vibration of bars, Torsional Vibration of Shafts, Lateral Vibration of beams.

Module:6	Fundamental of Acoustics	6 hours

Introduction to acoustics, loudness, decibel scale, adding decibels, weighting sound levels, octave, music scales, sound pressure and power levels, sound fields – near, far and free and reverberant, inverse square law, wave number, Equation of state, continuity, Euler's

equation. Linear wave equation and its solution.			
Module:7	**Acoustics Concepts**		**6 hours**
Acoustic intensity, specific acoustic impedance, plane waves, spherical waves, cylindrical waves, reflection and transmission, radiation, absorption and attenuation, noise control methods, vibration and acoustic measurements.			
Module:8	**Contemporary issues:**		**2 hours**
	Total Lecture hours:		**45 hours**
Text Books			
1.	Rao S.S, Mechanical Vibrations, 2016, 6th Edition, Pearson Education.		
2.	Lawrence E. Kinsler, Austin R. Frey, Alan B, 2000, Coppens and James V. Sanders, Fundamentals of Acoustics, 4th Edition, John Wiley & Sons Inc, Delhi.		
Reference Books			
1.	Dukkipati RV, Advanced Mechanical Vibrations, 2012, Narosa Publications.		
2.	Kelly SG, Mechanical Vibrations, 2013, Mcgraw Hill (India) Ltd.,		
3.	W.T. Thomson, Theory of Vibration with Applications, 2013, 5th Edition, Prentice – Hall.		
4.	L. Meirovitch, Elements of Vibration Analysis, 2001, Tata McGraw-Hill: New Delhi.		
5.	Munjal M. L., Noise and Vibration Control, , 2013, World Scientific Publishers in Collaboration with IISc Press, Singapore.		
Mode of Evaluation: CAT, Written assignment, Quiz, FAT			
Indicative Experiments			
1.	To determine the radius of gyration ‘k’ of Simple and Compound Pendulum.		
2.	To verify the Dunkerley’s rule.		
3.	Determination of Natural Frequency in Longitudinal Vibrating System.		
4.	To study the forced vibration of the beam with different boundary conditions.		
6.	To study the forced damped vibration of spring mass system.		
7.	To determine the radius of gyration of using bi filar system.		
8.	To determine the radius of gyration using tri-filar system.		
9.	To determine the natural frequency of undamped torsional vibration of a single and two rotor shaft system.		
10.	To study the damped torsional vibration of single rotor system and to determine the damping coefficient.		
11.	Determination of natural frequency and damping of beam using accelerometer and impact hammer.		
12.	Measurement of Noise.		
		Total Laboratory Hours	**30 hours**
Text Book			
Lab manual prepared by the faculty member.			
Mode of assessment: Continuous assessment, FAT, Oral examination			
Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE315L	Micro-Electromechanical Systems	L	T	P	C
		3	0	0	3
Pre-requisite	**BMEE201L, BMEE209L, BMEE209P**	**Syllabus version**			
		1.0			

Course Objectives

1. To introduce the elements of MEMS and develop understanding on importance of scaling laws effect in phenomenon.
2. To introduce different materials, fabrication process and micro manufacturing techniques used in MEMs.
3. To outline the basic principles and operation of micro sensors and micro actuators, and introduce essential components of microfluidic components.
4. To highlight the application of MEMS devices in addressing social needs and integration with emerging technology areas.

Course Outcome

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

1. Comprehend the MEMS importance and diverse application, and related engineering concepts.
2. Understand the importance of scaling laws in MEMS, and predict the scaling effect in related phenomenon.
3. Evaluate and select appropriate material for MEMS devices and fabrication process.
4. Select appropriate fabrication and micro manufacturing process, and develop process sequence for building MEMS devices.
5. Grasp the functions of micro-sensors and actuators used in diverse applications.
6. Perceive the application of physical, chemical, biological and engineering principles in the design and operation of micro devices and roles of MEMS devices for addressing societal needs and emerging technology areas.

Module:1	**Introduction to MEMS**	**5 hours**

History of MEMS development; Components of MEMS; Intrinsic characteristics of MEMS; Interdisciplinary nature of MEMS; Overview of typical MEMS Products; Applications of MEMS in industries – Automotive, Healthcare, Aerospace, Telecommunications, Industrial products, Consumer Products; Review of essential concepts – Electrical and Mechanical; Trends in MEMS – Technology, application and market.

Module:2	**Scaling laws in miniaturization**	**3 hours**

Introduction to Scaling – Need for scaling laws, Types of scaling laws; Motivation for miniaturization; Scaling in-geometry, rigid body dynamics-Trimmers force scaling vector, electrostatic forces, electromagnetic forces, electricity, fluid mechanics, heat conduction, heat convection, etc., Overview of MEMS design process.

Module:3	**Materials for MEMS**	**5 hours**

Single crystal silicon – crystal structure and atomic arrangements, extraction process; Silicon compounds – Silicon Carbide, Silicon Nitride, polycrystalline silicon; Silicon piezo-resistors; Gallium Arsenide; Germanium; Metals-Gold, Silver, Copper, Aluminium; Polymer materials-SU-8, PDMS, Liquid crystal polymers, PMMA, Polyaimide, Parylene, conductive polymers; Other materials-Quartz; Ceramics. Glass.

Module:4	**MEMS fabrication process and micro manufacturing**	**10 hours**

Microfabrication processes-Photolithography, Ion implantation, Diffusion, Oxidation, Physical Vapour Deposition (PVD), Chemical Vapour Deposition (CVD), Deposition by epitaxy; Bulk micro manufacturing- Etching, Isotropic and Anisotropic etching, Wet etching, Etchants, Etch stop, Dry etching, Plasma etching, Deep reactive Ion Etching, Process steps with case studies; Surface micromachining- Process steps with examples, Mechanical issues, , LIGA: Advantages and limitation, Process steps with case studies, Materials, SLIGA; Soft lithography and its application; Wafer bonding; Microsystems packaging.

Module:5	**Micro sensors and Micro-actuators**	**6 hours**

. Micro sensors: Elements and characteristics; Basic principles and operation of different

types of micro sensors - surface acoustic wave micro sensors, bio-medical sensors, bio sensors, chemical sensors, optical Sensors, pressure sensors, thermal sensors, acceleration sensors. Micro actuators: Elements and characteristics; Basic principles and working of different types micro actuator-Electrostatic actuators, Piezoelectric actuators, Parallel plate capacitor actuator, Thermal actuators, Magnetic actuators. SMA actuators,		
Module:6	**Microfluidics**	**6 hours**
Introduction; Motivation for microfluidics; Overview of fluid mechanics – Viscosity, surface tension, capillary rise, flow types, Reynolds number; Components of a micro fluidic system – Channels, Mixers, Sensors, reservoir; Methods of fluid movement in channels; Fabrication process of microfluidics components with examples		
Module:7	**Case studies**	**8 hours**
Application of MEMS devices for – Smart home, visually impaired, surgery, Brain sensors, Self-driving car, Wearable sensors, pollution monitoring and other emerging areas/products; Modelling and analysis of MEMs devices.		
Module:8	**Contemporary Issues**	**2 hours**
	Total lecture hours:	**45 hours**

Text Books	
1.	Tai-Ran-Hsui, MEMS & Microsystems: Design and Manufacture, Wiley,Online,edition ,2020
2.	Chang Liu, Foundations of MEMS,Pearson,2012
Reference Books	
1.	Nadim Maluf and Kirt Williams (2004), An Introduction to Micro electro mechanical Systems Engineering, Second Edition, Artech House
2.	Stephen R.Santuria (2001), Microsystem Design, Springer Science-Business Media Inc.
3.	Minhang Bao (2005), Analysis and Design Principles of MEMS devices, Elsevier
4.	Marc J. Madou (2002), Fundamentals of Micro Fabrication: The Science of Miniaturization, Second Edition, CRC
5.	Gad-EL-Hak The MEMS Handbook CRC Press 2002-modified 2019
6.	V.K.Atre, Ananthasuresh, K.J.Vinoy. S.Gopalakrishnan,K.V.Bhat, Micro and Smart Systems,(WIND), 2010

Mode of Evaluation: CAT / Written assignment / Quiz / FAT / Seminar / Case studies			
Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE316E	Industrial Robotics	L	T	P	C
		3	0	2	4
Pre-requisite	BMEE207L, BMEE207P	Syllabus version			
		1. 0			

Course Objectives

1. To impart knowledge on the fundamentals of industrial robot types and their positioning systems.
2. To impart the mathematic foundation of robot manipulators, trajectory planning, and control.
3. To provide knowledge to design, fabricate, and control the manipulator robotics with gripper system.

Course Outcome

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

1. Specify various types of Robots for industrial applications with sound knowledge of the positioning system.
2. Represent the rigid body motion and its transformation mathematically.
3. Solve and model the kinematics equations of various manipulator configurations.
4. Solve and model the differential motion and dynamics of various manipulator configurations.
5. Compute the collision-free trajectory planning.
6. Identify the challenges and control problems in manipulator robotics.
7. Design and fabricate the gripping system for selected robot applications.

Module:1	Anatomy and Positioning System of robot	5 hours

Introduction to Industrial robotics – Manipulator configuration (examples with product specification): two link planar, Cartesian, Cylindrical, Polar, Articulated, SCARA, Delta and Stewart platform – CAD modelling of manipulator configuration (students by own) – Analysis of Positioning Systems (Actuator + Gear reduction unit): open-loop study with stepper motor, Closed-loop study with servo motor – Precision in Positioning system: control resolution, accuracy and repeatability– Harmonic drives in robotic manipulators.

Module:2	Configuration space and Rigid body motion	4 hours

DOF – C-space: Topology and representation, velocity constraints – Rigid body Motion: Description of position, orientations and frames – Changing descriptions from frame to frame (Homogeneous matrix) – Operation: Translation, rotation (rotation and Euler matrix) and transformation – Denavit-Hartenberg representation – Numerical.

Module:3	Robot kinematics	8 hours

Forward and Inverse kinematics: Two link planar (RR), cylindrical robot (RPP) and articulated arm (RRR) with Modelling and 3D virtual realization – other manipulators configurations: 6DOF articulated robotic arm, SCARA and Stewart platform.

Module:4	Differential motion and dynamics of robot	8 hours

Angular velocity – Velocity kinematic: Jacobian for 2 link planar (RPP), cylindrical robot (RPP) and articulated arm (RRR) – Forward and inverse dynamics of simple pendulum, double stage pendulum and two link planar.

Module:5	Manipulator Trajectory planning	7 hours

Path Planning – Trajectory planning – Classification of Trajectory planning - Join space schemes: Cubic polynomials – Cubic polynomials via point – Higher order polynomials – Linear function with parabolic blends – Cartesian space schemes: Geometric problems with Cartesian paths – two link planar trajectory planning.

