

||Jai Sri Gurudev||

Sri Adichunchanagiri Shikshana Trust (R.)

SJC INSTITUTE OF TECHNOLOGY

An Autonomous Institution under VTU from 2024-25

AICTE Approved, Accredited by NAAC with A+ Grade & NBA (CSE, ISE, ECE, ME & CV), NIRF(151-300) in 2023,Gold Rated by QS I-Gauge

P.B. No.20, B.B Road, Chikkaballapur - 562 101, Karnataka

www.sjcit.ac.in

Estd : 1986

VI Semester
Scheme of B.E. Programme
Mechanical Engineering
(2024 Scheme)

Core Values

Spiritual, Judicious, Commitment, Integrity, Trustworthy



NATIONAL INSTITUTIONAL RANKING FRAMEWORK 151-300

INSTITUTION'S INNOVATION COUNCIL (Ministry of HRD Initiative) 4-Star Rating

SJC INSTITUTE OF TECHNOLOGY, CHIKKABALLAPURA

An Autonomous institution Under VTU from 2024 – 2025

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SCHEME OF TEACHING AND EXAMINATION – B.E. – Mechanical Engineering

(Applicable for students admitted from the Academic Year 2024-25 and onwards)

6th Semester

Mechanical Engineering													
Sl. No.	**Course Code**	**Course Title**	**Course Type**	**TD/ PSB**	**Teaching Hours / Week**			**Examination**					
					L	**T**	**P**	**SEE Duration (Hrs)**	**CIE Marks**	**SEE Marks**	**Total Marks**	**Credits**
1	BME601	Machine Design	PCC	ME	3	2	0	**3**	**50**	**50**	**100**	**4**
2	BME602	Finite Element Methods	IPCC	ME	3	0	2	**3**	**50**	**50**	**100**	**4**
3	BME623x	Professional Elective Course – II	PEC	ME	3	0	0	**3**	**50**	**50**	**100**	**3**
4	BME624x	Professional Elective Course – III	PEC	ME	3	0	0	**3**	**50**	**50**	**100**	**3**
5	BME645x	Open Elective Course – I	OEC	ME	3	0	0	**3**	**50**	**50**	**100**	**3**
6	BME636	Major Project Phase – I	PROJ	ME	0	0	4	**3**	**100**	**-**	**100**	**2**
7	BMEL607	Design lab	PCCL	ME	0	0	2	**3**	**50**	**50**	**100**	**1**
8	BCE608	Competency Enhancement Course-4	NCMC	CDCAC	0	2	0	**-**	**100**	**-**	**100**	**0**
9	BIK609	Indian Knowledge System	NCMC	Any Dept.	1	0	0	**1**	**100**	**-**	**100**	**0**
10	BNS610	National Service Scheme (NSS)	NCMC	NSS Coordinator	0	0	2	**-**	**100**	**-**	**100**	**0**
	BPE610	Physical Education (PE) (Sports and Athletics)		Physical Education Director								
	BYO610	Yoga		Yoga Teacher								
	BMU610	Music		Music Teacher								
									700	**300**	**1000**	**20**

ASC: Applied Science Course, PCC: Professional Core Course, IPCC: Integrated Professional Core Course, PCCL: Professional Core Course laboratory, UHV: Universal Human Value Course, NCMC: Non Credit Mandatory Course, AEC: Ability Enhancement Course, SEC: Skill Enhancement Course, ESC: Engineering

Science Course, ETC: Emerging Technology Course, PLC: Programming Language Course, L: Lecture, T: Tutorial, P: Practical, CIE: Continuous Internal Evaluation, SEE: Semester End Evaluation.

Professional Elective Course – II

Course Code	Course Name	Course Code	Course Name
BME623A	Total Quality Management	BME623C	MEMS and Microsystem Technology
BME623B	Refrigeration and Air conditioning	BME623D	Design for Manufacturing and Assembly

Professional Elective Course – III

Course Code	Course Name	Course Code	Course Name
BME624A	Additive Manufacturing	BME624C	Alternate Fuels and Technology
BME624B	Mechanics of Composite Materials	BME624D	Product Design and Management

Open Elective Course – I

Course Code	Course Name	Course Code	Course Name
BME645A	Project Management	BME645C	Introduction to Mechatronics
BME645B	Renewable Energy Power plants	BME645D	Modern Mobility

Professional Core Course (IPCC): Refers to Professional Core Course Theory Integrated with practical's of the same course. Credit for IPCC can be 04 and its Teaching– Learning hours (L : T : P) can be considered as (3 : 0 : 2) or (2 : 2 : 2). The theory part of the IPCC shall be evaluated both by CIE and SEE. The practical part shall be evaluated by only CIE (no SEE). However, questions from the practical part of IPCC shall be included in the SEE question paper. For more details, the regulation governing the Degree of Bachelor of Engineering (B.E.) 2024-25 may please be referred.

National Service Scheme /Physical Education/Yoga/Music: All students have to register for any one of the courses namely National Service Scheme (NSS), Physical Education (PE)(Sports and Athletics), Yoga and Music with the concerned coordinator / teacher of the course during the first week of 3rd semester. Activities shall be carried out between 3rd semester to the 6th semester (for 4 semesters). Successful completion of the registered course and requisite CIE score is mandatory for the award of the degree. The events shall be appropriately scheduled by the colleges and the same shall be reflected in the calendar prepared for the NSS, PE, Yoga and Music activities. These courses shall not be considered for vertical progression as well as for the calculation of SGPA and CGPA, but completion of the course is mandatory for the award of degree.

Professional Elective Courses (PEC): A professional elective (PEC) course is intended to enhance the depth and breadth of educational experience in the Engineering and Technology curriculum. Multidisciplinary courses that are added supplement the latest trend and advanced technology in the selected stream of engineering. Each group will provide an option to select one course. The minimum number of students' strengths for offering professional electives is 10. However, this conditional shall not be applicable to cases where the admission to the program is less than 10.

Open Elective Courses: Students belonging to a particular stream of Engineering and Technology are not entitled to the open electives offered by their parent Department. However, they can opt for an elective offered by other Departments, provided they satisfy the prerequisite condition if any. Registration to open electives shall be documented under the guidance of the Program Coordinator/ Advisor/Mentor. The minimum numbers of students' strength for offering Open Elective Course is 10. However, this condition shall not be applicable to class where the admission to the program is less than 10.

Project Phase-I: Students have to discuss with the mentor /guide and with their help he/she has to complete the literature survey and prepare the report and finally define the problem statement for the project work

Semester: VI						
Machine Design						
Course Code	**:**	**BME601**		**Credits**	**:**	04
Hours/Week (L:T:P)	**:**	3:2:0		**CIE**	**:**	50 Marks
Total Hours	**:**	50		**SEE**	**:**	50 Marks
Course Type	**:**	PCC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**Mechanics of Materials, Theory of Machines**
Knowledge on Fundamental Concepts	**Stress, Strain and Numerical Methods**
Knowledge on Connected Tools (If any)	**Nil**

Course Learning Objectives: This course will enable the students to	
CLO1	**Explain** the principles involved in design of machine elements, subjected to different kinds of forces, from the considerations of strength, rigidity.
CLO2	**Understand** and interpret different failure modes and application of appropriate criteria for design of machine elements
CLO3	**Develop** the capability to design elements like shafts, couplings and welded joints, screwed joints.
CLO4	**Learn** transmission elements like gears, belts, pulleys, bearings from the manufacturers' catalogue
CLO5	**Produce** assembly and working drawings of various mechanical systems involving machine elements like clutches and brakes

Module – 1	**10 Hrs**
Introduction and Review: Review of engineering materials and their properties and manufacturing processes; use of codes and standards, selection of preferred sizes. Review of axial, bending, shear and torsion loading on machine components, combined loading. **Design for static strength:** Factor of safety and service factor. Failure mode: definition and types., Failure of brittle and ductile materials; even and uneven materials; Stress concentration, stress concentration factor, Theories of failure: maximum normal stress theory, maximum shear stress theory, distortion energy theory, strain energy theory, Columba –Mohr theory and modified Mohr's theory **Fatigue loading:** Introduction to fatigue failure, Mechanism of fatigue failure, types of fatigue loading, SN Diagram, Low cycle fatigue, High cycle fatigue, Endurance limit. **Textbook-1: Chapter 1,2**	
Module – 2	**10 Hrs**
Design of shafts: Torsion of shafts, solid and hollow shaft design with steady loading based on strength and rigidity, ASME and BIS codes for power transmission shafting, design of shafts subjected to combined bending, torsion and axial loading, Discussion on engineering applications. **Design of keys and couplings:** Keys: Types of keys and their applications, design considerations in parallel and tapered sunk keys, Design of square and rectangular sunk keys. Couplings: Rigid and flexible coupling types and applications, design of Flange coupling, and Bush and Pin type coupling. **Textbook-1: Chapter 3,4 Textbook-2: Chapter 3**	

Module – 3	10 Hrs
Riveted joints: Types of rivets, rivet materials, Caulking and fullering, analysis of riveted joints, joint efficiency, failures of riveted joints, boiler joints, riveted brackets, Discussion on engineering applications. **Welded joints:** Types, strength of butt and fillet welds, eccentrically loaded welded joints, Discussion on engineering applications. **Spur Gears:** Definitions, stresses in gear tooth: Lewis equation and form factor, design for strength, dynamic load and wear. **Textbook-1: Chapter 5 Textbook-3: Chapter 4**	
Module – 4	**10 Hrs**
Helical Gears: Definitions, transverse and normal module, formative number of teeth, design based on strength, dynamic load and wear. **Bevel Gears:** Definitions, formative number of teeth, design based on strength, dynamic load and wear. **Worm Gears:** Definitions, types of worm and worm gears, and materials for worm and worm wheel. Design based on strength, dynamic, wear loads and efficiency of worm gear drives. **Textbook-2: Chapter 4 Textbook-2: Chapter 5**	
Module – 5	**10 Hrs**
Design of Clutches and Brakes: Design of single plate, multiplate based on uniform pressure and uniform wear theories. Design of band brakes, block brakes **Lubrication and Bearings:** Lubricants and their properties, bearing materials and properties; mechanisms of lubrication, hydrodynamic lubrication, pressure development in oil film, bear modulus, coefficient of friction, minimum oil film thickness, heat generated, and heat dissipated. **Textbook-1: Chapter 6 Textbook-3: Chapter 5**	

Course Outcomes: After completing the course, the students will be able to	
CO1	Analyze different types of loading and failure modes in machine components and **apply** appropriate theories of failure and fatigue criteria for safe design.
CO2	**Design** solid and hollow shafts, keys and couplings subjected to torsional, bending and combined loading considering strength, rigidity and applicable design codes.
CO3	**Analyze and design** riveted joints, welded joints and spur gears considering joint efficiency, strength, dynamic loading and wear.
CO4	**Design** helical, bevel and worm gear drives based on strength, dynamic loading, wear and efficiency requirements for power transmission applications.
CO5	**Design and evaluate** clutches and brakes and **analyze** lubrication and hydrodynamic bearing parameters for reliable machine operation.

