POOJYA DODDAPPA APPA COLLEGE OF ENGINEERING, KALABURAGI
Choice Based Credit System (CBCS)
Scheme of Teaching and Examination 2022 – 23
(Effective from the academic year 2021 – 22)

VII Semester B.E.Mechanical Engineering

Sl. No.	Course and Course Code		Course Title	Teaching Department	Teaching Hours/Week				Examination				Credits
					Theory Lecture	Tutorial	Practical /Drawing	Self Study	Duration in hours	SEE Marks	CIE Marks	Total Marks	
1.	PC	19ME71	COMPUTER INTEGRATED MANUFACTURING	ME	4	-	--		03	50	50	100	4
2.	PC	19ME72	ENERGY ENGINEERING	ME	4	-	--		03	50	50	100	4
3.	PE	19ME73X	Elective- 3	ME	3	-	--		03	50	50	100	3
4.	PE	19ME74X	Elective-4	ME	3	-	--		03	50	50	100	3
5.	OE	19OE75X	Open Elective- II	ALL	3	-	--		03	50	50	100	3
6.	PC	19MEL75	SIMULATION & CIM LAB	ME	-	-	2		03	50	50	100	1
7.	PC	19ME76	Seminar	ME	-	-	2		03	--	50	100	1
8.	PROJ	19MEP77	Project Work Phase - 1	ME	-		2		03	50	50	100	2
9.	INT	19MEIN78	Internship	(To be carried out during the intervening vacations of VI and VII semesters)					-	--	--	--	-
Total					**17**	**--**	**06**		**24**	**350**	**400**	**750**	**21**

Note: PC: Professional core, PE: Professional Elective, OE: Open Elective, MP: Mini-project, INT: Internship.

Internship: All the students admitted to III year of BE/B.Tech have to undergo mandatory internship of 4 weeks during the vacations of VI and VII semesters and /or VII and VIII semesters.

Elective- 3

1.19ME731: QUALITY ASSURANCE AND RELIABILITY

2. 19ME732: DESIGN FOR MANUFACTURE

3. 19ME733: FINITE ELEMENT METHODS

4. 19ME734: EXPERIMENTAL STRESS ANALYSIS

5. 19ME735: NANOTECHNOLOGY

Elective- 4

1.19ME741: ADVANCED FOUNDRY TECHNOLOGY

2. 19ME742: ADVANCED MATERIALS TECHNOLOGY

3. 19ME743: ALTERNATIVE FUELS

4. 19ME744: CRYOGENIC

5. 19ME745: MECHATRONICS

Open Elective- II

1.19OE751M: NON-CONVENTIONAL ENERGY SOURCES

POOJYA DODDAPPA APPA COLLEGE OF ENGINEERING, KALABURAGI
Choice Based Credit System (CBCS)
Scheme of Teaching and Examination 2022 – 22
(Effective from the academic year 2021 – 22)

VIII Semester B.E.Mechanical Engineering

Sl. No.	Course and Course Code		Course Title	Teaching Department	Teaching Hours/Week			Examination				Credits
					Theory Lecture	Tutorial	Practical /Drawing	Duration in hours	SEE Marks	CIE Marks	Total Marks	
1.	PC	19ME81	PROJECT MANAGEMENT	ME	4	-	--	03	50	50	100	4
2.	PE	19ME82X	Professional Elective- 5	ME	3	-	--	03	50	50	100	3
3.	OE	19OE83X	Open Elective- III	ALL	3	-	--	03	50	50	100	3
4.	MOOC	19ME8NTPEC	Certification Course	--	--	--	--	--	--	--	--	1
5.	PROJ	19MEP84	Project Work Phase - 2	ME	-		4	03	50	50	100	8
6.	INT	19MEIN78	Internship	(Completed during the intervening vacations of VI and VII semesters and /or VII and VIII semesters.)				-	--	--	--	2
Total					**10**	**-**	**04**	**12**	**200**	**200**	**400**	**21**

Note: PC: Professional core, PE: Professional Elective, OE: Open Elective, MP: Mini-project, INT: Internship.