Module:6	Manipulator control	5 hours

Linear control of manipulator: second-order linear system, control of second order system trajectory following control, disturbance rejection – Non-linear control: Control problems in manipulators, multi-input and multi-output control system – Lyapunov stability analysis –

adaptive control.		
Module:7	**Gripper Design**	**6 hours**
Gripper definitions and conceptual basics – Grasping in Natural system – Prehension strategy – Gripping procedure, conditions and force – Gripper Flexibility – Gripper classification – Requirements and gripper characteristics – Planning and selection of grippers – Impactive mechanical grippers: Single and multi-grippers– Ingressive gripper – Astrictive prehension – Special grippers: Microgrippers, soft grippers, compliance gripper.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book	
1.	Craig, John. J. (2008), Introduction to Robotics: Mechanics and Control, Second Edition, Pearson Education, New Delhi.
Reference Books	
1	Bruno Siciliano (2010) Robotics Modelling, Planning and Control, Springer-Verlag London Limited 2010.
2	Mikell P. Groover, Mitchell Weiss (2013), Industrial Robotics Technology – Programming and Applications, McGraw Hill Edition 2.
3	F. C. Park and K. M. Lynch (2017), Introduction To Robotics Mechanics, Planning, And Control, First Edition, Cambridge University Press.
4	Gareth J.Monkman, Stefan Hesse (2007) Robot Grippers, WILEY-VH Verlag GmbH & Co, KGaA, Weinheim.
Mode of Evaluation: CAT / written assignment / Quiz / FAT	

Indicative Experiments		
1.	Develop the code to realize the Forward kinematics equation for the selected manipulator configuration. Matlab: Minimum 2DOF to Maximum of 4DOF.	3 hours
2.	Develop the code to realize the Inverse kinematics equation for the selected manipulator configuration. Matlab: Minimum 2DOF to Maximum of 4DOF	3 hours
3.	Develop the code to realize the trajectory planning of single link arm using cubic polynomial equation and plot the response of position, velocity and acceleration. Matlab/Python	3 hours
4.	Develop the code to realize the trajectory planning of single link arm using linear function with parabolic blend (LFPB) and plot the response of position, velocity and acceleration. Matlab/Python	3 hours
5.	Realization of selected manipulator configuration in the virtual environment. [Coppeliasim, gazebo simulator, Sim-Mechanics (Matlab-Simulink) and any other virtual simulator].	3 hours
6.	Teach the industrial robot with appropriate Tool Centre Point (TCP) valve and USER Frame valve for the given tool and targeted location using three point teaching approach. [Simulation/Robo machine].	3 hours
7.	Program the Industrial robot to execute a 2D profile in a selected plane by recording the vertices of the 2D geometry profile using target teaching approach. **[**Simulation/Robo machine].	3 hours
8.	Program the Industrial robot to execute a 2D profile in a selected plane using position register, offset and other special functions (Target calculation approach). **[**Simulation/Robo machine].	3 hours
9.	Interface an End of Arm Tool (EOAT) for the selected industrial robot and establish the Digital Input connection to communicate the EOAT. **[**Simulation/Robo machine].	3 hours
10.	Design the robotic work cell for the given application along with all system integration components. Estimate the cycle time info with task profile. **[**Simulation only].	3 hours
	Total Laboratory Hours	**30 hours**

Textbook			
Lab Manual prepared by the Faculty member.			
Mode of assessment: Viva-voce examination, Lab performance & FAT			
Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE317L	Mechatronic Systems Design	L	T	P	C
		3	0	0	3
Pre-requisite	**BMEE210L, BMEE210P**	**Syllabus version**			
		1.0			

Course Objectives

1. To emphasize an understanding of multi-disciplinary study dealing with the integration of elements, mechanical devices, actuators, sensors, electronics, and intelligent controllers.
2. To impart knowledge of mechatronics device integration, conceptual design, analysis, modelling, synthesis, prototyping, validation, installation, and testing.
3. To raise an awareness and provide pertinent engineering methodologies and generate a know-how core in the integration of complex automation.

Course Outcome

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

1. Demonstrate the knowledge of basic concepts, applications, and elements of mechatronic systems.
2. Develop on integration of different hardware components of mechatronic systems.
3. Recommend to design the software that interacts with the hardware elements.
4. Familiarize with data acquisition and human machine interfaces.
5. Analyse the model-based design of mechatronics system.
6. Design mechatronics systems to solve real-world problems.

Module:1	**Introduction to Mechatronics**	**5 hours**

Introduction to Mechatronics system, Key elements, Mechatronics system design process, Types of design, Comparison between Traditional and Mechatronics approach.

Module:2	**Elements of Mechatronics Systems**	**7 hours**

Hardware Components in Mechatronics systems, Mechanisms, Sensors, Actuators, Controllers – Power and Data transfer, signal conditioning and processing, Issues with interfacing and Troubleshooting.

Module:3	**Software Integration**	**6 hours**

Software for Mechatronics, Needs and implementation, Control and Intelligence through Software integration for embedded controllers, Issues with software design and Troubleshooting.

Module:4	**Realtime System Interfacing**	**6 hours**

Introduction to data acquisition- Interface and communication standards, User interfaces in automation, Real time interfacing, Human Machine Interfaces, Fundamentals of graphical programming, DAQ Interfacing and Control systems design.

Module:5	**Model based design and development**	**5 hours**

Modelling and Simulation, Model based Design techniques, Hardware-in-loop Simulations – Code Implementation and Automatic Code generation – Validation and Verification - Installation and testing.

Module:6	**Case Studies- I**	**7 hours**

Case studies in design and integration of components in mechatronics systems such as industrial robot, motion control systems, Embedded vehicle control system, 3D printers, micro-robot, mechatronic control in automated manufacturing, machine tool control systems, automated dispensing systems.

Module:7	**Case Studies- II**	**7 hours**

Cyber-Physical Systems- home security using IoT, ADAS systems, electronic stability control, Online surface measurement using image processing, automated testing and inspection systems, bio mechatronics, bionic arm, waste management, precision agriculture-crop monitoring and analysis.

Module:8	**Contemporary issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Books

1. Bolton W., Mechatronics – Electronic Control Systems in Mechanical and Electrical

	Engineering, 2018, 7th Edition, Pearson Education.			
2.	Robert H. Bishop, The Mechatronics Handbook, 2017, CRC Press.			
Reference Books				
1.	Nitaigour Premchand Mahalik, Mechatronics Principles, Concepts and Applications, 2015, McGraw Hill Education, New Delhi.			
2	Peter Hehenberger, David Bradley, Mechatronic Futures: Challenges and Solutions for Mechatronic Systems and their Designers, 2016, Springer International.			
3.	Andy Judge, Mechatronics and Dynamic System Design, 2019, 3rd Edition.			
4.	Devadas Shetty, Richard A.Kolk, Mechatronics System Design, 2012, PWS Publishing Company.			
Mode of Evaluation: CAT, Written assignment, Quiz, FAT				
Recommended by Board of Studies		09-03-2022		
Approved by Academic Council		No. 65	Date	17-03-2022

BMEE318E	Fluid Power Systems	L	T	P	C
		3	0	2	4
Pre-requisite	**BMEE204L, BMEE204P**	**Syllabus version**			
		1.0			

Course Objectives

1. To introduce fundamental principles of fluids for power transmission.
2. To impart constructs to design fluid power circuits for widespread industrial applications.
3. To realize the maintenance and troubleshooting procedures for fluid power systems.

Course Outcomes

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

1. Demonstrate the fundamental concepts governing fluid power.
2. Analyse the functions of hydraulic and pneumatic components.
3. Design fluid power circuits for industrial applications.
4. Develop electro-hydraulic and electro–pneumatic systems for an industrial application.
5. Examine the maintenance and identify faults in fluid power systems.
6. Demonstrate fluid power circuits and analyse the experimental data.

Module:1	**Basics of fluid power system and fluid characteristics**	**5 hours**

Introduction to fluid power systems - structure, advantages, limitations, and applications. Properties of fluids, governing laws. Gas laws - Vacuum. Distribution of fluid power and energy losses. ISO symbols for fluid power system.

Module:2	**Hydraulic and Pneumatic Power Sources**	**6 hours**

Hydraulic pumps - classification, characteristics, and pump selection. Flow, pressure, drive torque and power - hydraulic power Pack - pump efficiency. Air compressors - types and performance - sizing. Vacuum pumps. Pneumatic conditioners: filters, regulators, lubricators, mufflers, and air dryers. Selection of prime movers for fluid power systems.

Module:3	**Fluid power actuators and control valves**	**6 hours**

Fluid power actuators: cylinders and motors - selection and characteristics. Control valves: pressure, flow, and direction control - electronic control components - valve configurations - selection criteria.

Module:4	**Basic fluid power circuits**	**7 hours**

Hydraulic circuits: control of single acting and double acting cylinder, regenerative, synchronizing, sequencing, and pressure intensifier circuits. Pneumatic circuits: meter-in, meter-out and bleed-off circuits, fail-safe, and counter-balance circuits.

Module:5	**Design of fluid power circuits**	**7 hours**

Design of hydraulic and pneumatic circuits: Cascade and sequential logic circuit - Compound circuit – Step counter circuit. Telescopic cylinder - Accumulator circuits.

Module:6	**Electro-hydraulic and electro-pneumatic systems**	**6 hours**

Electrical control of pneumatic and hydraulic circuits: relays, timers, counters, programmable logic controller, and servo systems - Applications.

Module:7	**Maintenance of fluid power systems**	**6 hours**

Installation and maintenance of hydraulic and pneumatic systems - pressure compensation - temperature effects - fault finding - safety procedures.

Module:8	**Contemporary issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book

1. John S. Cundiff, Michael F. Kocher, Fluid Power Circuits and Controls: Fundamentals and Applications, 2019, Second Edition. CRC Press.

Reference Books

1. Daines, J. R., Daines, M. J, Fluid Power: Hydraulics and Pneumatics, 2019, United States: Goodheart-Willcox Company, Incorporated.

2.	Anthony Esposito, Fluid Power with Applications, India: Dorling Kindersley, 2014.			
Mode of Evaluation: CAT, Written assignment, Quiz, FAT				
Indicative Experiments				
1.	Study of hydraulic/pneumatic components and standard symbols			
2.	Development of single cylinder hydraulic circuit with simulation software			
3.	Development of single multi-cylinder hydraulic circuits with simulation software			
4.	Development of electro-hydraulic circuits with simulation software			
5.	Development of single cylinder pneumatic circuits with simulation software			
6.	Development of multi-cylinder pneumatic circuits with simulation software			
7.	Development of electro-pneumatic circuits with simulation software			
8.	Development of PLC controlled fluid power circuits with simulation software			
9.	Design hydraulic circuits with single acting cylinder			
10.	Design hydraulic circuits with double acting cylinder			
11.	Design hydraulic circuits with hydraulic rotary actuator			
12.	Design of pneumatic circuits with multi cylinders			
13.	Design of multi-cylinders sequencing with pilot control valves			
14.	Design and control of multi-cylinders sequencing with PLC processor			
15.	Design fluid power circuits for an industrial application			
			Total Laboratory Hours	**30 hours**
Textbook				
Lab manual prepared by the Faculty member				
Mode of assessment: Continuous assessment, FAT, Oral examination				
Recommended by Board of Studies	09-03-2022			
Approved by Academic Council	No. 65	Date	17-03-2022	

BMEE319E	Advanced Materials Characterization Methods	L	T	P	C
		3	0	2	4
Pre-requisite	**BMEE209L, BMEE209P**	**Syllabus version**			
		1.0			

Course Objectives

1. To provide insight into the structural information using various characterization technique.
2. To understand theory and practice of diffraction phenomena.
3. To understand the various characterization techniques available for metallic materials.

Course Outcomes

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

1. Describe the various specimen preparation methods for microscopic and spectroscopic techniques.
2. Explain the diffraction phenomena and indexing of materials.
3. Demonstrate different structural information by various microscopy.
4. Elucidate the operation of SEM, TEM and EBSD.
5. Explain the advanced characterization techniques such as *insitu* and other combined techniques.
6. Apply advanced lighting, thermal, chemical and imaging techniques for materials characterization.