Text Books	
1	Shigley's Mechanical Engineering Design Richard G. Budynas, and J. Keith Nisbett McGrawHill Education 10th Edition, 2015
2	Fundamentals of Machine Component Design Juvinall R.C, and Marshek K.M John Wiley & Sons Third Edition 2007 Wiley student edition
3	Design of Machine Elements V. B. Bhandari Tata Mcgraw Hill 4th Ed 2016.
Web links and Video Lectures (e-Resources)	
1	https://en.wikipedia.org/wiki/Machine_element

2	https://cosmolearning.org
3	http://nevonprojects.com/miniprojectsformechanicalengineering/

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning Frequency

- Term Projects
- Course seminar

COURSE OUTCOMES	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	3										2	2
CO2	3	3										2	2
CO3	3	3										2	3
CO4	3	3										2	1
CO5	3	3										2	1

Semester: VI						
Finite Element Methods						
Course Code	**:**	**BME602**		**Credits**	**:**	04
Hours/Week (L:T:P)	**:**	3:0:2		**CIE**	**:**	50 Marks
Total Hours	**:**	40		**SEE**	**:**	50 Marks
Course Type	**:**	IPCC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**Mechanics of Materials**
Knowledge on Fundamental Concepts	**Stress, Strain, Numerical Methods**
Knowledge on Connected Tools (If any)	**ANSYS**

Course Learning Objectives: This course will enable the students to	
CLO1	Learn basic principles of finite element analysis procedure.
CLO2	Understand the theory and characteristics of finite elements that represent engineering structures.
CLO3	Apply finite element solutions to structural, thermal, dynamic problems
CLO4	Develop the knowledge and skills needed to effectively evaluate finite element analyses.

Module – 1	**08 Hrs**
Introduction to FEM: Introduction to FEM, engineering applications, advantages, General steps, Element types, Convergence criteria, Coordinate systems, commercial packages preprocessor, solver and post processor. Principles of Elasticity: Strain displacement relations, Stress strain relations for 1D, 2D, and 3D cases, Plain stress and Plain strain conditions, Introduction to Numerical Methods, Potential energy method, Rayleigh Ritz method and Galerkin method-applied to simple problems on axially loaded members, cantilever, simply supported beams, with point loads and distributed loads. **Text Book 1 : Ch 1 Text Book 2 : Ch 1 Text Book 5 : Ch 1**	
Module – 2	**08 Hrs**
One Dimensional Element: Formulation of a linear bar element, Shape Functions Polynomial, The Potential Energy Approach, derivation of stiffness matrix, Properties of stiffness matrix, Assembly of Global Stiffness Matrix and Load Vector, Boundary conditions elimination method and penalty method. Numerical Problems on straight and stepped bars. **(Problems with 2 elements only)** **Text Book 1 :Ch 2 Text Book 2 :Ch 2 Text Book 4 :Ch 2**	
Module – 3	**08 Hrs**
Trusses and Beams: Formulation plane trusses element, Stiffness matrix (No derivation), Numerical Problems on point load, Formulation beam element, derivation of Hermite shape functions, stiffness matrix and load vector (No derivations), Numerical Problems on beams carrying concentrated, UDL and couples. **(Problems with 2 elements only).** **Text Book 1 :Ch 3 Text Book 2 :Ch 3 Text Book 3 :Ch 3**	
Module – 4	**08 Hrs**

Two-dimensional Element: Formulation of triangular and quadrilateral elements. Displacement models and shape functions for linear and higher order elements, Lagrangian and serendipity elements, Iso parametric – sub parametric – super parametric elements, Introduction to axisymmetric– triangular elements. Convergence criteria, pascal triangle. (No numerical problems)

Text Book 1 :Ch 4 Text Book 2 :Ch 4 Text Book3 :Ch 4

Module – 5	**08 Hrs**

Dynamic considerations and Heat Transfer: Dynamic considerations: Formulation for point mass and distributed masses, Consistent mass matrices for 1D bar element, computation of eigen values and eigen vectors. Numerical Problems on straight and stepped bars. Heat Transfer Problems: Steady state heat transfer, 1D heat conduction governing equation, boundary conditions, Numerical problems on composite wall, 1D heat transfer in thin fins.

Text Book 1 :Ch 5 Text Book 2 :Ch 5 Text Book 5 :Ch 5

PRACTICAL COMPONENT OF IPCC (May cover all / major modules)

Sl. No	Experiments
1	Bars of constant cross section area, tapered cross section area and stepped bar with different materials
2	Trusses – (Minimum 3 exercises of different areas of cross sections of links, different supports such as fixed support, rolling support)
3	Beams – Simply supported, cantilever, beams with point load, UDL, beams with varying load etc. (Minimum 6 exercises)
4	Stress analysis of a rectangular plate with a circular hole
5	Thermal Analysis – 1D & 2D problem with conduction and convection boundary conditions (Heat transfer through composite section) Minimum of 2 exercises
6	Natural frequency of beam with fixed – fixed end condition
7	Response of beam with fixed – fixed end conditions subjected to forcing function
8	Demonstrate the use of graphics standards (IGES, STEP etc) to import the model from modeler to solver
9	**Can be Demo experiments for CIE** Demonstrate the use of graphics standards (IGES, STEP etc) to import the model from modeler to solver
10	**Can be Demo experiments for CIE** Demonstrate at least two different types of examples to model and analyze bars or plates made from composite material

Course Outcomes: After completing the course, the students will be able to	
CO1	**Describe** the basic concepts, definitions in finite element method related structural and heat transfer.
CO2	**Apply** suitable boundary conditions to a global equation for bars, trusses, beams, and heat transfer, axis symmetric and dynamic problems.
CO3	**Develop** element characteristic equations for 1D, 2D structural, Thermal and Dynamic elements.
CO4	**Solve** for stresses, strains, deformation and temperature of a structural and thermal components subjected to static, thermal and dynamic loading.
CO5	**Analyze** the basic mechanical components using FEM Tool

Text Books	
1	Logan, D. L., A first course in the finite element method,6th Edition, Cengage Learning, 2016.
2	Rao, S. S., Finite element method in engineering, 5th Edition, Pergaman Int. Library of Science, 2010.
3	Chandrupatla T. R., Finite Elements in engineering, 2nd Edition, PHI, 2013.
4	O. C. Zienkiewicz and Y.K. Cheung, The Finite Element Method in Structural and Soild Mechanics, McGraw Hill, London
5	J.N.Reddy, "Finite Element Method" McGraw Hill International Edition.
Web links and Video Lectures (e-Resources)	
1	http://icas.bf.rtu.lv/doc/Book.pdf
2	http://www.adina.com/MITRES2_002S10_linear.pdf
3	https://www.edx.org/course/finiteelementmethodfemanalysistsinghuax 70120073x

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning Frequency

- https://www.edx.org/course/handsintroductionengineeringcornellxengr2000x
- http://nptel.ac.in/courses/112104115/
- https://www.coursetalk.com/providers/mit/courses/finiteelementanalysisofsolidsand-fluidsi
- https://onlinelearning.tudelft.nl/courses/linearmodelingfem/

CO – PO MAPPING

COURSE OUTCOMES	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3											3	
CO2	3	3										3	
CO3	3	3	3									3	
CO4	2	3	3	2	3					2		3	
CO5	2	3	2	1	3			2	3	2			3

Semester: VI						
TOTAL QUALITY MANAGEMENT						
Course Code	**:**	**BME623A**		**Credits**	**:**	03
Hours/Week(L:T:P)	**:**	3:0:0		**CIE**	**:**	50 Marks
Total Hours	**:**	40		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**YES**
Knowledge on Fundamental Concepts	**YES**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	**Elucidate** the various approaches of Total Quality Management
CLO2	I**nfer** the customer perception of quality
CLO3	**Analyze** customer needs and perceptions to design feedback systems.
CLO4	**Apply** statistical tools for continuous improvement of systems
CLO5	**Develop** the tools and technique for effective implementation of Total Quality Management.

Module – 1	**08 Hrs**
Principles and Practice: Definition, basic approach, gurus of TQM, TQM Framework, awareness, defining quality, historical review, obstacles, benefits of TQM. **Quality Management Systems**: Introduction, benefits of ISO registration, ISO 9000 series of standards, ISO 9001 requirements. **Textbook-1: Chapter 1,2**	
Module – 2	**08 Hrs**
Leadership: Definition, characteristics of quality leaders, leadership concept, characteristics of effective people, ethics, the Deming philosophy, Role of TQM leaders, implementation, core values, concepts and framework, strategic planning communication, decision making, **Textbook-1: Chapter 3,4 Textbook-2: Chapter 3**	
Module – 3	**08 Hrs**
Customer Satisfaction and Customer Involvement: **Customer Satisfaction**: customer and customer perception of quality, feedback, using customer complaints, service quality, translating needs into requirements, customer retention, case studies. **Employee Involvement** – Motivation, employee surveys, empowerment, teams, suggestion system, recognition and reward, gain sharing, performance appraisal, unions and employee involvement, case studies. **Textbook-1: Chapter 5 Textbook-2: Chapter 4**	

Module – 4	08 Hrs
Continuous Process Improvement: The Juran trilogy, improvement strategies, types of problems, the PDSA Cycle, problem solving methods, Kaizen, reengineering, six sigma, case studies. **Statistical Process Control:** Pareto diagram, process flow diagram, cause and effect diagram, check sheets, histograms, statistical fundamentals, Control charts, state of control, out of control process, control charts for variables, control charts for attributes, scatter diagrams, case studies. **Textbook-2: Chapter 5**	
Module – 5	**08 Hrs**
Total Productive Maintenance (TPM): Definition, Types of Maintenance, Steps in introduction of TPM in an organization, Pillars of TPM – 5S, Jishu Hozen, Quality Maintenance, Planned Maintenance. **Quality by Design (QbD):** Definition, Key components of QbD, Role of QbD in Pharmaceutical Industry, Benefits and Challenges of QbD. **Environmental Management Systems (EMS):** Definition, Basic EMS, EMS under ISO 14001, Costs and Benefits of EMS. **Textbook-2: Chapter 6,7**	

Course Outcomes: After completing the course, the students will be able to	
CO1	Elucidate the various approaches of Total Quality Management
CO2	Infer the customer perception of quality.
CO3	Analyze customer needs and perceptions to design feedback systems.
CO4	Apply statistical tools for continuous improvement of systems.
CO5	Develop the tools and technique for effective implementation of Total Quality Management.