Internship: All the students admitted to III year of BE/B.Tech have to undergo mandatory internship of 4 weeks during the vacations of VI and VII semesters and /or VII and VIII semesters.

Elective- 5

1.19ME821: REPID PROTOTYPING AND MODELLING

2. 19ME822: FLEXIBLE MANUFACTURING SYSTEMS

3. 19ME823: VEHICLE DYNAMICS

4. 19ME824: COMPUTIONAL FLUID DYNAMICS

5. 19ME825: MICRO ELECTRO-MECHAICAL SYSTEMS **(**MEMS)

Open Elective- III

1.19OE831: TOTAL QUALITY MANAGEMENT

COMPUTER INTEGRATED MANUFACTURING(CIM)				
Subject Code	19ME71	Credits	04	CIE: 50
Number of Lecture Hours/Week	4 (Theory)			SEE: 50
Total Number of Lecture Hours	52			SEE Hours: 03

Course Objectives:

1) To impart knowledge of CIM and analysis.
2) To make students to understand the CNC Machine and its Tools, CNC part programming .
3) To expose students to Transfer mechanisms and automated flow lines.
4) To expose students to Material handling and storage systems.
5) To introduce the students to the concepts of computerized manufacturing planning and quality control

Modules	Teaching Hours
Module –I **COMPUTER INTEGRATED MANUFACTURING**: Introduction of CIM, CIM hardware and software, Role of the Elements of CIM system, Product development cycle, Sequential and concurrent engineering, Soft and hard prototyping. **FINITE ELEMENTAL MODELING AND ANALYSIS IN CIM:** Introduction ,General steps involved in FEM, Types of analysis, element and load types, simple numerical problems**.**	10 Hours
Module –II **COMPUTER NUMERICAL CONTROL:** Basic components of NC , Concepts of CNC , DNC, machining centers and their advantages. CNC tooling- turning tool geometry ,milling tooling system, tool presetting, work holding devices **CNC PROGRAMMING:** Steps involved in development of a part program, Manual part programming for turning, milling and drilling operations.	11 Hours
Module –III **HIGH VOLUME PRODUCTION SYSTEM:** Work part transport - continuous, Intermittent ,synchronous .Transfer mechanisms -linear-Walking beam, roller ,Chain drive, Rotary -Rack and pinion, ratchet and pawl, Geneva wheel. buffer storage, control functions. **ANALYSIS OF AUTOMATED FLOW LINE:** General terminology and analysis, Analysis of transfer line without storage, upper bound approach, lower bound approach, analysis of transfer lines with storage buffers and simple problems.	11 Hours
Module –IV **AUTOMATED MATERIAL HANDLING AND STORAGE:** Material handling functions, overview of metal handling equipment, Material handling analysis, Design of system, conveyor system, automated guided vehicle system, automated storage/ retrieval systems, carousel storage systems, Work in process storage .	10 Hours

Module –V	
COMPUTERIZED MANUFACTURING PLANNING SYSTEM: Computer-aided process planning: retrieval and generative type, material requirement planning, Capacity planning, Group technology: part family, parts classification and coding system. **COMPUTER AIDED QUALITY CONTROL:** Inspection methods ,non contact inspection methods, machine vision system ,optical inspection method, coordinate measuring machine, computer aided testing.	10 Hours

Question paper pattern:

1. Total of Ten Questions with two from each MODULE to be set covering the entire syllabus.
2. Five full questions are to be answered choosing at least one from each MODULE.
3. Each question should not have more than 4 sub divisions.