Module:1	**Structural Analysis**	**5 hours**
Specimen Preparation Techniques – Polishing and Etching, Development of microstructure, Grain Size Measurements, Quantitative Metallography.		
Module:2	**Diffraction and Imaging**	**7 hours**
Crystallography, Bragg's Law, Radiation Interaction and Response Signals, X-Ray Diffraction, XRD Analysis, Phase Analysis, Powdered and Textured Diffraction Fundamentals of Imaging: magnification, resolution, depth of field and depth of focus, aberration and astigmatism; X-Ray reflectivity, Edward sphere, Kikuchi pattern, Indexing, Texture of materials.		
Module:3	**Microscopy and Spectroscopy**	**7 hours**
Basic principles of operation (optical, SEM, AFM, TEM), Principles of Optical and Electron Microscopy, Estimation and comparison of grain size, grain boundary area through various microscopes, Volume fraction, Structure revealed through various microscopy and comparison. Basic principles of operation of EDS, WDS, EPMA, and ToF SIMS.		
Module:4	**Advanced Characterization Techniques**	**7 hours**
Introduction to Orientation Imaging Microscopy (OIM), 3-Dimensional FIB/EBSD, Insitu testing facilities, Nano indentation, Combined spectroscopy and microscopy techniques, Temperature related measurement (TG+DTA) and DSC, Thermomechanical physical simulator, Gleeble, Neutron diffraction techniques.		
Module:5	**Surface Properties**	**6 hours**
Microscopic Methods for Characterizing Surface Properties, Spectroscopic Methods for Characterizing Surface Properties.		
Module:6	**Electrical Characterization Techniques**	**5 hours**
Electrical resistivity in bulk and thin films, Hall effect, Magnetoresistance.		
Module:7	**Magnetic Characterization Techniques**	**6 hours**
Introduction to Magnetism, Measurement Methods, Measuring Magnetization by Force, Measuring Magnetization by Induction method. Types of measurements using magnetometers: M-H loop, temperature dependent magnetization, time dependent magnetization, Measurements using AC susceptibility, Magneto-optical Kerr effect, Nuclear Magnetic Resonance, Electron Spin Resonance.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Books				
1.	Materials Characterization, 2019, Volume 10, ASM Handbook.			
2.	Dalip Singh Verma, Latif Ullah Khan Shalendra Kumar, Sher Bahadar Khan, Handbook of Materials Characterization, , 2018, Springer International Publishing.			
Reference Books				
1.	Ranganathan N., Materials Characterization Modern Methods and Applications, 2016, CRC press.			
Mode of Evaluation: CAT, Written assignment, Quiz, FAT				
Indicative Experiments				
1.	Metallographic preparation of metallic specimens			
2.	Grain Size determination by linear intercept methods			
3.	Observation of structures by optical microscopy and Scanning Electron Microscopy			
4.	Demonstration and Indexing of XRD peaks			
5.	XRD peak identification by various methods: manual, database and software			
6.	Study of fracture surface of materials by Scanning Electron Microscopy			
7.	Image formation (bright and dark) and interpretation by Scanning Electron Microscopy			
8.	Demonstration of Nano Indentation and X-Ray Diffraction Residual stress			
9.	Demonstration of Spectroscopic analysis (ICPMS and XPS)			
10.	Demonstration of Transmission Electron Microscopy and Electron Backscattered Diffraction			
			Total Laboratory Hours	**30 hours**
Text book				
Lab manual prepared by the Faculty member				
Mode of assessment: Continuous assessment, FAT, Oral examination				
Recommended by Board of Studies	09-03-2022			
Approved by Academic Council	No. 65	Date	17-03-2022	

BMEE320L	Refrigeration and Air-Conditioning	L	T	P	C
		3	0	0	3
Pre-requisite	**BMEE303L, BMEE303P**	**Syllabus version**			
		1.0			

Course objectives

1. To teach the principles of air and vapour refrigeration systems.
2. To make the students understand the thermodynamics of various refrigeration systems.
3. To enable the students to design summer and winter air conditioning systems.
4. To design various components and controls of refrigeration systems.

Course outcome

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

1. Analyse the performance of air cycle refrigeration systems.
2. Analyse the performance of vapour compression refrigeration system for various applications.
3. Demonstrate system components and controls of refrigeration and air-conditioning systems.
4. Compare refrigerants and system applications.
5. Analyse the performance of different air-conditioning systems.
6. Apply the knowledge of psychrometry for calculating cooling and heating loads.

Module:1	**Introduction**	**8 hours**

Review of fundamentals of fluid mechanics and heat transfer. Basic refrigeration systems – vapour compression refrigeration system (VCRS), vapour absorption refrigeration system (VARS), air cycle refrigeration system, steam jet refrigeration system, thermoelectric system and vortex tube system. Joule thompson coefficient and inversion temperature. Reversed carnot cycle and its limitations, Bell-Coleman, joule or reversed brayton cycle. Aircraft refrigeration cycles.

Module:2	**Vapour compression refrigeration systems**	**6 hours**

Standard vapour compression refrigeration cycle, actual VCRS, superheat horn and throttling losses, superheating and subcooling in VCRS. Multi-stage VCRS – multi-pressure systems, multi-evaporator systems, cascade systems. LiBr – H_2O based VARS and NH_3 – H_2O based VARS.

Module:3	**Refrigeration system components**	**6 hours**

Classifications of compressors, performance characteristics of reciprocating compressors. Classifications of evaporators & condensers and their characteristics. Expansion devices – capillary tube and thermostatic expansion valves.

Module:4	**Refrigerants**	**5 hours**

Classification of refrigerants, refrigerant properties, water and lubricating oil compatibility, environmental impact, montreal / kyoto protocols, eco-friendly refrigerants. Refrigeration tools – evacuation and charging unit, recovery and recycling unit, vacuum pumps.

Module:5	**Psychrometry and air-conditioning systems**	**6 hours**

Composition of moist air, psychrometry – properties, processes and chart. Relation between psychrometric properties, combined heat and mass transfer processes, adiabatic mixing, evaporative cooling, desiccants.

Summer air-conditioning systems (hot –wet weather and hot-dry weather), winter air-conditioning systems, all year air-conditioning systems.

Module:6	**Cooling-heating load estimations and control systems**	**7 hours**

Thermal comfort, infiltration and ventilation, winter heating load estimations, summer cooling load estimations, RSHF, bypass factor. Applications with specified ventilation air quantity, use of ERSHF and GRSHF, application with low latent heat loads and high latent heat loads. Control Systems – selection, types and devices. control based on space temperature,

outside temperature, cooling-heating medium.		
Module:7	**Applications of refrigeration and air-conditioning**	**5 hours**
Food processing and preservation, freezing and drying, cold storage, refrigerated containers and trucks. Case studies.		
Module:8	**Contemporary issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Books	
1.	Arora C.P, Refrigeration and Air-Conditioning, 2020, Edition:4, McGraw Hill.
2.	Eugene Silberstein, Refrigeration and Air Conditioning Technology, 2016, Edition:9, Delmar publications.
Reference Books	
1.	Frank Kreith, Shan K Wang and Paul Norton, Air Conditioning and Refrigeration Engineering, 2019, Edition:1, CRC Press.
2.	Andrew D. Althouse, Carl H. Turnquist, A.F. Bracciano, D.C. Bracciano, G.M. Bracciano, Modern Refrigeration and Air Conditioning, 2017, Edition:20, Goodheart-Willcox Publications.

Mode of Evaluation: CAT, Digital Assignment, Quiz, FAT			
Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE321L	Composite Materials	L	T	P	C
		3	0	0	3
Pre-requisite	**BMEE202L, BMEE202P**	**Syllabus version**			
		1.0			

Course Objectives

1. Provide students a basic understanding and uses of composite materials, develop skill to understand different composites manufacturing methods.
2. To enable the students to find physical and mechanical properties of composites using micromechanics and experimental methods.
3. Illuminate the knowledge and skills to design the composite laminate subjected to different in-plane loading conditions by applying the mechanics and failure theories of the composite materials.

Course Outcome

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

1. Analyse the various fabrication techniques and select suitable method for given application.
2. Evaluate material properties of composite material using micromechanics.
3. Calculate displacement, strain and stresses in composite laminates.
4. Propose the construction of laminate for given loading conditions.
5. Examine the failure of laminate using different failure theories.
6. Evaluate experimentally the material properties of the composite laminates.

Module:1	**Introduction**	**5 hours**

Definition, Classification of Composites, Applications of Composites Reinforcing Fibers: Synthetic fiber, Natural Fibers; Matrix Materials: Polymers such as Thermosetting and Thermoplastic Polymers, Metals and ceramics.
Fabrication of PMC's, MMC's C/C and CMC's Composites.

Module:2	**Micromechanics of Unidirectional Composites**	**6 hours**

Introduction, Micromechanical Analysis of a Lamina-Volume and Weight Fractions and void content Prediction of Elastic constants using Micromechanics, Ultimate Strengths of a Unidirectional Lamina, Coefficients of thermal and Moisture expansion.

Module:3	**Macro mechanical Analysis of Lamina**	**8 hours**

Introduction, Stress–Strain Relations for Orthotropic Materials, Transversely Isotropic Material, Isotropic Material, Transformation of Engineering Constants, Hooke's Law and Stiffness and Compliance Matrices: General Anisotropic Material, Transformation of Stress and Strain, Orthotropic Material under Plane Stress Compliance Tensor and Compliance Matrix, Relations between Engineering Constants and Elements of Stiffness and Compliance Matrices, Transformation of Stiffness and Compliance Matrices.

Module:4	**Analysis of Laminated Composites**	**8 hours**

Classical Lamination Theory (CLT): Introduction, Laminate Displacements and Strains, Laminate Stresses, Resultant Forces and Moments, Laminate Constitutive Relations, Laminate Description System Design, Construction and Properties of Laminates: Symmetric Laminates Unidirectional, Cross-Ply, and Angle-Ply Laminates Quasi-Isotropic Laminates

Module:5	**Theories of Failures**	**6 hours**

Strengths of an Orthotropic Lamina, Failure of Laminates, Maximum-Stress Theory, Maximum-Strain Theory, Maximum-Work Theory, Tsai-Hill's Failure Criterion for Composites. Tensor Polynomial (Tsai-Wu) Failure criterion. Initial Failure Laminate Analysis after Initial Failure, Hygrothermal Stresses in Laminates

Module:6	**Experimental Characterization of Composites**	**4 hours**

Introduction, Measurement of Physical Properties, Density, Constituent Weight and Volume Fractions, Void Volume Fraction, Thermal Expansion Coefficients, Moisture Absorption and Diffusivity Moisture Expansion Coefficients

Module:7	**Mechanical Properties and Damage assessment of composites**	**6 hours**
Properties in Tension, Properties in Compression, In-Plane Shear Properties, Flexural Properties, Interlaminar Shear Strength and Fracture Toughness, In-Plane Fracture Toughness Tests, Dynamic properties, Impact Tests, Tests for Aerospace Applications, Damage Identification Using Non-destructive Evaluation Techniques, Ultrasonics Acoustic Emission X-Radiography Thermography Laser Shearography		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

TextBook	
1.	Autar K. Kaw, Mechanics of Composite Materials, 2006, 2nd Edition, Taylor & Francis
Reference Books	
1.	Robert Millard Jones Mechanics of Composite Materials 2nd Edition CRC Press.
2.	Jack R. Vinson, Robert L. Sierakowski The behavior of structures composed of composite materials, 2006, Springer, Dordrecht
3.	M. W. Hyer, Scott R. White Stress Analysis of Fiber-reinforced Composite Materials, 2009 DEStech Publications.

Mode of Evaluation: CAT, Written assignment, Quiz, FAT			
Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE322L	Engineering Failure Analysis	L	T	P	C
		3	0	0	3
Pre-requisite	**BMEE202L, BMEE202P**	**Syllabus version**			
		1.0			

Course Objectives:

1. To familiarize the importance of failure analysis of mechanical components.
2. To provide insight on various material characterization tools.
3. To impart knowledge on design against failures and skills required for failure analysis.