Text Books	
1	Total Quality Management, Dale H. Besterfield, Pearson Education India, Edition 03. ISBN: 8129702606,
2	Total Quality Management for Engineers, M. Zairi, Wood head Publishing, ISBN:185573024 3

Reference Books	
1	Managing for Quality and Performance Excellence, James R. Evans and William M Lindsay, Cengage Learning., 9th edition.
2	Four revolutions in management , Shoji Shiba, Alan Graham, David Walden, Oregon, 1990
3	Organizational Excellence through TQM, H. Lal, New age Publications, 2008

4	Engineering Optimization Methods and Applications, A Ravindran, K, M. Ragsdell, Willey India Private Limited, 2nd Edition,2006

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning	
1	Case studies Quiz
2	Topic Seminar presentation
3	Assignments

CO – PO MAPPING

COURSE OUTCOMES	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	1					2							
CO2	2					2		2	2	2			
CO3	2	2							2	2			
CO4	2	2							2	2			
CO5	2												

Semester: VI						
Subject Name: Refrigeration & Air Conditioning						
Course Code	**:**	**BME623B**		**Credits**	**:**	03
Hours/Week(L:T:P)	**:**	3:0:0		**CIE**	**:**	50 Marks
Total Hours	**:**	40		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	Physics, Mathematics and Chemistry
Knowledge on Fundamental Concepts	Thermodynamics & Heat Transfer
Knowledge on Connected Tools (If any)	NIL

Course Learning Objectives: This course will enable the students to	
CLO1	Study the basic definition, ASHRAE Nomenclature for refrigerating systems.
CLO2	Understand the working principles and applications of different types of refrigeration systems.
CLO3	Study the working of air conditioning systems and their applications.
CL04	Identify the performance parameters and their relations of an air conditioning system.

Module – 1	**08 Hrs.**
Introduction to Refrigeration –Basic Definitions, ASHRAE Nomenclature, Air Refrigeration Cycles reversed Carnot cycle, Bell-Coleman cycle analysis, Air Refrigeration systems - merits and demerits and applications; Aircraft refrigeration cycles, Joule Thompson coefficient and Inversion Temperature, Linde, Claude and Stirling cycles for liquefaction of air. **Industrial Refrigeration**- Chemical and process industries, Dairy plants, Petroleum refineries, Food processing and food chain, Miscellaneous **Textbook-1: Chapter 1,2**	
Module – 2	**08 Hrs.**
Vapour Compression Refrigeration System(VCRS): Comparison of Vapour Compression Cycle and Gas cycle, Vapour Compression Refrigeration system Working and analysis, Limitations, Superheat horn and throttling loss for various refrigerants, efficiency, Modifications to standard cycle – liquid suction heat exchangers, Grindlay cycle and Lorenz cycle, Optimum suction condition for optimum COP – Ewing's construction and Gosney's method. Actual cycles with pressure drops, Complete Vapour Compression Refrigeration System, Multi-Pressure, Ulti-evaporator systems or Compound Vapour Compression Refrigeration Systems – Methods like Flash Gas removal, Flash inter cooling and water Inter cooling. **Textbook-1: Chapter 3,4 Textbook-2: Chapter 3**	

Module – 3	**08 Hrs.**
Vapour Absorption Refrigeration Systems: Absorbent – Refrigerant combinations, Water-Ammonia Systems, Practical problems, Lithium- Bromide System, Contrast between the two systems, Modified Version of Aqua-Ammonia System with Rectifier and Analyzer Assembly. Practical problems – crystallization and air leakage, Commercial systems. **Other types of Refrigeration systems**: Brief Discussion on (i) Steam-Jet refrigeration system and ii) Thermoelectric refrigeration, pulse tube refrigeration, thermo acoustic refrigeration systems **Entropy:** Clausius inequality, Statement- proof, Entropy- definition, a property, change of entropy, entropy as a quantitative test for irreversibility, principle of increase in entropy, entropy as a coordinate. Problems **Textbook-1: Chapter 5 Textbook-3: Chapter 4**	
Module – 4	**08 Hrs.**
Refrigerants: Primary and secondary refrigerants, Designation of Refrigerants, Desirable properties of refrigerants including solubility in water and lubricating oil, material compatibility, toxicity, flammability, leak detection, cost, environment and performance issues Thermodynamic properties of refrigerants, Synthetic and natural refrigerants, Comparison between different refrigerants and applications, Special issues and practical implications Refrigerant mixtures – zoetrope and azeotropic mixtures. **Refrigeration systems Equipment:** Compressors, Condensers, Expansion Devices and Evaporators, A brief look at other components of the system. **Textbook-2: Chapter 4 Textbook-2: Chapter 5**	
Module – 5	**08 Hrs.**
Air-Conditioning: Introduction to Air-Conditioning, Basic Definition, Classification, power rating, Mathematical Analysis of Air-Conditioning Loads, Related Aspects, Different Air-Conditioning Systems- Central – Station Air-Conditioning System, Unitary Air-Conditioning System, Window Air Conditioner and Packaged Air-Conditioner, Components related to Air-Conditioning Systems. **Transport air conditioning Systems:** Air conditioning systems for automobiles (cars, buses etc.), Air conditioning systems for trains, Air conditioning systems for ships **Textbook-1: Chapter 6 Textbook-3: Chapter 5**	

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand the principles, nomenclature and applications of refrigeration systems.
CO2	Explain vapour compression refrigeration system and identify methods for performance improvement
CO3	Illustrate the working principles of air, vapour absorption, thermoelectric and steam jet and thermo acoustic refrigeration systems.
CO4	Estimate the performance of air-conditioning systems using the principles of psychrometry.
CO5	Compute and Interpret cooling and heating loads in an air-conditioning system.

Text Books	
1	Roy J. Dossat, Principles of Refrigeration, Wiley Limited
2	Arora C.P., Refrigeration and Air-conditioning, Tata Mc Graw –Hill, New Delhi, 2ndEdition, 2001.
3	Stoecker W.F., and Jones J.W., Refrigeration and Air-conditioning, Mc Graw - Hill, New Delhi 2nd edition, 1982.

Reference Books	
1	Dossat, Principles of Refrigeration Pearson-2006
2	S C Arora& S Domkundwar, Refrigeration and Air-Conditioning Dhanpat Rai Publication
3	Refrigeration and Air-Conditioning' by Manohar prasad

Web links and Video Lectures (e-Resources)	
1	http://nptel.ac.in/courses/112105128/#

CO – PO MAPPING

COURSE OUTCOMES	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	2		1			1					1		
CO2	1		1										
CO3	1		2		2			2					
CO4	1		2										
CO5	1						1			1			

Semester: VI						
ALTERNATE FUELS AND TECHNOLOGY						
Course Code	**:**	**BME624C**		**Credits**	**:**	03
Hours/Week(L:T:P)	**:**	3:0:0		**CIE**	**:**	50 Marks
Total Hours	**:**	40		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**NIL**
Knowledge on Fundamental Concepts	**NIL**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	To introduce the concepts and principles of various energy fuels.
CLO2	To know about the technical aspects and specifications.
CLO3	To learn the application aspects of various energy fuels.

Module – 1	**08 Hrs**
Alcohols as Fuels: Introduction to alternative fuels. - Need for alternative fuels - Availability of different alternative fuels for SI and CI engines. Alcohols as fuels. Production methods of alcohols. Properties of alcohols as fuels. Methods of using alcohols in CI and SI engines. Blending, dual fuel operation, surface ignition and oxygenated additives. Performance emission and combustion characteristics in CI and SI engines. **Textbook-1: Chapter 1,2**	
Module – 2	**08 Hrs**
Vegetable oils: Various vegetable oils and their important properties. Different methods of using vegetable oils engines – Blending, preheating Transesterification and emulsification of Vegetable oils - Performance in engines – Performance, Emission and Combustion Characteristics in diesel engines. **Textbook-1: Chapter 3,4 Textbook-2: Chapter 3**	
Module – 3	**08 Hrs**
Hydrogen as Engine Fuel : Production methods of hydrogen. Combustive properties of hydrogen. Problems associated with hydrogen as fuel and solutions. Different methods of using hydrogen in SI and CI engines. Performance, emission and combustion analysis in engines. Hydrogen storage - safety aspects of hydrogen. **Textbook-1: Chapter 5 Textbook-2: Chapter 4**	
Module – 4	**08 Hrs**
Electric, Hybrid and Fuel Cell Vehicles: Layout of Electric vehicle and Hybrid vehicles – Advantages and drawbacks of electric and hybrid vehicles. System components, Electronic control system – Different configurations of Hybrid vehicles. Power split device. High energy and power density batteries – Basics of Fuel cell. **Textbook-1: Chapter 6 Textbook-2: Chapter 5**	

Module – 5	08 Hrs
Biogas, Natural Gas and LPG as Fuels Production methods of Biogas, Natural gas and LPG. Properties studies. CO2 and H2S scrubbing in Biogas., Modification required to use in SI and CI Engines- Performance and emission characteristics of Biogas, NG and LPG in SI and CI engines. **Textbook-1: Chapter 7 Textbook-3: Chapter 5**	

Course Outcomes: After completing the course, the students will be able to	
CO1	Describe the various energy fuels.
CO2	Apply the fundamental knowledge of mechanical engineering to various fuels.
CO3	Analyse the implications of energy fuels for various applications.
CO4	Interpret the impact of energy sources on the environment.

Text Books	
1	Ayhan Demirbas, 'Biodiesel A Realistic Fuel Alternative for Diesel Engines', Springer-Verlag London Limited 2008,ISBN-13: 9781846289941
2	Automobile engineering, Kirpal Singh, Vol I and II (12th Edition) Standard Publishers 2011

Reference Books	
1	Devaradjane. Dr. G., Kumaresan. Dr. M., "Automobile Engineering", AMK Publishers, 2013
2	Gerhard Knothe, Jon Van Gerpen, Jargon Krahl, The Biodiesel Handbook, AOCS Press Champaign, Illinois 2005.
3	Gerhard Knothe, Jon Van Gerpen, Jargon Krahl, The Biodiesel Handbook, AOCS Press Champaign, Illinois 2005.

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning	
1	Group of students visit CNG/LPG plant for gaining practical exposure that leads to comprehensive learning

CO – PO MAPPING

COURSE OUTCOMES	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	1	2	1	2		1						1	1
CO2	1	2	1									1	1
CO3	2	2	1									1	2
CO4	1	2	1	3								1	1

Semester: VI						
DESIGN FOR MANUFACTURING AND ASSEMBLY						
Course Code	**:**	**BME623D**		**Credits**	**:**	03
Hours/Week(L:T:P)	**:**	3:0:0		**CIE**	**:**	50 Marks
Total Hours	**:**	40		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**NIL**
Knowledge on Fundamental Concepts	**NIL**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	Understand the concepts of Geometric dimensioning and Tolerances in Engineering Drawing.
CLO2	Analyze the process capabilities and datum features in various components.
CLO3	Evaluate the design considerations of casting, injection moulding, die casting and powder metallurgical components.
CLO4	Estimate the assembly limits, machining sequence and process parameters.
CLO5	Analyzing global, regional, and local environmental issues influencing design decisions.

Module – 1	**08 Hrs**
Introduction: History of DFM, Design philosophy steps in Design process General Design rules for manufacturability basic principles of designing for economical production creativity in design. Evaluation method, Process capability. **Materials:** Selection of Materials for design Developments in Material technology criteria for material selection. **Text Book-1: Ch 1, Text Book-2: Ch 1, Ch 2, Reference Book-2: Ch 1, Ch 2**	
Module – 2	**08 Hrs**
Component Design-I: Machining Consideration: Design features to facilitate machining: drills,milling cutters, keyways, Doweling procedures, counter sunk screws, Reduction of machined area, simplification by separation, simplification by amalgamation, Design for machinability, Design for economy, Design for clampability, Design for accessibility, Design for assembly. **Component Design-II**: Casting Consideration: Redesign of castings based on parting line considerations, Minimizing core requirements, machined holes, redesign of cast members to obviate cores. Identification of uneconomical design, Modifying the design, group technology, Computer Applications for DFMA **Text Book-1: Ch 2, Text Book-2: Ch 3, Ch 4, Reference Book-2: Ch 3**	

Module – 3	08 Hrs
Assemble advantages: Development of the assemble process, choice of assemble method assemble advantages social effects of automation. **Automatic assembly transfer systems:** Continuous transfer, intermittent transfer, indexing mechanisms, and operator paced free – transfer machine. **GD&T** – Symbols, Three datum concept of dimensioning, Straightness, concentricity, Runout,Location Tolerance, Assembly of parts having concentric cylinders, Control of feature location by true position, Body of revolution, Roundness, Profile dimensioning, Tapers, Shaft of two diameters. Examples. **Text Book-1: Ch 3, Text Book-2: Ch 6**	
Module – 4	**08 Hrs**
Design of manual assembly: Design for assembly fits in the design process, general design guidelines for manual assembly, development of the systematic DFA methodology, assembly efficiency, classification system for manual handling, classification system for manual insertion and fastening, effect of part symmetry on handling time, effect of part thickness and size on handling time, effect of weight on handling time, parts requiring two hands for manipulation, effects of combinations of factors, effect of symmetry effect of chamfer design on insertion operations, estimation of insertion time. **Text Book-1: Ch 6, Text Book-3: Ch 5**	
Module – 5	**08 Hrs**
Design for the Environment: Introduction, Environmental objectives, Global issues, Regional and local issues, Basic DFE methods, Design guide lines, Example application, Lifecycle assessment, Basic method, Environmentally responsible product assessment, Weighted sum assessment method, Lifecycle assessment method, Techniques to reduce environmental impact, Design to minimize material usage, Design for disassembly, Design for recyclability, Design for remanufacture, Design for energy efficiency, Design to regulations and standard. **Text Book-1: Ch 7, Text Book-3: Ch 6**	

Course Outcomes: After completing the course, the students will be able to	
CO1	Apply the concepts of Geometrical dimensioning, selection of materials and tolerance for engineering products.
CO2	Analyze the design principles related to various manufacturing processes and assembly method
CO3	Develop the appropriate material and machining sequence for manufacturing processes
CO4	Estimating assembly times based on design parameters to enhance productivity and ergonomics.
CO5	Select a suitable manufacturing system considering environmental factors

Text Books	
1	Designing for Manufacture, Peck H, Pitman Publications, 1983
2	Engineering Design: A Materials and processing Approach, Dieter, G.E. McGraw Hill Co.Ltd 2000
3	Engineering Metrology, R K Jain, Khanna Publications, 2000.

Reference Books	
1	ASM Hand book, Vol.20. Material selection & Design.
2	Handbook of Products Design for Manufacturing: A Practical Guide to Lowcost Production Bralla, James G. McGraw Hill, New York, 1986.
3	Product Design for Manufacture and Assembly, Geoffery Boothroyed et al, Mercel Dekker Inc.New York.

CO – PO MAPPING

COURSE OUTCOMES	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	2	2		1						3	1
CO2	2	3	3	2								3	2
CO3	2	3	3	2								3	2
CO4	1	2	3	3								3	3
CO5	2	2	2	2	3	2						2	3

Semester: VI						
Additive Manufacturing						
Course Code	**:**	**BME624A**		**Credits**	**:**	03
Hours/Week(L:T:P)	**:**	3:0:0		**CIE**	**:**	50 Marks
Total Hours	**:**	40 hours Theory		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**NIL**
Knowledge on Fundamental Concepts	**NIL**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	To know the principal methods, areas of usage, possibilities and limitations of the Additive Manufacturing technologies.
CLO2	To be familiar with the characteristics of the different materials those are used in Additive Manufacturing.
CLO3	To know the principles of polymerization and powder metallurgy process, extrusion based system printing processes, sheet lamination processes, beam deposition processes, direct write technologies Direct Digital Manufacturing.
CLO4	To get exposed to process selection, software issues and post processing.

Module – 1	**08 Hrs**
Introduction and basic principles: Need for Additive Manufacturing, Generic AM process, stereo lithography or 3dprinting, rapid prototyping, the benefits of AM, distinction between AM and CNC machining, other related technologies reverse engineering technology. **Development of Additive Manufacturing Technology**: Introduction, computers, computer aided design technology, other associated technologies, the use of layers, classification of AM processes, metals systems, hybrid systems, milestones in AM development. **Additive Manufacturing Process chain**: Introduction, the eight steps in additive manufacture, variations from one AM machine to another, metal systems, maintenance of equipment, materials handling issues, design for AM, and application areas. **Textbook-1: Chapter1,2 Textbook-2: Chapter1**	
Module – 2	**08 Hrs**
Photo polymerization processes: Stereo lithography (SL), Materials, SL resin curing process, Micro Stereo lithography, Process Benefits and Drawbacks, Applications of Photo Polymerization Processes. **Powder bed fusion processes**: Introduction, Selective laser Sintering (SLS), Materials, Powder fusion mechanism, SLS Metal and ceramic part creation, Electron Beam melting (EBM), Process Benefits and Drawbacks, Applications of Powder Bed Fusion Processes. **Extrusion based systems**: Fused Deposition Modelling (FDM), Principles, Materials, Plotting and path control, Bio-Extrusion, Process Benefits and Drawbacks, Applications of Extrusion Based Processes. **Textbook-1: Chapter 3,4 Textbook-3: Chapter 3,4**	

Module – 3	08 Hrs
Printing Processes: evolution of printing as an additive manufacturing process, research achievements in printing deposition, technical challenges of printing, printing process modelling, material modification methods, three dimensional printing, advantages of binder printing **Sheet Lamination Processes**: Materials, Laminated Object Manufacturing (LOM), Ultrasonic Consolidation (UC), Gluing, Thermal bonding, LOM and UC applications. Beam Deposition Processes: introduction, general beam deposition process, description material delivery, BD systems, process parameters, typical materials and microstructure, processing structure–properties relationships, BD benefits and drawbacks. **Direct Write Technologies**: Background, ink –based DW, laser transfer, DW thermals pray, DW beam deposition, DW liquid phase direct deposition. **Textbook-1: Chapter5,6 Textbook-4: Chapter 3,4**	
Module – 4	**08 Hrs**
Guidelines for Process Selection: Introduction, selection methods for apart, challenges of selection, example system for preliminary selection, production planning and control. **Software issues for Additive Manufacturing**: Introduction, preparation of cad models – the STL file, problems with STL files, STL file manipulation. **Post Processing**: Support material removal, surface texture improvements, preparation for use as a pattern, property enhancements using non-thermal techniques and thermal techniques. **Textbook-1: Chapter5 Textbook-2: Chapter 5**	
Module – 5	**08 Hrs**
The use of multiple materials in additive manufacturing: Introduction, multiple material approaches, discrete multiple material processes, porous multiple material processes, blended multiple material processes, commercial applications using multiple materials, future directions. **AM Applications**: Examples for Aerospace, defence, automobile, Biomedical and general engineering industries. Direct digital manufacturing: Align Technology, Siemens and Phonak, DDM drivers, manufacturing vs. prototyping, lifecycle costing, future of direct digital manufacturing. **Textbook-1: Chapter6 Textbook-2: Chapter 6**	

Course Outcomes: After completing the course, the students will be able to	
CO1	Demonstrate the knowledge of the broad range of AM processes, devices, capabilities and materials that are available.
CO2	Describe the various software tools, processes and techniques that enable advanced/additive manufacturing.
CO3	Apply the concepts of additive manufacturing to design and create components that satisfy product development/prototyping requirements, using advanced/additive manufacturing devices and processes.
CO4	Elucidate characterization techniques in additive manufacturing.
CO5	Illustrate the latest trends and business opportunities in additive manufacturing.

Text Books	
1	Additive Manufacturing Technologies Rapid Prototyping to Direct Digital Manufacturing I. Gibson l D. W. Rosen l B. Stucker Springer New York Heidelberg Dordrecht, London ISBN: 978 1 441911193 eISBN: 978 14419 11209 DOI 10.1007/978 14419 11209.