Course Outcome:

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

1. Differentiate types of failure of engineering materials and their characteristic features.
2. Apply various theories of failure to the components subjected to multidirectional loading.
3. Determine the life of a mechanical component subjected to variable loading.
4. Design for failure against corrosion, wear, creep and fracture.
5. Develop expertise on the experimental techniques and simulations used for failure analysis of various components and interpret the probable reasons for failure.
6. Apply concepts of statistics for failure analysis.

Module:1	**Analysis of a Mechanical Failure**	**4 hours**
Preliminary Analysis, Microscopic Analysis-Fractography, Mechanisms of Damage and Failure, Case-studies involving failures.		
Module:2	**Statistical Analysis of Failure**	**6 hours**
Industrial Engineering Tools, Basics of statistics, Normal, Weibull and log-normal distribution, Statistical modelling of failure		
Module:3	**Mechanical aspects of Failure**	**7 hours**
Tensile Deformation of Ductile Metal, Combined stress, Principal stresses, Theories of failure, Tri-axial stresses and constraint, Plane stress, Plane strain, Stress concentration factors and notch sensitivity. Shock and impact loading.		
Module:4	**Fatigue**	**7 hours**
Loading under high cycle fatigue conditions, Test methods, S-N curves, endurance diagrams, influence factors - Low cycle fatigue, fretting fatigue; Fatigue design for combined stress; cumulative damage and life prediction, statistical interpretation of fatigue test data.		
Module:5	**Environmentally-Induced, Temperature Failures**	**7 hours**
Failures related to corrosion, hot corrosion and stress corrosion cracking; Damages due to hydrogen; Creep of materials, service failures during high temperature; Failures due to wear.		
Module:6	**Fracture Mechanics**	**7 hours**
Fracture processes, Ductile and brittle fracture, Effect of strain rate and temperature. Fracture mechanics and Failures, Linear elastic fracture mechanics, fracture mechanics principles in design practice, Elastic Plastic Fracture Mechanics, Examples of crack-growth Analysis for cyclic loading.		
Module:7	**Damage and Failure Mechanisms in Machinery**	**5 hours**
Modes of Failure in Shafts, Failures of Bearings, Failure of Transmission Elements: Gears and Coupling, Failure of Fasteners, Bolts, and Other Threaded Elements, Characteristic Failures in Turbo Machines		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book

1	Jose Luis Otegui, Failure Analysis, Springer International Publishing, Switzerland, 2014

Reference Books

1.	Jones. D.R.H, , Failure Analysis Case Studies II,2001, ELSEVIER SCIENCE Ltd, UK
2	Best Practice Guide on Statistical Analysis of Fatigue Data, Schneide C.R.A and

	Maddox S J, 2015, TWI, Granta Park, Great Abington, Cambridge, UK			
3	George. E. Dieter, Mechanical Metallurgy, 2017, 3rd Edition, McGrawHill,			
4	Anderson T.L. Fracture Mechanics, 2005, 3rd Edition, CRC Press, Taylor & Francis Group,			
5	Suresh S, Fatigue of Materials, 1998(Print), 2nd Edition, Cambridge University Press 2012(Online)			
Mode of Evaluation: CAT, Written assignment, Quiz, FAT				
Recommended by Board of Studies		09-03-2022		
Approved by Academic Council		No. 65	Date	17-03-2022

BMEE323L	Gas Dynamics	L	T	P	C
		3	0	0	3
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives

1. To introduce students to the basics of compressible flow, with a particular emphasis on a wide range of one-dimensional steady-flow problems.
2. To provide a thorough knowledge of supersonic flow characteristics such as shock waves and expansion fans, as well as their applications in practical systems.
3. To impart the knowledge of compressible flow through a constant area duct with friction.
4. To impart the knowledge of compressible flow through a constant area duct with heat transfer.
5. To familiarize the student with the numerical techniques suited for the design of supersonic nozzles.

Course Outcomes

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

1. Explain the features of compressible flows.
2. Design C-D nozzles by applying the concepts of isentropic compressible flow through variable area duct.
3. Analyse normal shock, oblique shock and their interactions in high-speed flows.
4. Apply the knowledge of Prandtl-Meyer expansion fan and shock-expansion theory.
5. Apply the concepts of Fanno flow and Rayleigh flow towards the design of combustion sections and jet pipes.
6. Apply the concept of Method of Characteristics for the design of jet engine nozzle.

Module:1	**Introduction to compressible fluid flow and control volume analysis**	**4 hours**

Introduction to compressible flow; Coefficient of Compressibility; Speed of sound; Mach number; Stagnation state; Critical state; Classification of flows based on Mach number- Physical significance of Mach number - Effect of Mach number on compressibility- Mach cone - Differences between Incompressible and Compressible flows. Properties of atmosphere - Conservation laws for mass, momentum and energy.

Module:2	**Isentropic Variable area flows**	**6 hours**

Isentropic flow through a variable area duct; Mach number variation; Area ratio as a function of Mach number; Impulse function; Mass flow rate through nozzles and diffusers; Phenomenon of choking; subsonic and supersonic designs; Effect of back pressure; Over-expanded and under-expanded Convergent-Divergent nozzles; T-S and H-S diagrams showing Nozzle and Diffuser process, Supersonic wind tunnels.

Module:3	**Normal shock waves**	**6 hours**

Flow with normal shock waves; Governing equations; Prandtl relation; Impossibility of rarefaction shock; Mach number downstream of the shock; Property variations across the shock; Strength of shock wave; Entropy change and stagnation pressure drop; Rankine-Hugoniot equation; Normal shock waves in Convergent-Divergent nozzles, Moving normal shock waves; Physical features of wave propagation; Shock tube and property relations.

Module:4	**Oblique Shock Waves**	**7 hours**

Oblique shock wave and its governing equations, θ-β-M relations, The Hodograph and Shock Polar, Supersonic flow over wedges and cones, Mach line, Attached and Detached shock, Reflections and interaction of oblique shock waves, Oblique shock wave applications.

Module:5	**Prandtl-Meyer Flows and Shock-Expansion Theory**	**6 hours**

Expansion waves, Prandtl-Meyer flow and its governing equations, Supersonic flow over convex and concave corners, Approximation of continuous expansion waves by discrete waves; Expansion fan interactions and reflections, Shock-Expansion Theory, Lift and drag calculation for Diamond airfoil.

Module:6	**Fanno and Rayleigh Flows**	**7 hours**
Fanno flow governing equations and their closed-form solutions; Fanno curves; Variation of flow properties with duct length; Frictional choking; Applications; Normal shocks in Fanno flow. Rayleigh flow equations; Rayleigh line; Variation of flow properties; Maximum heat transfer, thermal choking; Applications; Normal shocks in Rayleigh flow.		
Module:7	**Method of Characteristics**	**7 hours**
Philosophy of the method of characteristics, MoC for Planar flow, determination of the characteristic lines; compatibility equations, unit processes; Initial value line; Zones of influence and Dependence; Properties of characteristic regions; Centered expansions; Compression turns; Supersonic nozzle design		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book	
1.	Hodge B.K, Koenig C, Compressible Fluid Dynamics with personal computer applications, 2015, 1st edition, Pearson Education India.
Reference Books	
1.	Anderson J.D, Modern Compressible Flow: With Historical Perspective, 2021, 4th Edition. McGrawHill.
2.	Robert D. Zucker, Oscar Biblarz, Fundamentals of Gas Dynamics, 2019, 3rd Edition. John Wiley & Sons Inc.
3.	Oosthuizen, Patrick H, William E. Carscallen, Introduction to compressible fluid flow, 2013, CRC press.
4.	Saad M.A, Compressible Fluid Flow, 1993, 2nd ed. Upper Saddle River, NJ: Prentice-Hall.
5.	Rathakrishnan E, Gas Dynamics, 2017, 6th Edition. Prentice-Hall of India Pvt. Ltd.

Mode of Evaluation: CAT, written assignment, Quiz, FAT.			
Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE324E	Turbomachines	L	T	P	C
		2	0	2	3
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives

1. To familiarize the student with the working of various Turbo machines.
2. To impart the design-oriented knowledge related to various Turbo machines.
3. To develop problem solving abilities in Turbo machines.
4. To develop the skills of experimental design.

Course Outcome

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

1. Apply Euler's equation of energy transfer for turbomachines.
2. Demonstrate the aerofoil and cascade nomenclature.
3. Design the stages of centrifugal compressors and fans.
4. Analyse the stage parameters and performance characteristics of Axial Fans and Axial Compressors.
5. Evaluate the performance parameters of radial and axial turbines.
6. Experimentally determine the performance characteristics of both power absorbing and power generating turbo machines.

Module:1	**Energy Transfer**	**5 hours**

Definition and classification of turbo machines, Specific work - T-s and h-s diagram - Euler's equation of energy transfer - Losses - Various efficiencies - Effect of reheat - Preheat- Incompressible vs compressible turbomachines - review of incompressible turbomachines: Peloton, Francis, Kaplan Turbines and Centrifugal Pump.

Module:2	**Cascading**	**3 hours**

Aerofoil section - Cascading of compressor and Turbine blades - Energy Transfer in terms of lift and drag co-efficient for compressor and turbine blades - variation of lift - Deflection and stagnation pressure loss with incidence.

Module:3	**Centrifugal Compressors**	**4 hours**

Centrifugal Fans, Blowers and Compressors - Construction details – Inducers - Backward and Radial blades – Diffuser - Volute casing stage work - Stage pressure rise - Stage pressure co-efficient - Stage efficiency - Degree of reaction - Various slip factors.

Module:4	**Axial Fans**	**4 hours**

Axial flow Fans with various guide vane mechanisms: Stage with upstream guide vanes - Stage with downstream guide vanes - Stage with both upstream and downstream guide vanes- Stage velocity triangles - Flow coefficient - Stage pressure coefficient - T-S diagram and h-s diagram - Degree of reaction.

Module:5	**Axial Compressors**	**4 hours**

Axial Compressors with guide vane mechanisms - Stage velocity triangles - Flow coefficient- Stage pressure coefficient - Static pressure rise- T-S diagram and h-S diagram - Degree of reaction- work done factors - Stalling and Surging.

Module:6	**Radial Turbines**	**3 hours**

Inward flow radial flow turbine stages - Cantilever IFR turbine and 90 IFR Turbine - Stage velocity triangles - T-S diagram and h-s diagram - Degree of reaction.

Module:7	**Axial turbines**	**5 hours**

Axial turbine stages - Stage velocity triangles - T-s diagram and h-s diagram - work – Single stage Impulse Turbine - Speed ratio maximum utilization factor - Multistage velocity compounded impulse - Multi stage pressure compounded impulse - Reaction stage - Degree of reaction - Fifty percent reaction stages.

Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	Yahya S.M, Turbine, Fans and Compressors, 2017, 4th Edition, Tata McGraw-Hill.
2.	Dubey M, Prasad BVSSS, Nema A, Turbomachinery, 2019, 1st Edition, McGraw Hill Education (India).
Reference Books	
1.	Larry Dixon S, Cesare Hall, Fluid Mechanics and Thermodynamics of Turbomachinery, 2013, 7th Edition, Butterworth- Heinemann.
2.	Kadambi, Prasad, Energy conversion Vol.III- Turbomachines, 2011, New Age International.
3.	Korpela, Seppo A, Principles of Turbomachinery, 2019, John Wiley & Sons.
4.	Round, George Frederick, Incompressible Flow Turbomachines: Design, Selection, Applications and Theory, 2004, Elsevier.
Mode of Evaluation: CAT, written assignment, Quiz, FAT.	
Indicative Experiments	
1.	To study the performance of gear pump at different discharge pressures
2.	To study the Performance of Reciprocating Pump at different discharge pressures.
3.	To study the performance characteristics of Variable Speed Centrifugal Pump at different speeds and different discharge pressures.
4.	To study the performance of jet Pump at different discharge pressures.
5.	To study the performance of Submersible Pump at different discharge pressures.
6.	To study the performance of Kaplan turbines at constant speed, constant load and different vane and blade positions
7.	To study the performance of Francis Turbine at constant speed, constant load and different vane positions
8.	To study the impact of jet on vanes.
9.	To study the performance of a radial blower at different discharge pressures
10.	To study the performance of a constant speed Axial Fan
11.	To study the flow characteristics in a Boundary layer
Total Laboratory Hours	**30 hours**
Mode of assessment: Continuous assessment, FAT, Oral Examination.	
Recommended by Board of Studies	09-03-2022
Approved by Academic Council	No. 65 Date 17-03-2022

BMEE325L	Internal Combustion Engines	L	T	P	C
		3	0	0	3
Pre-requisite	**BMEE303L, BMEE303P**	**Syllabus version**			
		1.0			

Course Objectives

1. To introduce students to the working of spark ignition and compression ignition engines.
2. To provide an in-depth knowledge of combustion process and engine management systems used in the engines.
3. To teach students about the usage of alternative fuels for IC engines.
4. To enhance the understanding of students in engine emissions and control techniques.
5. To create awareness about engine testing and certification.
6. To impart knowledge on the modern trends in IC engines.