2	"Rapid Prototyping: Principles & Applications Chua Chee Kai, Leong Kah Fai World Scientific 2003.
3	Rapid Prototyping: Theory & Practice Ali K. Kamrani, Springer 2006 Emand Abouel Nasr.
4	Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling" D.T. Pham, S.S. Dimov Springer 2001.

Web links and Video Lectures (e-Resources)	
1	NPTEL course on 3D printing and Additive manufacturing techniques
2	Videos on Additive Manufacturing and 3D printing Techniques

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning	
1	Quiz
2	Assignments/Presentations
3	Group Activity

CO – PO MAPPING

COURSE OUTCOMES	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	2	2	2	2		1						1	1
CO2	2	2	1									1	1
CO3	2	2	1									1	2
CO4	1	2	1	3								1	3
CO5	2	2	2	2	1	2						2	3

Semester: VI						
Mechanics of Composite Materials						
Course Code	**:**	**BME624B**		**Credits**	**:**	03
Hours/Week(L:T:P)	**:**	3:0:0		**CIE**	**:**	50 Marks
Total Hours	**:**	40 hours Theory		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**NIL**
Knowledge on Fundamental Concepts	**NIL**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	Understand the different matrix and reinforcements in composites and their properties.
CLO2	Interpret the properties, mechanics, and performance of composite materials
CLO3	Comprehend the various applications of Composite materials
CLO4	Interpret the various characterization techniques

Module – 1	**08 Hrs**
Introduction to Composite Materials and their testing: Definition, classification, and history of composite materials, mechanical advantage of composites, Constituents of composite materials: reinforcements, matrix, and fibers, Classification of composites, wettability, types of bonding at the interface, interfacial bond strength, ASTM Standards for Tensile, Compression, Fatigue, Impact Testing, **Characterization of Composites**: Working principles of: Scanning electron Microscope(SEM), Scanning Tunneling Microscopy (STM), Atomic Force Microscopy (AFM). **Textbook-1: Chapter 1,2**	
Module – 2	**08 Hrs**
Composites Processing Techniques: Layup and curing, open and closed mold processing, Hand layup techniques, Bag moulding and filament winding. Pultrusion, Pull-forming, Thermoforming, Injection moulding, -Diffusion bonding, Squeeze casting, Powder metallurgy, Cutting, Machining, and joining, tooling, Quality assurance. **Textbook-1: Chapter 3,4 Textbook-2: Chapter 3**	
Module – 3	**08 Hrs**
Macro Mechanics of a Lamina Introduction, Review of Definitions, Stress, Strain, Elastic Moduli, Strain Energy. Hooke's Law for Different Types of Materials: Anisotropic Material, Monoclinic Material, Orthotropic	

Material, Transversely Isotropic Material, Isotropic Material. Hooke's Law for a Two-Dimensional Unidirectional Lamina. Plane Stress Assumption. Reduction of Hooke's Law in Three Dimensions to Two Dimensions. Hooke's Law for a Two-Dimensional Angle Lamina, Engineering Constants of an Angle Lamina. Strength Failure Theories of an Angle, Maximum Stress Failure Theory, Maximum Strain Failure Theory, Tsai–Hill Failure Theory, Tsai–Wu Failure Theory. Numerical problems.

Textbook-1: Chapter 5 Textbook-3: Chapter 4

Module – 4	**08 Hrs**

Micro Mechanical Analysis of a Lamina

Introduction, Volume and Mass Fractions, Density, and Void Content, Volume Fractions, Mass Fractions, Density, Void Content. Evaluation of the Four Elastic Moduli, Strength of Materials Approach. Numerical problems.

Textbook-2: Chapter 4 Textbook-2: Chapter 5

Module – 5	**08 Hrs**

Interfaces, Applications and Testing of Composites

Interface in PMCs: Glass fiber/polymer, Carbon fiber/Polymer. Mechanical properties and applications of PMCs, interface in MMCs, Properties and applications of MMCs, Wear and Friction Testing of MMCs: Pin on Disk Testing, Abrasion and Scratch testing, Interfaces in CMCs, Properties of CMCs, Application of CMCs: Cutting tool inserts, Ceramic composite filters and other applications, Non-destructive testing of ceramic composites: Ultrasonic testing and X-Ray radiography.

Textbook-1: Chapter 6 Textbook-3: Chapter 5

Course Outcomes: After completing the course, the students will be able to	
CO1	Explain the classification, manufacturing, and standard testing processes of composites.
CO2	Apply mechanics theory in design of fiber reinforced composites
CO3	Analyze the performance of composites in engineering applications.
CO4	Investigate the processing technique, properties, and applications of a composite material through literature and prepare a suitable report.
* CO4 is assessed through Activity Based Assessment only	

Text Books	
1	Composite Materials: Science and Engineering, K. Krishan Chawla, Third Edition, 2012, Springer.
2	Mechanics of Composite Materials, Autar K. Kaw, Second Edition, 2005, CRC Press.
3	Characterization of Composite Materials, Hatsuo Ishida, Manning Publications Co.,2010

Reference Books	
1	An Introduction to Composite Materials by D. Hull and T. W. Clyne, 3rd Edition, 2019, Cambridge Solid State Science Series.
2	Mechanics of composite materials by Robert M. Jones, 2nd Edition 2015, Materials Science and Engineering Series Taylor & Francis.

Web links and Video Lectures (e-Resources)	
1	NPTEL course on Composite materials
2	Videos on composite material processing Techniques

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning	
1	Quiz
2	Assignments/Presentations
3	Group Activity

CO – PO MAPPING

COURSE OUTCOMES	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	2	1	1			1					1		
CO2	2	1	1										
CO3	1	1	2		2			2					
CO4	1	1	2								1		
CO5	1	1					1			1			

Semester: VI						
Subject Name: Refrigeration & Air Conditioning						
Course Code	**:**	**BME623B**		**Credits**	**:**	03
Hours/Week(L:T:P)	**:**	3:0:0		**CIE**	**:**	50 Marks
Total Hours	**:**	40		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	Physics, Mathematics and Chemistry
Knowledge on Fundamental Concepts	Thermodynamics & Heat Transfer
Knowledge on Connected Tools (If any)	NIL

Course Learning Objectives: This course will enable the students to	
CLO1	Study the basic definition, ASHRAE Nomenclature for refrigerating systems.
CLO2	Understand the working principles and applications of different types of refrigeration systems.
CLO3	Study the working of air conditioning systems and their applications.
CL04	Identify the performance parameters and their relations of an air conditioning system.

Module – 1	**08 Hrs.**
Introduction to Refrigeration –Basic Definitions, ASHRAE Nomenclature, Air Refrigeration Cycles reversed Carnot cycle, Bell-Coleman cycle analysis, Air Refrigeration systems - merits and demerits and applications; Aircraft refrigeration cycles, Joule Thompson coefficient and Inversion Temperature, Linde, Claude and Stirling cycles for liquefaction of air. **Industrial Refrigeration**- Chemical and process industries, Dairy plants, Petroleum refineries, Food processing and food chain, Miscellaneous **Textbook-1: Chapter 1,2**	
Module – 2	**08 Hrs.**
Vapour Compression Refrigeration System(VCRS): Comparison of Vapour Compression Cycle and Gas cycle, Vapour Compression Refrigeration system Working and analysis, Limitations, Superheat horn and throttling loss for various refrigerants, efficiency, Modifications to standard cycle – liquid suction heat exchangers, Grindlay cycle and Lorenz cycle, Optimum suction condition for optimum COP – Ewing's construction and Gosney's method. Actual cycles with pressure drops, Complete Vapour Compression Refrigeration System, Multi-Pressure, Ulti-evaporator systems or Compound Vapour Compression Refrigeration Systems – Methods like Flash Gas removal, Flash inter cooling and water Inter cooling. **Textbook-1: Chapter 3,4 Textbook-2: Chapter 3**	

Module – 3	**08 Hrs.**
Vapour Absorption Refrigeration Systems: Absorbent – Refrigerant combinations, Water-Ammonia Systems, Practical problems, Lithium- Bromide System, Contrast between the two systems, Modified Version of Aqua-Ammonia System with Rectifier and Analyzer Assembly. Practical problems – crystallization and air leakage, Commercial systems. **Other types of Refrigeration systems**: Brief Discussion on (i) Steam-Jet refrigeration system and ii) Thermoelectric refrigeration, pulse tube refrigeration, thermo acoustic refrigeration systems **Entropy:** Clausius inequality, Statement- proof, Entropy- definition, a property, change of entropy, entropy as a quantitative test for irreversibility, principle of increase in entropy, entropy as a coordinate. Problems **Textbook-1: Chapter 5 Textbook-3: Chapter 4**	
Module – 4	**08 Hrs.**
Refrigerants: Primary and secondary refrigerants, Designation of Refrigerants, Desirable properties of refrigerants including solubility in water and lubricating oil, material compatibility, toxicity, flammability, leak detection, cost, environment and performance issues Thermodynamic properties of refrigerants, Synthetic and natural refrigerants, Comparison between different refrigerants and applications, Special issues and practical implications Refrigerant mixtures – zoetrope and azeotropic mixtures. **Refrigeration systems Equipment:** Compressors, Condensers, Expansion Devices and Evaporators, A brief look at other components of the system. **Textbook-2: Chapter 4 Textbook-2: Chapter 5**	
Module – 5	**08 Hrs.**
Air-Conditioning: Introduction to Air-Conditioning, Basic Definition, Classification, power rating, Mathematical Analysis of Air-Conditioning Loads, Related Aspects, Different Air-Conditioning Systems- Central – Station Air-Conditioning System, Unitary Air-Conditioning System, Window Air Conditioner and Packaged Air-Conditioner, Components related to Air-Conditioning Systems. **Transport air conditioning Systems:** Air conditioning systems for automobiles (cars, buses etc.), Air conditioning systems for trains, Air conditioning systems for ships **Textbook-1: Chapter 6 Textbook-3: Chapter 5**	

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand the principles, nomenclature and applications of refrigeration systems.
CO2	Explain vapour compression refrigeration system and identify methods for performance improvement
CO3	Illustrate the working principles of air, vapour absorption, thermoelectric and steam jet and thermo acoustic refrigeration systems.
CO4	Estimate the performance of air-conditioning systems using the principles of psychrometry.
CO5	Compute and Interpret cooling and heating loads in an air-conditioning system.