Course Outcome

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

1. Compare the merits and demerits of different types of fuel injection and power boosting systems used in IC engines.
2. Realize the combustion process in engines and the various sensors incorporated in the engine management systems.
3. Analyze the emissions from IC engines and its effects on human beings and environment.
4. Comprehend the various engine testing and certification process.
5. Identify and critically evaluate different types of alternative fuels for automotive engines.
6. Demonstrate the recent developments to enhance the performance of IC engines.

Module:1	**Engine configurations and mixture formation**	**8 hours**

Basic components and terminology of IC engines, working of four stroke/two stroke - SI/CI engine, classification and application of IC engines, engine performance and emission parameters. Mixture formation in spark ignition engines - spark ignition (SI) engine mixture requirements, feedback control carburetors, properties of fuel, injection systems, monopoint and multipoint injection, gasoline direct injection - air motion.

Mixture formation in compression ignition (CI) engines - direct and indirect injection systems, properties of fuel, fuel spray behaviour, spray structure, spray penetration and evaporation, air motion - injectors and nozzles.

Module:2	**Combustion process in SI and CI engines**	**6 hours**

Combustion stoichiometric, stages of combustion in SI and CI engines, knocking combustion in engines, features and design consideration of combustion chambers for engines, cyclic variations, heat release rate correlations.

Module:3	**Engine management systems**	**6 hours**

Fuel injection control, ignition timing control, lambda control, idle speed control, knock control, emission control, on-board diagnostics (OBD), open loop and closed loop control, basic sensor arrangement, types of sensors - oxygen sensor, fuel metering sensor, crank angle position sensor, MAF/MAP sensors, engine/vehicle speed sensor, detonation sensors, altitude sensor, throttle position sensor, engine oil/coolant temperature sensor.

Module:4	**Engine emissions and control**	**6 hours**

Pollutant - sources and types, effect on environment and human health, formation of NOx, hydrocarbon emission mechanism, carbon monoxide formation, particulate emissions, methods of controlling emissions - catalytic converters and particulate traps, selective catalytic reduction (SCR), diesel oxidation catalyst (DOC), emissions measurement.

Module:5	**Alternative fuels**	**6 hours**

Alcohol, hydrogen, natural gas, liquefied petroleum gas, producer gas, biodiesel, biogas - properties and production process, engine modifications, benefits and challenges as fuels, Indian and Euro norms.

Module:6	**Engines testing and certification**	**5 hours**
Engine dynamometer, engine instrumentation - fuel flow measurement, air flow measurement, temperature and pressure measurement, in-cylinder combustion pressure measurement-Fuel injection pressure measurement. Engine certification - regulations overview (ECE, EEC, FMVSS, BS, ADR), type approval and conformity of production, regulation norms for engine, engine power test, Indian driving cycle, vehicle mass emission, evaporative emission.		
Module:7	**Advanced engine technologies**	**6 hours**
Low heat rejection engines, learn burn engines, stratified charge spark ignition engine, low temperature combustion mode, solar powered vehicles, plasma ignition, electric/hybrid vehicles, fuel cell vehicles, six stroke engine concept, rotary engines.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book	
1.	Ganesan V, Internal Combustion Engine, 2017, 4th edition, Tata Mc-Graw Hill, New Delhi.
2.	Plint, Michael a Martyr, Anthony, Engine Testing : Theory and Practice, 2007, 3rd edition, SAE Publication.
Reference Books	
1.	John B. Heywood, Internal Combustion Engine Fundamentals, 2018. 2nd Edition, McGraw-Hill Education.
2.	Richard Stone, Introduction to Internal Combustion Engines, 2012, 4th edition, Palgrave Macmillan.
3.	Gasoline Engine Management, 2004, 3rd Edition, Robert Bosch, Bentley Publications.
4.	Diesel Engine Management, 2005, 4th Edition, Robert Bosch, Newness Publications.
4.	Colin R. Ferguson, Allan T. Kirkpatrick, Internal Combustion Engines: Applied Thermosciences, 2015, 3rd Edition, John Wiley.
Mode of Evaluation: CAT, written assignment, Quiz, FAT.	

Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE326L	Power Plant Engineering	L	T	P	C
		3	0	0	3
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives

1. To equip students about the working of various power generation units and steam cycles.
2. To educate the students about the steam generators, combustion and firing methods in order to make the fullest use of thermal power potentialities.
3. Enable the students to understand in detail about nuclear, gas turbine, diesel and renewable power plants, which play an important role in power generation.

Course Outcome

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

1. Demonstrate the various components and layouts of steam power plant.
2. Analyze the different types of steam generators and their subsystems.
3. Analyze the gas turbine, nuclear and diesel power plants.
4. Assess the selection and layout of different renewable power plants.
5. Evaluate the economic aspects of power plant installation and operation.

Module:1	**Introduction to Power Plants**	**4 hours**

Classification power plants - Current scenario of national and global power generation, per capita energy consumption - Energy trilemma index - Climate change - Carbon capture and storage.

Module:2	**Steam Power Plant**	**7 hours**

Site selection, Components and Layouts - Coal handling and preparation - Combustion equipment and firing methods - Mechanical stokers - Pulverized coal firing systems - Cyclone furnace - Ash handling systems- Dust collection - Electrostatic precipitator- Fabric filter and Bag house - Chimney draught systems.

Module:3	**Steam Generators and heat exchangers**	**6 hours**

Vapor power cycles - Steam Generators - Classification of Boilers: Fire tube and Water tube boilers, High pressure and Supercritical boilers - Positive circulation boilers - Fluidized bed boiler - Waste heat recovery boiler.

Heat Exchangers: Feed water heaters - Super heaters - Reheater - Economizer - Condenser - Cooling tower.

Module:4	**Nuclear Power Plants**	**7 hours**

Site selection, Principles of nuclear energy - Energy from nuclear reactions - Indian nuclear programme. Components and Layout, Thermal reactors: Boiling water reactor - Pressurized water reactor- Pressurized Heavy Water Reactor - Gas cooled reactor - High temperature gas cooled reactor - Fast breeder reactor -reactor materials - Radiation shielding- Nuclear waste disposal.

Module:5	**Gas Turbine and Diesel Power Plants**	**8 hours**

Gas Turbine plant: Site selection, Components and Layout, Open and closed cycles - Intercooling - Reheating and Regenerating - Combined cycle power plant, Cogeneration plants.

Diesel power plant: Site selection, Components and Layout, Subsystems: starting and stopping, air intake and exhaust systems - Lubricating and Cooling systems - Constraints in operating range.

Module:6	**Renewable power plants**	**6 hours**

Hydroelectric power plant: Site selection, Components and Layout, Estimation of power potential, Classification of Hydro - electric power plants- Selection of turbines- Governing of turbines. Introduction to solar, wind, tidal and geo-thermal power plants.

Module:7	**Economics of Power Plants**	**5 hours**

Terminologies in power plant economics - Load curves - Cost of electric energy generation

-Energy rates - Types of tariffs – Payback period- Affordable and clean energy.				
Module:8	**Contemporary issues**			**2 hours**
	Total Lecture hours:			**45 hours**
Text Books				
1.	El-Wakil M.M, Power Plant Technology, 2017, 1st Edition, Tata McGraw-Hill Publishing Company Ltd., New Delhi.			
2.	Nag P.K, Power Plant Engineering: Steam and Nuclear, 2017, 4th Edition, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2017.			
Reference Books				
1.	Hegde R.K, Power Plant Engineering, 2015, 1st edition, Pearson India Education services (P) Ltd., Noida, India.			
Mode of Evaluation: CAT, written assignment, Quiz, FAT.				
Recommended by Board of Studies		09-03-2022		
Approved by Academic Council		No. 65	Date	17-03-2022

BMEE403L	Design of Jigs Fixtures and Press Tools	L	T	P	C
		3	0	0	3
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives:

1. To impart knowledge on the principles of jigs and fixtures design, locating principles, locating elements and clamping Devices.
2. To design and analyze Jigs, Fixtures and dies for press working.
3. To select appropriate work holding devices for various applications.

Course Outcome:

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

1. Justify the requirements of jigs and fixtures for manufacturing, testing and assembly.
2. Design and develop locating and clamping systems for the given component based on geometrical and dimensional features.
3. Design and develop jigs fixtures, press tools and forming dies for various manufacturing processes.
4. Design of smart work holding for industrial applications.
5. Suggest and design appropriate tools for various manufacturing processes.

Module:1	**Tool Design**	**4 hours**

Tool engineering – tool classifications– tool design objectives – tool design in manufacturing-challenges and requirements- standards in tool design-tool drawings -surface finish – fits and tolerances - tooling Materials.

Module:2	**Locating elements**	**4 hours**

Jigs and Fixtures- basic elements – degrees of freedom- principles of location – locating methods and devices – function and advantages of jigs and fixtures -redundant location.

Module:3	**Clamping elements**	**4 hours**

Principles of clamping – mechanical actuation – pneumatic and hydraulic actuation standard parts – types of clamps-clamping force calculation-design of clamps-smart work holding devices.

Module:4	**Design of Jigs**	**7 hours**

Types of jigs; plate, latch, channel, box, post, angle plate, angular post, turnover, pot jigs- jig bushes- types of bushes- automatic drill jigs-rack and pinion operated - air operated jigs - design and development of jigs for specified components.

Module:5	**Design of Fixtures**	**8 hours**

General principles of boring, lathe, milling and broaching fixtures - grinding, planning and shaping fixtures, assembly, inspection and welding fixtures- modular fixtures – quick change fixtures-design and development of fixtures for specified component.

Module:6	**Design of Press Tool and Dies**	**8 hours**

Press working terminologies – operations – types of presses – press accessories – computation of press capacity – strip layout – material utilization – shearing action – clearances – press work materials – centre of pressure- design of various elements of dies – design of blanking, piercing dies- compound and progressive dies - design considerations in forging, extrusion, casting and plastic dies.

Module:7	**Design of Forming Dies**	**8 hours**

Difference between bending and drawing – blank development for above operations – types of bending dies – press capacity – spring back – knockouts – direct and indirect – pressure pads – ejectors – variables affecting metal flow in drawing operations – draw die inserts – draw beads- ironing – design and development of bending, forming, drawing, reverse redrawing and combination dies – blank development for axisymmetric, rectangular and elliptic parts – single and double action dies.

Module 8	**Contemporary issues:**	**2 hours**

	Total Lecture hours:			**45 hours**
Text Books				
1.	Donaldson C, Tool Design, 2012, Tata McGraw-Hill.			
2.	Edward G Hoffman, Jigs & Fixture Design, 2004, Thomson – Delmar Learning, Singapore.			
Reference Books				
1.	Kempster, Jigs & Fixtures Design, 1978, The English Language Book Society.			
2.	Joshi, P.H, Jigs & Fixtures, 2004, 2nd Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi.			
3.	Hiram E Grant, Jigs and Fixture, 2003, Tata McGraw-Hill, New Delhi.			
4	Fundamentals of Tool Design, 1983, CEEE Edition, ASTME.			
Mode of Evaluation: CAT, written assignment, Quiz, FAT.				
Recommended by Board of Studies		09-03-2022		
Approved by Academic Council		No. 65	Date	17-03-2022

BMEE404L	Design of Transmission Systems	L	T	P	C
		2	1	0	3
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives

1. To provide the knowledge on materials selection and mechanical properties from manufacturer's catalogue.
2. To impart knowledge on design procedure of flexible and rigid mechanical transmission drives.
3. To analyze various components of forces acting on the power transmission elements and evaluate load carrying capacity.

Course Outcomes

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

1. Design flexible power transmission systems such as belt drives, chain drives and wire ropes.
2. Examine the selection of rolling and sliding contact bearings in power transmission systems.
3. Recommend suitable materials and design gears using manufacturer's catalogue.
4. Analyze forces acting on the gear tooth and design based on strength and wear considerations
5. Construct the layout of multispeed gearbox used in machine tools.
6. Design different types of clutches and brakes used in the mechanical drives.

Module:1	**Design of Flexible Mechanical Drives**	**7 hours**

Introduction to flexible drives – Design of flat belt drive and pulley – Design of V-belt drive and pulley – Ratio of Tensions – Belt materials – Design procedure using manufacturer's catalogue – Design of chain drives and sprockets – Load carrying capacity – Design of wire ropes – construction and designation – Selection procedure.

Module:2	**Design of Bearings**	**6 hours**

Rolling contact bearings – Types – Designation – Design procedure – Selection of rolling contact bearings – Design of sliding contact bearings – Types – Basic concepts of hydrodynamic lubrication – Bearing characteristics number – Design parameters for journal bearing – Bearing life – Heat generation and heat dissipation.

Module:3	**Parallel Axes Gear Drives**	**7 hours**

Gear Nomenclature – Stresses on gear tooth – Gear Materials – Design of spur gear pair – Design of helical gear pair – Surface compressive stress and bending stress calculation – Force analysis of parallel axes gear drives – Design based on beam strength and wear considerations – Gear tooth failures.

Module:4	**Design of Bevel Gears**	**5 hours**

Introduction to bevel gear drive – Types – Terminology of bevel gears – Stresses on bevel gear tooth – Design of bevel gear drive using manufacturer's catalogue – Equivalent number of teeth – Force analysis on bevel gear – Design based on beam strength and wear considerations

Module:5	**Design of Worm and Worm Wheel**	**6 hours**

Friction in worm gear pair – Design procedure for worm and worm wheel – Selection of materials – Efficiency of worm gear drive – Modes of failure – Thermal considerations – Analysis of forces – Design based on beam strength and wear considerations.

Module:6	**Design of Multispeed Gearbox**	**5 hours**

Introduction to multispeed gearbox – Components of speed reduction unit – Principles for optimum gearbox design – Progression ratio – Construction of kinematic layout and speed diagram – Centre distance calculation – Selection of number of teeth.

Module:7	**Design of Clutches and Brakes**	**7 hours**

Friction materials – Types of clutches – Uniform pressure and uniform wear theories –

Design of disc or plate clutches – Cone clutch – Centrifugal clutch – Types of mechanical brakes – Design procedure – Block brakes with short and long shoe – Internal expanding shoe brakes – Band brakes – Disc brakes – Thermal considerations.				
Module:8	**Contemporary Topics**			**2 hours**
	Total Lecture hours:			**45 hours**
Text Book				
1.	Bhandari V.B, Design of Machine Elements, 2020, 5th edition, Tata Mc Graw Hill.			
Reference Books				
1.	Richard G. Budynas, Keith Nisbett J, Shigley's Mechanical Engineering Design, 2020, 11th edition (in SI Units), McGraw Hill.			
2.	Robert L. Norton, Machine Design, 2018, 5th edition, Pearson.			
3.	Juvinal R.C, Kurt M. Marshek, 2016, Machine Component Design, Wiley.			
4.	Robert L Mott, Machine Elements in Mechanical Design, 2020, Pearson Education.			
5.	PSG Design Data: Data Book of Engineers, Kalaikathir Achchagam, 2020.			
Mode of Evaluation: CAT, Written assignment, Quiz, FAT.				
Recommended by Board of Studies	09-03-2022			
Approved by Academic Council	No. 65	Date	17-03-2022	

BMEE405L	Industrial Automation	L	T	P	C
		3	0	0	3
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives:

1. To gain knowledge on the industrial automation process and understand the construction, operation and installation of PLCs.
2. To provide the knowledge on interfacing the PLCs and field devices with communication protocols.
3. To understand the concepts of DCS and SCADA systems.
4. To acquire skills on wireless sensor networks and the industrial networking.

Expected Course Outcome:

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

1. Comprehend the need for industrial process automation.
2. Differentiate various types of automation systems and components of automation.
3. Illustrate the programmable logic controller and distributed control systems.
4. Formulate various types of industrial networking.
5. Perform supervisory control and data acquisition.
6. Develop simple automation programs for application specific automation.

Module:1	**Industrial Process Automation**	**5 hours**

Introduction to Industrial Process Automation-Definition of Process-Meaning of Automation and Control-Necessity and Evolution of Automation-Role of Automation in Process Industry-Architecture of Industrial Automation Network-Types of Automation Systems-Role of Information Technology in Process Automation-Process Automation with Smart and Intelligent Instruments-Challenges of Process Automation-Industry 1.0 to Industry 4.0.

Module:2	**Programmable Logic Controller (PLC)**	**7 hours**

Basics of PLC- I/O Devices of PLC-PLC Programming Devices-PLC Selection Criteria-Design and Operation of PLC-Architecture of PLC-Central Control Unit of PLC-Functional Modes of PLC.

Module:3	**PLC Programming**	**6 hours**

PLC Program Structure and Execution-Programming Devices for PLC-PLC Programming Tools-Timer-Counters-Registers-Advanced PLC Functions-PLC Communication-PLC Protocols-Selection and Commissioning of PLC.

Module:4	**Distributed Control System (DCS)**	**6 hours**

Computers in Process Automation-Architecture of Computer-Based Industrial Automation System-Hardware and Software Configuration-Process Automation Network-PC-Based Control Loop-Sampling of Process Data- Distributed Control System-Hardware Units of DCS-Communications in DCS Architecture-Software Packages of DCS-Operation, Monitoring, Control, and Data Acquisition in DCS-Integration of DCS with PLC and SCADA-DCS based Process Control Simulations.

Module:5	**Supervisory Control and Data Acquisition (SCADA)**	**6 hours**

Introduction-SCADA Basics-Different SCADA System Topologies-Evolution of SCADA-SCADA Architecture-Functions of SCADA-Elements of SCADA-SCADA, DCS, and PLC: A Comparison-SCADA Security: Threats, Vulnerabilities, and Consequences-SCADA Standards Organizations-Application Areas of SCADA-SCADA and IIoT SCADA Implementations for Automation Industries.

Module:6	**Industrial Networking**	**7 hours**

Introduction to industrial Networking-Network Devices- Fieldbus-Types- Topology-Benefits-Foundation Fieldbus-Comparison with OSI Model-Medium Access Control (MAC)-PROFIBUS-Communication via PROFIBUS,PROFINET,DP Bus Access-HART: Highway Addressable Remote Transducer-Wireless field bus-WHART-Wireless Sensor Network(WSN) -Introduction-Types-ISM Band-Wireless Standards-Structure of a Node-A Sensor Network Arrangement-Characteristic Features of a WSN-Challenges and

Constraints-Integrating WSN in Internet-Topology in Wireless Sensor Networks-Advantages/Disadvantages.		
Module:7	**Applied Automation**	**6 hours**
Building Automation, Home Automation, Systems Design & Operation, Automated HVAC systems,Production Automation,Business Automation,Waste Management Automation,Highway System Automation.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Books	
1.	Dey, Chanchal, and Sunit Kumar Sen, Industrial automation technologies. CRC Press,
2.	2020. Gilchrist, Alasdair. Industrial Internet use-cases. Industry 4.0., Apress, Berkeley, CA, 2016.
Reference Books	
1.	Johnson, David. Programmable Controllers for Factory Automation. N.p.: 2020, CRC
2.	Press.
3.	Sharma, K. L. S. Overview of industrial process automation, 2016, Elsevier.
4.	Mikell P Groover., Automation,Production Systems and Computer- Integrated Manufacturing, 2016, Pearson. Frank D. Petruzella.,Programmable Logic Controllers, 2019, McGrawHill.

Mode of Evaluation: CAT, Written assignment, Quiz , FAT			
Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE406E	Advanced Manufacturing Processes	L	T	P	C
		3	0	2	4
Pre-requisite	BMEE302L, BMEE302P, BMEE304L, BMEE304P	**Syllabus version**			
		1.0			

Course Objectives

1. To impart knowledge on the advancements of metal forming and metal casting processes.
2. To give an insight on specialized moulding process, micromachining and finishing processes with potential applications in medical field.
3. To facilitate students to understand the advanced machining and hybrid machining processes.

Course Outcomes

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

1. Demonstrate the basics of advanced metal forming and metal casting processes.
2. Discuss various advanced metal casting process with industrial applications.
3. Select the appropriate machining process based on tool-workpiece interaction and source of energy for the end product.
4. Recognize the material removal mechanism and process parameters of ultra-precision machining process and micromanufacturing process.
5. Identify and use various hybrid machining process for state of art application.

Module:1	**Advanced Metal forming Process**	**6 hours**

Unconventional Forming Methods: Classification, Process Principle, Applications, Equipment's, Process Analysis and Die Design of Explosive Forming, Stretch forming, Contour roll forming Laser Beam Bending and Laser Assisted Deep Drawing. Micro Forming Processes: Classification, Process Principle and Applications of Conventional Micro Forming Processes, Unconventional Micro-Forming Processes.

Module:2	**Advanced Metal casting Process**	**5 hours**

Metal mould casting basics, continuous casting, permanent mould casting, pressure die casting, Vacuum mould casting, Evaporative pattern casting (EPC)- Hybrid and vacuum, Ceramic shell investment casting.

Module:3	**Specialized Molding Techniques**	**6 hours**

Injection moulding using pressurized gas assistance, Injection moulding using reaction gas assistance, Injection Moulding for Thin-Wall Applications, Multi-Material Injection Moulding, Water-Assisted Foaming, Moulding by direct compounding, Injection Compression Moulding. Ultrasonic Molding Technology: Recent Advances and Potential Applications in the Medical Industry, Variable Mold Temperature Technologies, Micro injection molding-Issues in Molding Parts with Microfeatures, Influencing Factors in Microinjection Molding, Applications.

Module:4	**Welding-Based Additive Manufacturing (WAM)**	**6 hours**

Classification of WAM by motion controller, raw material and heat source. Powder-bed AM: Selective laser sintering (SLS), Selective Laser Melting (SLM) and Electron Beam Melting (EBM). Wire-feed based WAM: Wire and Laser Additive Manufacturing (WLAM), Electron Beam Freeform Fabrication (EBF3), Wire and Arc Additive Manufacturing (WAAM).

Module:5	**Ultra-Precision Machining**	**6 hours**

Diamond turning- mechanism of material removal - process Parameters and Optimization- tool path strategies in surface generation- applications.