Text Books	
1	Roy J. Dossat, Principles of Refrigeration, Wiley Limited
2	Arora C.P., Refrigeration and Air-conditioning, Tata Mc Graw –Hill, New Delhi, 2ndEdition, 2001.
3	Stoecker W.F., and Jones J.W., Refrigeration and Air-conditioning, Mc Graw - Hill, New Delhi 2nd edition, 1982.

Reference Books	
1	Dossat, Principles of Refrigeration Pearson-2006
2	S C Arora& S Domkundwar, Refrigeration and Air-Conditioning Dhanpat Rai Publication
3	Refrigeration and Air-Conditioning' by Manohar prasad

Web links and Video Lectures (e-Resources)	
1	http://nptel.ac.in/courses/112105128/#

CO – PO MAPPING

COURSE OUTCOMES	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	2		1			1					1		
CO2	1		1										
CO3	1		2		2			2					
CO4	1		2										
CO5	1						1			1			

Semester: VI						
PRODUCT DESIGN AND MANAGEMENT						
Course Code	**:**	**BME624D**		**Credits**	**:**	03
Hours/Week(L:T:P)	**:**	3:0:0		**CIE**	**:**	50 Marks
Total Hours	**:**	40		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**NIL**
Knowledge on Fundamental Concepts	**NIL**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	Understanding the user centred design process including form and colour theory.
CLO2	Understanding product metamorphosis, and ergonomics
CLO3	Implement the principles of ergonomics and how to apply the principles to industrial design.
CLO4	Understand the importance and techniques of human biological data collection and experiments.
CLO5	Obtain a knowledge and ability towards Accident Investigation and Safety Management

Module – 1	**08 Hrs**
Introduction to Product Design: Asimows Model: Definition of product design, Design by Evaluation, Design by Innovation, Essential Factors of Product Design, Flow and Value Addition in the Production Consumption Cycle. The Morphology of Design (The seven Phase), Primary Design phase and flowcharting, role of Allowance, Process Capability. **Textbook-1: Chapter 1,2**	
Module – 2	**08 Hrs**
Ergonomics and Industrial Design: Introduction general approach to the man machine relationship workstation designworking position. **Ergonomics and Production:** Ergonomics and product design –ergonomics in automated systems expert systems for ergonomic design. Anthropometric data and its applications in ergonomic, design limitations of anthropometric data use of computerized database. Case study. **Textbook-1: Chapter 3,4 Textbook-2: Chapter 3**	
Module – 3	**08 Hrs**
Aesthetic Concepts: Concept of unity concept of order with variety concept of purpose style and environment Aesthetic expressions. Style components of style house style, observation style in capital goods, case study. **Textbook-1: Chapter 5 Textbook-3: Chapter 4**	
Module – 4	**08 Hrs**
Visual Effects of Line and Form: The mechanics of seeing psychology of seeing general influences of line and form. **Colour:** Colour and light colour and objects colour and the eye colour consistency colour	

terms reactions to colour and colour continuation colour on engineering equipment's. **Textbook-2: Chapter 4 Textbook-2: Chapter 5**
Module – 5 **08 Hrs**
Ergonomics of Technology Management: Office Systems and Ergonomics, Consumer Ergonomics, Ergonomics Quality and Safety, Quality of Life. **Textbook-1: Chapter 6 Textbook-3: Chapter 5**

Course Outcomes: After completing the course, the students will be able to	
CO1	Illustrate the concept of product design and the ergonomics.
CO2	Design the various controls and displays by knowing the anthropometric data.
CO3	Characterize the psychology of visuals effects.
CO4	Evaluate the different colour combinations for optimal design of engineering equipments.
CO5	Understand the importance of environmental factors and aesthetics in industrial design and management.

Text Books	
1	Human Factors in Engineering and Design By Sanders & Mccormick (McGrawHill Publication)
2	Occupational Ergonomics – Principles and Applications By Tayyari & Smith (Chapman & Hall Publication)
3	The Power of Ergonomics as a Competitive Strategy By Gross & Right (Productivity Press)

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning	
1	Anthropometry
2	Hand strength and Back strength
3	Measurement of Environmental Factors
4	Grip Strength – Hand and Pinch

CO – PO MAPPING

COURSE OUTCOMES	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	2		1			1					1	1	
CO2	1		1									1	
CO3	1		2									1	
CO4	1		2									1	
CO5	1		1				1			1		1	

Semester: VI						
PROJECT MANAGEMENT						
Course Code	**:**	**BME645A**		**Credits**	**:**	03
Hours/Week(L:T:P)	**:**	3:0:0		**CIE**	**:**	50 Marks
Total Hours	**:**	40		**SEE**	**:**	50 Marks
Course Type	**:**	OEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**YES**
Knowledge on Fundamental Concepts	**NIL**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	To apprehend projects, classify their types, and analyze scalability of project tools.
CLO2	Develop a Work Breakdown Structure (WBS) and integrate it with organizational systems.
CLO3	Implement risk management plans (identification, analysis, response) and quality management tools.
CLO4	Manage project supply chains (contracts, partnerships) and apply the Balanced Scorecard approach.
CLO5	Optimize projects through crashing and probability-based time predictions.

Module – 1	**08 Hrs**
Introduction: Definition of project, characteristics of projects, understand projects, types of projects, scalability of project tools, project roles. **Project Selection and Prioritization** – Strategic planning process, Strategic analysis, strategic objectives, portfolio alignment – identifying potential projects, methods of selecting projects, financial mode / scoring models to select projects, prioritizing projects, securing and negotiating projects. **Textbook-1: Chapter 1,2 Reference book-3: Chapter 1**	
Module – 2	**08 Hrs**
Planning Projects: Defining the project scope, Project scope checklist, Project priorities, Work Breakdown Structure (WBS), Integrating WBS with organization, coding the WBS for the information system. **Scheduling Projects:** Purpose of a project schedule, historical development, how project schedules are limited and created, develop project schedules, uncertainty in project schedules, Gantt chart. **Textbook-1: Chapter 3,4 Reference book-2: Chapter 2**	
Module – 3	**08 Hrs**
Resourcing Projects: Abilities needed when resourcing projects, estimate resource needs, creating staffing management plant, project team composition issues, Budgeting Projects: Cost planning, cost estimating, cost budgeting, establishing cost control.	

Project Risk Planning: Risk Management Planning, risk identification, risk analysis, risk response planning, Project Quality Planning and Project Kick off: Development of quality concepts, project quality management plan, project quality tools, kicks off project, baseline and communicate project management plan, using Microsoft Project for project baselines.

Textbook-1: Chapter 5, Textbook-2: Chapter 3 Reference book-1: Chapter 3

Module – 4	**08 Hrs**

Performing Projects: Project supply chain management: Plan purchasing and acquisitions, plan contracting, contact types, project partnering and collaborations, project supply chain management.

Project Progress and Results: Project Balanced Scorecard Approach, Internal project, customer, financial issues, Finishing the project: Terminate project early, finish projects on time, secure customer feedback and approval, knowledge management, perform administrative and contract closure.

Textbook-2: Chapter 5, Textbook-3: Chapter 4 Reference book-2: Chapter 4

Module – 5	**08 Hrs**

Network Analysis: Introduction, network construction rules, Fulkerson's rule for numbering the events, AON and AOA diagrams; Critical path method (CPM) to find the expected completion time of a project, floats; PERT for finding expected duration of an activity and project, determining the probability of completing a project, predicting the completion time of project; crashing of simple projects.

Textbook-1: Chapter 6, Textbook-2: Chapter 5 Reference book-1: Chapter 5

Course Outcomes: After completing the course, the students will be able to	
CO1	Interpret the selection, prioritization and initiation of individual projects and strategic role of project management.
CO2	Realize the work breakdown structure by integrating it with organization.
CO3	Recognize the scheduling and uncertainty in projects and risk management planning using project quality tools.
CO4	Master the activities like purchasing, acquisitions, contracting, partnering and elaborations related to performing projects.
CO5	Draw the network diagram to calculate the duration of the project and reduce it using crashing.

Text Books	
1	Project Management, Timothy J Kloppenborg, Cengage Learning, Edition 2009.
2	Project Management, A systems approach to planning scheduling and controlling by Harold kerzner, CBS publication.
3	Project Management by S Choudhury, Mc Graw Hill Education (India) Pvt. Ltd. New Delhi,2016

Reference Books	
1	Project Management, Pennington Lawrence, Mc Graw hill
2	Project Management, A Moder Joseph and Phillips New Yark Van Nostrand, Reinhold.
3	Project Management, Bhavesh M. Patal, Vikas publishing House,

CO – PO MAPPING

COURSE OUTCOMES	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	2	1		2						2	3
CO2	2	3	3	2	2							3	2
CO3	2	3	2	3	1	2						3	2
CO4	1	2	3	2	3	3						3	1
CO5	2	3	3	3								3	2

Semester: VI						
RENEWABLE ENERGY POWER PLANTS						
Course Code	**:**	**BME645B**		**Credits**	**:**	03
Hours/Week(L:T:P)	**:**	3:0:0		**CIE**	**:**	50 Marks
Total Hours	**:**	40		**SEE**	**:**	50 Marks
Course Type	**:**	OEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**NIL**
Knowledge on Fundamental Concepts	**NIL**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	To explore society's present needs and future energy demands.
CLO2	To introduce the concepts of solar energy.
CLO3	To introduce the concepts and applications of Wind energy, Biomass energy, geothermal energy and Ocean energy as alternative energy sources.
CLO4	To get exposed to energy conservation methods.