Module:6	**Micromanufacturing**	**7 hours**

Focused ion beam (FIB) Micro-/Nano-fabrication, Laser Micro structuring. Hot Embossing, Hot punching, Roller Embossing, Applications-Micro optical devices, Micro fluidic devices. Net Shape Manufacture of Freestanding Ceramic Micro-components through Soft Lithography, micro-fields-activated sintering technology (Micro-FAST). Micromachining- Micro turning, Micro grinding, Ultra Sonic Micromachining, Abrasive Water Jet Micro Machining, Chemical and Electro Chemical Micro Machining – Electric discharge micro

machining, Laser Beam Micro Machining. Handling for Micromanufacturing.		
Module:7	**Hybrid Machining Process (HMPs)**	**7 hours**
Classification of Hybrid Machining process, Elements of Hybrid Machining Technology (Hybrid Machine Tools, Hybrid Tooling, Hybrid Machining Processes, Metrology System, Work Handling System, Process Monitoring Technique). Vibration assisted grinding, Vibration Assisted EDM, Ultrasonic assisted ECM. Heat Assisted HMPs, Laser assisted turning, laser-assisted ECM(LAECM), Laser-Assisted EDM (LAEDM). Magnetic Field assisted EDM, Magnetic field Assisted electro discharge deposition (EDD) process. Electro chemical discharge machining (ECDM), Electro chemical honing, Electro chemical discharge grinding.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Books	
1.	Kalpakjian and Schmid, Manufacturing Processes for Engineering Materials, 2017, 5th edition, Prentice Hall.
2.	Hassan Abdel-Gawad ElHofy, Fundamentals of Machining Processes (Conventional and Nonconventional Processes), 2018, 3rd Edition, CRC press.
3.	A. Ghosh, and A.K. Mallik, Manufacturing Science, Affiliated East-West Press Pvt. Ltd. New Delhi.
4.	V.K.Jain, Micro manufacturing processes, 2013, CRC Press.
Reference Books	
1.	Balasubramaniam R, Sarepaka RV, Subbiah S. Diamond turn machining: Theory and practice. 2017, CRC press.
2.	Heine R. W., Loper C. R., and Rosenthal P. C. Principles of Metal Castings, 1997, 2nd Edition, Tata McGraw Hill, New Delhi.
3.	Murty, R. L., Precision Engineering in Manufacturing, New Age International (P) Limited, New Delhi.
4.	Mark J. Jackson, Micro and Nano fabrication, 2010, CRC Press, Taylor & Francis Group
5.	Yi Qin, Micro-Manufacturing Engineering and Technology, 2010, Elsevier Publisher, ISBN: 978-0-8155-1545-6
6.	MuammerKoc, TrugelOzel, Micro manufacturing, Design and manufacturing of micro products, 2011, Wiley Publishers
Mode of Evaluation: CAT, Written assignment, Quiz, FAT	
Indicative Experiments	
1.	Learn the forming characteristics of sheet metal specimens with Deep Drawing operation.
2.	Extrude a cylindrical cup by backward extrusion, determine the load variation with the thickness of the bottom of the cup.
3.	Evaluate the machinability of difficult to machine materials by EDM die sinking and EDM milling.
4.	Evaluate the process parameters (Wire feed, wire tension, wire material, WWR) for machining the given material by WEDM process.
5.	Study on Electric discharge coating process by P/M tool and conventional tool.
6.	Study on Micro turning process parameters on the given job.
7.	Experimental investigation on metals and alloys by micro drilling process and analyzing the responses and tool wear.
8.	Experimental Analysis on drill preparation by micro drilling on natural fiber composites and studying the roundness error.
9.	Experimental study on slot preparation by micro milling on metals and alloys.
10.	Experimental study on slot preparation by micro milling on natural fiber composites.
	Total Laboratory Hours **30 hours**

Text book			
Lab manual prepared by the Faculty member			
Mode of assessment: Continuous assessment, FAT, Oral examination			
Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE408E	Additive Manufacturing	L	T	P	C
		3	0	2	4
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives

1. To impart the knowledge on additive manufacturing fundamentals and various 3D printing technologies.
2. To familiarize the concept of preprocessing and post processing methods for the additive manufacturing.
3. To explore the various 3D printing tools for components.

Course Outcome

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

1. Demonstrate the concepts, capabilities and limitations of additive technologies.
2. Develop 3D components using various software and 3D printing tools.
3. Construct customized extrusion-based 3D printers for specific choice of applications.
4. Explore the capabilities and design freedom provided by 3D printing technologies.
5. Recognize the post processing concept for additive Manufacturing.

Module:1	**Introduction to Additive Manufacturing**	**6 hours**

Additive Manufacturing Terminologies – Concepts of Layer Manufacturing – Additive Manufacturing Vs Subtractive Manufacturing – Custom, Batch and Mass Production Scenarios – Role of AM in Product Development – Applications of AM in Automotive, Aerospace and Bio-medical.

Module:2	**Planning for Additive Manufacturing**	**6 hours**

3D Model Data Creation, Concept of Reverse Engineering, Data collection, Modeling for printing – File Formats: STL, OBJ, AMF, 3MF, CLI – STL file Errors, Correction and Printability Analysis – Optimization of Part Orientation and Support Structure Generation - Types of Supports – Slicing Parameters – Tool Path Generation.

Module:3	**Additive Manufacturing Technologies**	**6 hours**

Extrusion Based Technologies – FDM, Stereolithography and other Photo polymerization based Technologies – SLA & DLP, Laser Sintering – SLS & DMLS, Laser and Electron Beam Powder Bed Fusion Technologies – SLM&EBM, Wire and Powder based Direct Energy Deposition Technologies – Material Jetting – Binder Jetting – Hybrid AM Processes.

Module:4	**Post-Processing for Additive Manufacturing**	**6 hours**

Support Structure Removal – Surface Texture Improvement – Surface Treatments – Polymer & Metal ,Heat Treatment – HIP & Residual Stress Relieving, UV Curing – Cleaning & de-powdering – Machining – Surface Coating & Infiltration.

Module:5	**Design for Additive Manufacturing**	**6 hours**

General Guidelines – Exploring Unique Capabilities and Design Freedom – Complex Geometries – Customized Geometries – Part Consolidation – Tooling Design – Design Guidelines for Printing Polymer parts, Metal parts, Ceramic and Sand mould – Functionality based DFAM – Case Studies.

Module:6	**AM Simulation and Characterization Techniques**	**7 hours**

Traditional analysis – Microstructural Analysis – Parameter Optimization – Failure Detection – Wetting Behaviour – Balling Effect – Stress Analysis – Melt Pool Life – Heat transfer phenomena – Defects analysis.

Module:7	**Materials for AM**	**6 hours**

Selection of candidate materials for Additive Manufacturing, Nature of Polymers for AM environment , Am thermoplastics and thermosetting polymers, Types of Polymerizations at 3D printing environment, Properties of Polymers based on FDM, SLA/DLP, and SLS, Degradation of Polymers after printing, Metal and Ceramic Powders for AM, Composites, Functionally Graded Materials (FGM's) for 3D printing.

Module:8	**Contemporary Issues**	**2 hours**

	Total Lecture hours:	**45 hours**
Text Books		
1.	Andreas Gebhardt, Jan-Steffen Hötter, Additive Manufacturing: 3D Printing for Prototyping and Manufacturing, 2016, Hanser Publishers, Munich.	
2.	Olaf Diegel, Axel Nordin, Damien Motte, A Practical Guide to Design for Additive Manufacturing, 2020, Springer Nature Singapore Pte Ltd.	
3.	C P Paul , A N Jinoop, Additive Manufacturing – Pricniples, technologies and Applications, 2021, Mc Graw Hill Publication.	
Reference Books		
1.	Ben Redwood, Filemon Schöffer, Brian Garret, The 3D Printing Handbook, 2017, 3D Hubs.	
2.	Srivatsan, T. S., Sudarshan, T. S, Additive manufacturing: innovations, advances, and applications, 2016, CRC Press.	
Mode of Evaluation: CAT, Assignment, Quiz, FAT, Lab		
Indicative Experiments		
1	3D CAD model creation by Reverse Engineering.	
2	Printing and dimensional evaluation of simple part with one material / one colour – FDM.	
3	Printing and dimensional evaluation of simple part with two material / two colour – FDM.	
4	Printing and dimensional evaluation of simple part by SLS.	
5	Printing and evaluation of simple part by SLA/DLP.	
6	Evaluation of print orientation (x, y, z) effects on ASTM standard Tensile Test specimen using FDM	
7	Evaluation of print orientation (x, y, z) effects on ASTM standard Tensile Test specimen using SLS	
8	Evaluation of print orientation (x, y, z) effects on ASTM standard Tensile Test specimen using SLA	
9	Comparing the surface quality of the parts printed at different print orientation using FDM.	
10	Finding optimum depth to diameter ratio to print holes using FDM.	
11	Finding optimum width to length ratio to print square beams using FDM.	
12	Demo on SLM.	
	Total Laboratory Hours	**30 hours**
Text Book		
1.	Lab Manual prepared by course faculty members	
Mode of assessment: Continuous assessment, FAT, Oral examination and others		
Recommended by Board of Studies	09-03-2022	
Approved by Academic Council	No. 65	Date 17-03-2022

BMEE409E	Computational Fluid Dynamics	L	T	P	C
		2	0	2	3
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives

1. To familiarise students with the mathematical representation of governing equations for fluid flow and heat transfer problems.
2. To equip the students to address complex fluid flow and heat transfer problems by approximating the governing equations through Finite difference and finite volume discretization methods.
3. To enable students to understand different types of grids and their suitability for different engineering applications.
4. Develop the students to use appropriate turbulence model for solving engineering problems.

Course Outcomes

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

1. Apply mathematical and engineering fundamentals to recognize the type of flow and arrive at equations governing the flow.
2. Apply the numerical techniques to find the solution for the system of algebraic equations.
3. Generate appropriate type of grids required for solving engineering problems.
4. Solve governing equations using finite difference and finite volume approaches.
5. Apply suitable turbulence model for the analysis of real world engineering problems.
6. Solve fluid flow and heat transfer problems using commercial CFD tools.

Module:1	**Fundamental of Fluid Dynamics and Governing Equations**	**6 hours**

Introduction and fundamentals of CFD, Classification of flows, Overview and Importance of CFD, Physical verses Numerical Techniques, Applications of CFD

Conservation and Non-conservation form – Continuity, Momentum, Energy and Species Transport Equations, Simplified Mathematical models – Incompressible – Inviscid – Potential – Creeping flow, Characteristics of PDE: Elliptic, Parabolic and Hyperbolic.

Module:2	**Solution of Linear Algebraic Equations**	**4 hours**

Direct Methods - Elimination methods, Tri-diagonal Algorithm, LU Decomposition method, Error Analysis. Iteration Methods - Point iterative/block iterative methods, Gauss-Seidel iteration (concept of central coefficient and residue, Success over Relaxation) and other techniques

Module:3	**Grid Generation**	**3 hours**

Overview of mesh generation, Structured and Unstructured meshes, Guideline on mesh quality and design, Mesh refinement and adaptation, Grid Transformation.

Module:4	**Finite Difference Method and Discretization**	**6 hours**

Comparison of finite difference and finite volume techniques. Convergence, Consistency, Error and Stability, Accuracy, Boundary conditions, CFD model formulation.

Finite Difference Method: Taylor series - Forward, Backward and Central difference schemes, One Dimension and Two Dimension FDM Problems – Explicit, Implicit and Semi-Implicit schemes.

Module:5	**Finite Volume Method**	**3 hours**

Integral form of Discretization – Steady and Transient One and Two-dimensional diffusion. Properties of discretization schemes – Conservativeness, boundedness and transportiveness

Convection and Diffusion: Central difference, upwind and QUICK schemes.