Module – 1	**08 Hrs**
Introduction to Renewable Energy: Overview of global energy demand and the need for renewable energy, Comparison of renewable and nonrenewable energy sources, Environmental benefits and challenges of renewable energy. Solar Radiation: Extra Terrestrial radiation, spectral distribution of extraterrestrial radiation, solar constant, solar radiation at the earth's surface, beam, diffuse and global radiation. **Textbook-1: Chapter 1**	
Module – 2	**08 Hrs**
Solar Power Plants: **Measurement of Solar Radiation:** Pyrometer, shading ring pyrheliometer, sunshine recorder, schematic diagrams and principle of working. Solar Thermal Conversion: Collection and storage, thermal collection devices. Fundamentals of solar energy and photovoltaic (PV) technology, Types of solar power plants: gridtied,offgrid, and hybrid systems, Design considerations for solar power plants: site selection, orientation, and shading analysis, PV system components and their functionalities, Operation, maintenance, and performance monitoring of solar power plants. **Textbook-1: Chapter 2 Textbook-2: Chapter 2**	
Module – 3	**08 Hrs**
Wind Power Plants: Basics of wind energy and wind turbine technology, Types of wind turbines: horizontal axis and vertical axis; Wind resource assessment and site selection for wind power plants, Wind farm layout optimization and wake effects, Grid integration and power system considerations for wind power plants	

Geothermal Energy Conversion: Principle of working, types of geothermal station with schematic diagram, geothermal plants in the world, problems associated with geothermal conversion, scope of geothermal energy. **Textbook-3: Chapter 3 Textbook-4: Chapter 3**
Module – 4 **08 Hrs**
Tidal Power: Tides and waves as energy suppliers and their mechanics; fundamental characteristics of tidal power, harnessing tidal energy, advantages and limitations. **Ocean Thermal Energy Conversion:** Principle of working, OTEC power stations in the world, problems associated with OTEC. **Textbook-1: Chapter 4 Textbook-4: Chapter 4**
Module – 5 **08 Hrs**
Biomass Power Plants: Biomass as a renewable energy source: types and characteristics, Conversion technologies: combustion, gasification, and anaerobic digestion, biomass feedstock selection and availability, Environmental impacts and sustainability of biomass power plants, Integration of biomass power plants with other energy systems. **Hydrogen Energy:** Properties of Hydrogen with respected to its utilization as a renewable form of energy, sources of hydrogen, production of hydrogen, electrolysis of water, thermal decomposition of water, thermos Chemical production biochemical production. **Textbook-1: Chapter 5,6 Textbook-2: Chapter 5**

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand the need of renewable energy resources, historical and latest developments.
CO2	Describe the use of solar energy and the various components used in the energy production.
CO3	Appreciate the need of Wind Energy and the various components used in energy generation And the classifications.
CO4	Acquire the knowledge of fuel cells, wave power, tidal power and geothermal principles and Applications.
CO5	Understand the concept of Biomass energy resources and their classification, types of biogas Plants applications.

Text Books	
1	Nonconventional Energy sources, G D Rai, Khanna Publication, Fourth Edition,
2	Energy Technology, S.Rao and Dr. B.B. Parulekar, Khanna Publication. Solar energy, Subhas P Sukhatme, TataMcGrawHill, 2ndEdition,1996
3	Principles of Energy conversion, A.W.Culp Jr. McGraw Hill, 1996
4	Non Convention Energy Resources, ShobhNath Singh, Pearson, 2018

Web links and Video Lectures (eResources):	
1	https://www.investopedia.com/terms/i/internetenergy
2	Ebook URL: https://www.pdfdrive.com/nonconventionalenergysourcese10086374.html
3	Ebook URL: https://www.pdfdrive.com/nonconventionalenergysystemsnpteld17376903.html

4	Ebook URL: https://www.pdfdrive.com/renewableenergysourcesandtheirapplicationse33423592.Html
5	html https://onlinecourses.nptel.ac.in/noc18_ge09/preview
6	Ebook URL: https://www.pdfdrive.com/lecturenotesonrenewableenergysourcese34339149.

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning	
1	Visit nearest power plants and know the principles of power production
2	Seminar/poster presentation of all Renewable power plants
3	Assignments
4	Quiz

CO-PO MAPPING

COURSE OUTCOMES	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3						2						
CO2	3						2						
CO3	2												
CO4	2	3					2						
CO5	2	3					2						

Semester: VI						
Introduction to MECHATRONICS						
Course Code	**:**	**BME645C**		**Credits**	**:**	03
Hours/Week(L:T:P)	**:**	3:0:0		**CIE**	**:**	50 Marks
Total Hours	**:**	40		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**NIL**
Knowledge on Fundamental Concepts	**NIL**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	To acquire a strong foundation in science and focus in mechanical, electronics, control, software, and computer engineering, and a solid command of the newest technologies.
CLO2	To understand the evolution and development of Mechatronics as a discipline.
CLO3	To substantiate the need for interdisciplinary study in technology education
CLO4	To understand the applications of microprocessors in various systems and to know the functions of each element.
CLO5	To demonstrate the integration philosophy in view of Mechatronics technology
CLO6	To be able to work efficiently in multidisciplinary teams.

Module – 1	**08 Hrs**
Introduction: Scope and elements of Mechatronics, Mechatronics design process, measurement system, requirements and types of control systems, feedback principle, Basic elements of feedback control systems, Classification of control system. Examples of Mechatronics Systems such as Automatic Car Park system, Engine management system, Antilock braking system (ABS) control, Automatic washing machine. **Transducers and sensors:** Definition and classification of transducers, Difference between transducer and sensor, Definition and classification of sensors, Principle of working and applications of light sensors, Potentiometers, LVDT, Capacitance sensors, force and pressure sensors, Strain gauges, temperature sensors, proximity switches and Hall Effect sensors. **Text Book-1: Ch 1,2 Text Book-2: Ch 1, Ch 2**	
Module – 2	**08 Hrs**
Signal Conditioning: Introduction – Hardware – Digital I/O, Analog to digital conversions, resolution, Filtering Noise using passive components – Registers, capacitors, amplifying signals using OP amps. Digital Signal Processing – Digital to Analog	

conversion, Low pass, high pass, notch filtering. Data acquisition systems DAQS), data loggers, Supervisory control and data acquisition (SCADA), Communication methods.
Electro Mechanical Drives: Relays and Solenoids – Stepper Motors – DC brushed motors – DC brushless motors – DC servo motors – 4quadrant servo drives, PWM's – Pulse Width Modulation.
Text Book-1: Ch 3,4 Text Book-3: Ch 3, Ch 4

Module – 3	**08 Hrs**

Microprocessor & Microcontrollers: Introduction, Microprocessor systems, Basic elements of control systems, Microcontrollers, Difference between Microprocessor and Microcontrollers. Microprocessor Architecture: Microprocessor architecture and terminology CPU,memory and address, I/O and Peripheral devices, ALU, Instruction and Program, Assembler, Data Registers, Program Counter, Flags, Fetch cycle, write cycle, state, bus interrupts. Intel's 8085A Microprocessor.
Text Book-3: Ch 5 Text Book-4: Ch 5

Module – 4	**08 Hrs**

Programmable Logic Controller: Introduction to PLCs, Basic structure of PLC, Principle of operation, input and output processing, PLC programming language, ladder diagram, ladder diagrams circuits, timer counters, internal relays, master control, jump control, shift registers, data handling, and manipulations, analogue input and output, selection of PLC for application.
Application of PLC control: Extending and retracting a pneumatic piston using latches, control of two pneumatic pistons, control of process motor, control of vibrating machine, control of process tank, control of conveyer motor etc.
Text Book-1: Ch 6,8 Text Book-2: Ch 5, Ch 6

Module – 5	**08 Hrs**

Mechatronics in Computer Numerical Control (CNC) machines: Design of modern CNC machines – Machine Elements: Different types of guide ways, Linear Motion guide ways. Bearings: antifriction bearings, hydrostatic bearing and hydrodynamic bearing. Recirculating ball screws. Typical elements of open and closed loop control systems. Adaptive controllers for machine tools.
Mechatronics Design process: Stages of design process – Traditional and Mechatronics design concepts – Case studies of Mechatronics systems – Pick and place Robot – Automatic car park barrier.
Text Book-3: Ch 5,6 Text Book-4: Ch 6

Course Outcomes: After completing the course, the students will be able to	
CO1	Illustrate various components of Mechatronics systems.
CO2	Assess various control systems used in automation.
CO3	Design and conduct experiments to evaluate the performance of a Mechatronics system or Component with respect to specifications, as well as to analyses and interpret data.
CO4	Apply the principles of Mechatronics design to product design.
CO5	Function effectively as members of multidisciplinary teams.

Text Books	
1	Mechatronics System Design by Devdas Shetty and Richard A Kolk, Second edition, Thomson Learning Publishing

2	Company, Vikas publishing house, 2001.
3	W. Bolton, “Mechatronics” Addison Wesley Longman Publication, 1999.
4	Shetty and Kolk “Mechatronics System Design”Cengage Learning, 2010

Web links and Video Lectures (eResources):	
1	https://nptel.ac.in

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning	
1	Quiz
2	Presentations
3	Group Activity

CO – PO MAPPING

COURSE OUTCOMES	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1								3	2
CO2	2	3	2	2								3	1
CO3	2	3	2	3	2	1						3	2
CO4	2	2	3	2								3	3
CO5												2	3

Semester: VI						
MODERN MOBILITY						
Course Code	**:**	**BME645D**		**Credits**	**:**	03
Hours/Week(L:T:P)	**:**	3:0:0		**CIE**	**:**	50 Marks
Total Hours	**:**	40		**SEE**	**:**	50 Marks
Course Type	**:**	OEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**NIL**
Knowledge on Fundamental Concepts	**NIL**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	To understand the different chassis design & main components of automobile
CLO2	To understand the working of transmission and control system employed in automobiles
CLO3	To understand the automotive pollution and alternative automotive technologies under trail
CLO4	To understand the upcoming electric vehicle technology

Module – 1 Mobility Systems	**08 Hrs**
History of Automobile, Classification of Automobile w.r.t Usage, Chassis, Body, Power Sources, capacity, main components of Internal Combustion Engines and their Functions, Modern Fuel supply system, Cooling System, Lubrication System & Ignition System, Engine Management System. **Text Book-1: Ch 1 Text Book-2: Ch 1**	
Module – 2 Power Transmission	**08 Hrs**
Clutches; Plate Clutches, Cone Clutch, Centrifugal Clutch, Fluid Flywheel **Gear Box;** Gear Shifting mechanism, synchromesh Gear box, Torque converter, Automatic Manual Transmission (AMT), Automatic Transmission (AT), Continuously Variable Transmission (CVT), Infinitely Variable Transmission (IVT)& IMT, Working of Differential. **Types of Tyres** Radial & Conventional, Tubeless Tyres, Tubed Tyres Puncture patching. **Text Book-1: Ch 2 Text Book-2: Ch 2**	
Module – 3 Direction Control & Braking	**08 Hrs**
Steering system mechanisms & Linkages, Steering gear boxes Rack & pinion, worm & wheel construction & working, power Steering construction & working, steering geometry, Wheel balancing **Braking System** Mechanism and Linkages; Mechanical Brakes, Hydraulic Brakes, Power Brakes, Parking brakes, ABS **Suspension** – layout & working of Hydraulic& Air suspension, independent suspension. **Text Book-3: Ch 3 Text Book-4: Ch 3**	