Module:6	**Solution Techniques for Incompressible Flows**	**3 hours**

Pressure-Velocity coupling, collocated and staggered grid arrangements, velocity-stream function approach, MAC algorithm, SIMPLE and PIMPLE algorithms.

Module:7	**Turbulence Modelling**	**3 hours**

Introduction – Types of Turbulence modelling – Reynolds Time Averaging, Boussinesq approach – One equation and Two equation models, Introduction to LES, DES and DNS.				
Module:8	**Contemporary Issues**			**2 hours**
	Total Lecture hours:			**30 hours**
Text Book				
1.	Joel H. Ferziger, Milovan Peric, Robert L. Street, Computational Methods for Fluid Dynamics, 2020, 4th Edition, Springer Publisher.			
Reference Books				
1.	Versteeg H.K, Malalasekara W, An Introduction to Computational Fluid Dynamics – The Finite Volume Method, 2011, 3rd Edition, Pearson.			
2.	John D Anderson, Computational Fluid Dynamics – The Basics with Applications, 1st Edition, McGraw Hill 2012.			
3.	Muralidhar K, Sundararajan T, Computational Fluid Flow and Heat Transfer, 2014, Narosa Publications, New Delhi.			
4.	Chung T.J, 2014, Computational Fluid Dynamics, Cambridge University Press.			
Mode of Evaluation: CAT, written assignment, Quiz, FAT.				
Indicative Experiments				
1.	Modeling of simple and Complex geometries			2 hours
2.	Meshing of simple and complex geometries			2 hours
3.	Pre-processing : Case setup and analysing for already mesh generated model			2 hours
4.	Steady state temperature distribution in rectangular plate			2 hours
5.	Flow in a circular pipe – Laminar and Turbulent			2 hours
6.	Flow over an air foil – Laminar and Turbulent flow			2 hours
7.	Diffuser for a hydro-power turbine			2 hours
8.	Two phase flow in a pipe			2 hours
9.	Supersonic flow past a wedge in a channel			2 hours
10.	Exercise Problem (for each student – different exercise) : Pre-processing, solver and post-processing			2 hours
			Total Laboratory Hours:	**30 hours**
Mode of assessment: Viva-voce examination, Lab performance, FAT.				
Recommended by Board of Studies	09-03-2022			
Approved by Academic Council	No. 65	Date	17-03-2022	

BMEE391J	Technical Answers to Real Problems Project	L	T	P	C
		0	0	0	3
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives:

1. To gain an understanding of real-life issues faced by society.
2. To study appropriate technologies in order to find a solution to real life issues.
3. Students will design system components intended to solve a real-life issue.

Course Outcome:

1. Identify real life issue(s) faced by society.
2. Apply appropriate technologies to suggest a solution to the identified issue(s).
3. Design the related system components/processes intended to provide a solution to the identified issue(s).

Module Content

Students are expected to perform a survey and interact with society to find out the real life issues.

Logical steps with the application of appropriate technologies should be suggested to solve the identified issues.

Subsequently the student should design the related system components or processes which is intended to provide the solution to the identified real-life issues.

General Guidelines:

1. Identification of real-life problems
2. Field visits can be arranged by the faculty concerned
3. Maximum of 3 students can form a team (within the same/different discipline)
4. Minimum of eight hours on self-managed team activity
5. Appropriate scientific methodologies to be utilized to solve the identified issue
6. Solution should be in the form of fabrication/coding/modelling/product design/process design/relevant scientific methodology(ies)
7. Consolidated report to be submitted for assessment
8. Participation, involvement and contribution in group discussions during the contact hours will be used as the modalities for the continuous assessment of the theory component
9. Project outcome to be evaluated in terms of technical, economical, social, environmental, political and demographic feasibility
10. Contribution of each group member to be assessed

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Mark weightage of 20:30:50 – Report to be submitted, presentation and project reviews

Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No.65	Date	17-03-2022

BMEE392J	Design Project	L	T	P	C
		0	0	0	3
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives:

1. Students will be able to upgrade a prototype to a design prototype.
2. Describe and demonstrate the techniques and skills necessary for the project.
3. Acquire knowledge and better understanding of design systems.

Course Outcome:

1. Develop new skills and demonstrate the ability to upgrade a prototype to a design prototype or working model.
2. Utilize the techniques, skills, and modern tools necessary for the project.
3. Synthesize knowledge and use insight and creativity to better understand and improve design systems.

Module Content

Students are expected to develop new skills and demonstrate the ability to develop prototypes to design prototype or working models related to an engineering product or a process.

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Mark weightage of 20:30:50 – Report to be submitted, presentation and project reviews.

Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE393J	Laboratory Project	L	T	P	C
		0	0	0	3
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives:

1. The student will be able to conduct experiments on the concepts already learnt.
2. Analyse experimental data.
3. Present the results with appropriate interpretation.

Course Outcome:

1. Design and conduct experiments in order to gain hands-on experience on the concepts already studied.
2. Analyse and interpret experimental data.
3. Write clear and concise technical reports and research articles

Module Content

Students are expected to perform experiments and gain hands-on experience on the theory courses they have already studied or registered in the ongoing semester. The theory course registered is not expected to have laboratory component and the student is expected to register with the same faculty who handled the theory course. This is mostly applicable to the elective courses. The nature of the laboratory experiments is depended on the course.

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Mark weightage of 20:30:50 – Report to be submitted, presentation and project reviews.

Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE394J	**Product Development Project**	**L**	**T**	**P**	**C**
		0	**0**	**0**	**3**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives:

1. Students will be able to translate a prototype to a useful product.
2. Apply relevant codes and standards during product development.
3. The student will be able to present his results by means of clear technical reports.

Course Outcome:

1. Demonstrate the ability to translate the developed prototype/working model to a viable product useful to society/industry.
2. Apply the appropriate codes/regulations/standards during product development.
3. Write clear and concise technical reports and research articles

Module Content

Students are expected to translate the developed prototypes / working models into a product which has application to society or industry.

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Mark weightage of 20:30:50 – Report to be submitted, presentation and project reviews

Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No.65	Date	17-03-2022

BMEE395J	Computer Project	L	T	P	C
		0	0	0	3
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives:

1. Students will be able to analyse complex engineering processes.
2. Describe the applications and limitations of a given engineering process.
3. Present the results in written reports and oral presentations.

Course Outcome:

1. Utilize programming skills/modelling to analyse complex engineering processes/problems.
2. Demonstrate the ability to evaluate the applicability and limitations of the given engineering process.
3. Communicate effectively through written reports, oral presentations, and discussion.

Module Content

Students are expected to use programming skills or modelling to analyse complex engineering processes. The student should be able to evaluate the application and limitations of the said engineering processes.

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Mark weightage of 20:30:50 – Report to be submitted, presentation and project reviews.

Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No.65	Date	17-03-2022

BMEE396J	Reading Course	L	T	P	C
		0	0	0	3
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives:

1. The student will be able to analyse and interpret published literature for information pertaining to niche areas.
2. Scrutinize technical literature and arrive at conclusions.
3. Use insight and creativity for a better understanding of the domain of interest.

Course Outcome:

1. Retrieve, analyse, and interpret published literature/books providing information related to niche areas/focused domains.
2. Examine technical literature, resolve ambiguity, and develop conclusions.
3. Synthesize knowledge and use insight and creativity to better understand the domain of interest.

Module Content

This is oriented towards reading published literature or books related to niche areas or focussed domains under the guidance of a faculty.

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Mark weightage of 20:30:50 – Report to be submitted, presentation and project reviews.

Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No.65	Date	17-03-2022

BMEE397J	Special Project	L	T	P	C
		0	0	0	3
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives:

1. Students will be able to identify and solve problems in a time-bound manner.
2. Describe major approaches and findings in the area of interest.
3. Present the results in a clear and concise manner.

Course Outcome:

1. To identify, formulate, and solve problems using appropriate information and approaches in a time-bound manner.
2. To demonstrate an understanding of major approaches, concepts, and current research findings in the area of interest.
3. Write clear and concise research articles for publication in conference proceedings/peer-reviewed journals.

Module Content

This is an open-ended course in which the student is expected to work on a time bound research project under the supervision of a faculty. The result may be a tangible output in terms of publication of research articles in a conference proceeding or in a peer-reviewed Scopus indexed journal.

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Mark weightage of 20:30:50 – project report to be submitted, presentation and project reviews.

Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE398J	Simulation Project	L	T	P	C
		0	0	0	3
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives:

1. Students will be able to simulate a real system.
2. Identify the variables which affect the system.
3. Describe the performance of a real system.

Course Outcome:

1. Demonstrate the ability to simulate and critically analyse the working of a real system.
2. Identify and study the different variables which affect the system elaborately.
3. Evaluate the impact and performance of the real system.

Module Content

The student is expected to simulate and critically analyse the working of a real system. Role of different variables which affect the system has to be studied extensively such that the impact of each step in the process is understood, thereby the performance of each step of the engineering process is evaluated.

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Mark weightage of 20:30:50 – project report to be submitted, presentation and project reviews.

Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE399J	Summer Industrial Internship	L	T	P	C
		0	0	0	1
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives:

1. The course is designed so as to expose the students to industry environment and to take up on-site assignment as trainees or interns.

Course Outcome:

1. Demonstrate professional and ethical responsibility.
2. Understand the impact of engineering solutions in a global, economic, environmental and societal context.
3. Develop the ability to engage in research and to involve in life-long learning.
4. Comprehend contemporary issues.

Module Content

Four weeks of work at industry site.
Supervised by an expert at the industry.

Mode of Evaluation: Internship Report, Presentation and Project Review

Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE497J	Project - I	L	T	P	C
		0	0	0	3
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives:

To provide sufficient hands-on learning experience related to the design, development and analysis of suitable product / process so as to enhance the technical skill sets in the chosen field.

Course Outcome:

1. Demonstrate professional and ethical responsibility.
2. Evaluate evidence to determine and implement best practice.
3. Mentor and support peers to achieve excellence in practice of the discipline.
4. Work in multi-disciplinary teams and provide solutions to problems that arise in multi-disciplinary work.

Module Content

Project may be a theoretical analysis, modeling & simulation, experimentation & analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, applied research and any other related activities.

Can be individual work or a group project, with a maximum of 3 students.

In case of group projects, the individual project report of each student should specify the individual's contribution to the group project.

Carried out inside or outside the university, in any relevant industry or research institution.

Publications in the peer reviewed journals / International Conferences will be an added advantage.

Mode of Evaluation: Assessment on the project - project report to be submitted, presentation and project reviews

Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022

BMEE498J	Project – II / Internship	L	T	P	C
		0	0	0	5
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives:

To provide sufficient hands-on learning experience related to the design, development and analysis of suitable product / process so as to enhance the technical skill sets in the chosen field.

Course Outcome:

1. Formulate specific problem statements for well-defined real life problems with reasonable assumptions and constraints.
2. Perform literature search and / or patent search in the area of interest.
3. Conduct experiments / Design and Analysis / solution iterations and document the results.
4. Perform error analysis / benchmarking / costing.
5. Synthesize the results and arrive at scientific conclusions / products / solution.
6. Document the results in the form of technical report / presentation.

Module Content

1. Project may be a theoretical analysis, modeling & simulation, experimentation & analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, applied research and any other related activities.
2. Project can be for one or two semesters based on the completion of required number of credits as per the academic regulations.
3. Can be individual work or a group project, with a maximum of 3 students.
4. In case of group projects, the individual project report of each student should specify the individual's contribution to the group project.
5. Carried out inside or outside the university, in any relevant industry or research institution.
6. Publications in the peer reviewed journals / International Conferences will be an added advantage.

Mode of Evaluation: : Assessment on the project - project report to be submitted, presentation and project reviews.

Recommended by Board of Studies	09-03-2022		
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