Module – 4 Exhaust Emission & Alternate Sources	**08 Hrs**
Exhaust gas pollutants and their effects on environment, Emission norms, IC engine fuel types, extraction& availability, **BIOFUELS** – Production and impact. Ethanol engines, CNG vehicles operation, advantages & disadvantages, overview of Hydrogen fuel cell vehicles, advantages & disadvantages, IC engine/ electric hybrid vehicles overview, layout, transmission & control system, solar powered vehicles wind powered vehicles, super capacitors, supply rails. **Text Book-1: Ch 4 Text Book-4: Ch 4**	
Module – 5 Electrical Vehicles	**08 Hrs**
Electric vehicles principle and components layout of two & 4wheeler, Motors used in Electric vehicles –types overview of construction and working, power transmission & control system in Electric vehicles. Batteries – construction & working principle of Lead acid, nickel based, sodium based, Lithium & Metal Air batteries. Battery charging types and requirements. **Text Book-1: Ch 5 Text Book-2: Ch 5**	

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand the working of different systems employed in automobile
CO2	Analyse the limitation of present day automobiles
CO3	Evaluate the energy sources suitability
CO4	Apply the knowledge for selection of automobiles based on their suitability

Text Books	
1	Electric Vehicle Technology Explained James Larminie Oxford Brookes University, Oxford, UK John Lowry Acenti Designs Ltd., UK
2	Automobile engineering, Kirpal Singh, Vol I and II (12th Edition) Standard Publishers 2011
3	Automotive Mechanics, S. Srinivasan, (2nd Edition) Tata McGraw Hill 2003.
4	Automotive mechanics, William H Crouse & Donald L Anglin (10th Edition) Tata McGraw Hill Publishing Company Ltd., 2007

Web links and Video Lectures (e-Resources)	
1	https://archive.nptel.ac.in/courses/107/106/107106088/
2	https://onlinecourses.nptel.ac.in/noc20_de06/preview
3	https://www.digimat.in/nptel/courses/video/107106088/L01.html
4	https://nptel.ac.in/courses/107106088
5	https://www.youtube.com/watch?v=LZ82iANWBL0&list=PLbMVogVj5nJTW50jj9_gvJmdwFWHaqR5J

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning	
1	Operate the cut section models of complete vehicle chassis and observe the working of all components
2	Dismantle & Assemble the Automotive Engine, Gear Box, Clutch, brakes
3	Prepare the posters of automobile chassis & display
4	Visit nearby automobile showrooms/ service station
5	Prepare a comparison statement of different automobiles using specification provided by respective manufacturers
6	Visit auto expo

CO – PO MAPPING

COURSE OUTCOMES	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1								3	2
CO2	2	3	2	2								3	1
CO3	2	3	2	3	2	1						3	2
CO4	2	2	3	2								3	3

Semester:VI						
DESIGN LAB						
Course Code	**:**	**BMEL607**		**Credits**	**:**	01
Hours/Week(L:T:P)	**:**	0:0:2		**CIE**	**:**	50 Marks
Total Hours	**:**	30		**SEE**	**:**	50 Marks
Course Type	**:**	PCCL		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**YES**
Knowledge on Fundamental Concepts	**NIL**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	To understand the concepts of natural frequency, logarithmic decrement, damping and damping ratio.
CLO2	To understand the techniques of balancing of rotating masses and influence of gyroscopic couple.
CLO3	To verify the concept of the critical speed of a rotating shaft.
CLO4	To illustrate the concept of stress concentration using Photo elasticity.
CLO5	To appreciate the equilibrium speed, sensitiveness, power and effort of a Governor.
CLO6	To illustrate the principles of pressure development in an oil film of a hydrodynamic journal bearing.
CLO7	To visualize different mechanisms and cam motions
CLO8	Modern computing techniques are preferred to be used wherever possible

Sl No.	**Experiments**
1	Determination of natural frequency, logarithmic decrement, damping ratio and damping coefficient in a single degree of freedom vibrating systems (longitudinal and torsional)
2	Balancing of rotating masses
3	Determination of critical speed of a rotating shaft
4	Determination of equilibrium speed, sensitiveness, power and effort of Porter/Proell /Hartnell Governor.
5	Determination of Pressure distribution in Journal bearing
6	Study of different types of cams, types of followers and typical follower motions.
7	Obtain cam profile for any two types of follower motions and types of followers
8	Determination of Fringe constant of Photo elastic material using. a) Circular disc subjected to diametral compression. b) Pure bending specimen (four point bending).

Demonstration Experiments (For CIE)	
9	Study the principle of working of a Gyroscope and demonstrate the Effect of gyroscopic Couple on plane disc
10	Demonstration and study of operation of different Mechanisms and their Inversions: Slider crank chain, Double slider crank chain and its inversions, Quick return motion mechanisms Peaucellier's mechanism. Geneva wheel mechanism, Ratchet and Pawl mechanism, toggle mechanism, pantograph, Ackerman steering gear mechanism
11	Demonstration of stress concentration using Photo elasticity for simple components like plate with a hole under tension or bending, circular disk with circular hole under compression

Course Outcomes: After completing the course, the students will be able to	
CO1	Compute the natural frequency of the free and forced vibration of single degree freedom systems, critical speed of shafts.
CO2	Carry out balancing of rotating masses and gyroscope phenomenon.
CO3	Analyse the governor characteristics.
CO4	Determine stresses in disk, beams and plates using photo elastic bench.
CO5	Determination of Pressure distribution in Journal bearing

Semester: VI						
Indian Knowledge Systems (Theory) Common to all UG Programs						
Course Code	**:**	**BIK609**		**Credits**	**:**	03
Hours/Week(L:T:P)	**:**	1:0:0		**CIE**	**:**	100 Marks
Total Hours	**:**	15 hours		**SEE**	**:**	
Course Type	**:**	NCMC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**NIL**
Knowledge on Fundamental Concepts	**NIL**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	To facilitate the students with the concepts of Indian traditional knowledge and to make them understand the Importance of roots of knowledge system.
CLO2	To make the students understand the traditional knowledge and analyse it and apply it to their day-to-day life.

Module – 1	**08 Hrs**
Introduction to Indian Knowledge Systems (IKS): Overview, Vedic Corpus, Philosophy, Character scope and importance, traditional knowledge vis-a-vis indigenous knowledge, traditional knowledge vs. western knowledge. **Text Book-1: Ch 1 Text Book-2: Ch 1**	
Module – 2	**08 Hrs**
Traditional Knowledge in Humanities and Sciences: Lingistics, Number and measurements- Mathematics, Chemistry, Physics, Art, Astronomy, Astrology, Crafts and Trade in India and Engineering and Technology. **Text Book-1: Ch 2 Text Book-2: Ch 2**	
Module – 3	**08 Hrs**
Traditional Knowledge in Professional domain: Town planning and architecture-Construction, Health, wellness and Psychology-Medicine, Agriculture, Governance and public administration, United Nations Sustainable development goals. **Text Book-3: Ch 3 Text Book-3: Ch 3**	

Course Outcomes: After completing the course, the students will be able to	
CO1	Provide an overview of the concept of the Indian Knowledge System and its importance.
CO2	Appreciate the need and importance of protecting traditional knowledge.
CO3	Recognize the relevance of Traditional knowledge in different domains.
CO4	Establish the significance of Indian Knowledge systems in the contemporary world.

Text Books	
1	**Introduction to Indian Knowledge System- concepts and applications**, B Mahadevan, Vinayak Rajat Bhat, Nagendra Pavana R N, 2022, PHI Learning Private Ltd, ISBN-978-93- 91818-21-0
2	**Traditional Knowledge System in India**, Amit Jha, 2009, Atlantic Publishers and Distributors (P) Ltd., ISBN-13: 978-8126912230,
3	**Knowledge Traditions and Practices of India**, Kapil Kapoor, Avadesh Kumar Singh, Vol. 1, 2005, DK Print World (P) Ltd., ISBN 81-246-0334,

Web links and Video Lectures (e-Resources)	
1	https://www.youtube.com/watch?v=LZP1StpYEPM
2	https://nptel.ac.in/courses/121106003
3	http://www.iitkgp.ac.in/department/KS;jsessionid=C5042785F727F6EB46CBF432D7683B63 (Centre of Excellence for Indian Knowledge System, IIT Kharagpur)
4	https://www.wipo.int/pressroom/en/briefs/tk_ip.html
5	https://unctad.org/system/files/official-document/ditcted10_en.pdf
6	http://nbaindia.org/uploaded/docs/traditionalknowledge_190707.pdf
7	https://unfoundation.org/what-we-do/issues/sustainable-development-20goals/?gclid=EAIaIQobChMInp-Jtb_p8gIVTeN3Ch27LAmPEAAYASAAEgIm1vD_BwE

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning	
1	Quiz
2	Presentations

CO – PO MAPPING

COURSE OUTCOMES	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	1					3	2	2		2			
CO2		1				3	2	3		2			
CO3	2	2	1			3	3	2		2			
CO4	1	2	2	1		3	3	2		2			

Institute Vision

Preparing Competent Engineering and Management Professionals to Serve the Society

Institute Mission

- Providing Students with a Sound Knowledge in Fundamentals of their branch of Study.
- Promoting Excellence in Teaching, Training, Research and Consultancy.
- Exposing Students to Emerging Frontiers in various domains enabling Continuous Learning.
- Developing Entrepreneurial acumen to venture into Innovative areas.
- Imparting Value based Professional Education with a sense of Social Responsibility.

Department Vision

Building Technically Competent Engineers to Serve the Society

Department Mission

- Imparting strong fundamental knowledge in Mechanical Engineering and allied fields.
- Fostering a culture of collaboration and propagating Industry institute interactions to enhance advances in latest technologies.
- Creating State-of-Art facilities benefitting students and faculty to carryout Research, Innovation and Consultancy.
- Providing conducive environment for both students and faculty to engage in lifelong learning activities.
- Inculcating Professional ethics, Leadership qualities and Entrepreneurial skills among students.

SJC INSTITUTE OF TECHNOLOGY

An Autonomous Institution under VTU from 2024-25

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