Text books:

1 Automation, Production Systems and Computer-Integrated Manufacturing. Mikell P Groover 4th Edition,2015.
2 CAD / CAM Principles and Applications P N Rao Tata McGraw-Hill 3rd Edition, 2015.
3 CAD/CAM/CIM Dr. P. Radhakrishnan New Age International Publishers, New Delhi. 3rd edition

Reference Books:

1 . CAD/CAM -zimmers & grover-PHL

2. CAD/CAM zeild-Mc-Graw Hill-2005.

E books and online course materials:

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

CO	Course Outcomes
CO1	Discuss the role of CIM in manufacturing and analysis.
CO2	Explain the concept of CNC and able to prepare part programs for simple jobs.
CO3	Discuss various transfer mechanisms and analysis of automated flow line's
CO4	Recognize various material handling , storage systems.
CO5	Understand the modern trends in manufacturing like CAPP ,GT and CAQC.

ENERGY ENGINEERING				
Subject Code	19ME72	Credits	04	CIE: 50
Number of Lecture Hours/Week	4 (Theory)			SEE: 50
Total Number of Lecture Hours	52			SEE Hours: 03
Prerequisite : The Energy Engineering major interweaves the fundamentals of classical and modern physics, chemistry, and mathematics with energy engineering applications.				

Course Objectives:

1. To Define and understand steam power plant machinery and process.
2. To Understand the functioning of boiler accessories, natural, forced and balanced draft systems.
3. To Understand the diesel engine power plant, accessories and layout.
4. To Define and understand the cogeneration, hydroelectric, gas turbine power plants, accessories and Layouts.
5. To Define and understand nuclear power plant fundamentals, nuclear fuels-use and disposal of nuclear waste.
6. To Understand and analyze the power plant economics as well as performance.

Modules	Teaching Hours
Module –I **Steam Power Plant:** Layout of steam power plant, different types of fuels used for steam generation, Equipment of burning (overfeed and underfeed stokers), Burners (long flame, turbulent flame, tangential, cyclone burners),unit system and bin system. Pulverised fuel furnaces (No numericals). **Coal, Ash Handling and Different Types of Boilers:** Coal and Ash handling, Generation of steam using forced circulation, high and supercritical pressures, A brief account of LaMount, Benson, Velox, and Loeffer steam generators (No numericals).	10 Hours
Module –II **Chimneys:** Types of chimneys (Natural, forced, induced and balanced draft) Calculations involving height of chimney to produce a given draft (Numerical). **Accessories for the Steam Generator Cooling Towers and Ponds:** Air Pre-heaters Study of different types of cooling towers and ponds. Accessories for the Steam Generator such as super-heaters, de-super heater, Re heaters, Economizers (No numericals).	10 Hours
Module –III **Diesel Engine Power Plant:** Layout of a diesel power plant. Method of starting diesel engines, cooling and lubrication system for the diesel engine. Filters, centrifuges, Oil heaters, Intake and exhaust system. Advantages and disadvantages of the diesel power plant. (No numericals) **Nuclear Power Plant:** Principles of release of nuclear energy fusion & fission reactions. Nuclear fuels used in the reactors. Radiation hazards, Shieldings, Radio active waste disposal, Nuclear reactors and its types (PWR, BWR, HGR,GCR, LMCR, Fast Breeder reactor) Site selection criteria area.(No numericals).	10 Hours

Module –IV **Hydro-Electric Plants:** Storage and pondage, flow duration and mass curves, hydrographs, Low, medium and high head plants, pumped storage plants, Penstock, water hammer, surge tanks, gates and valves, power house, general layout. A brief description of some of the important Hydel Installations in India (Numerical). **Gas Turbine Power Plant:** Advantages & Disadvantages of the gas turbine plant, Open & closed cycle turbine plants with the accessories. Multi stage expansion and multi stage compression Different methods of improving efficiency (Reheat regeneration and inter cooling) (No numericals)	11 Hours
Module –V **Choice of Site for Power Station:** Load estimation, load duration curve, load factor, capacity factor, use factor, diversity factor, demand factor, Effect of variable load on power plant, selection of the number and size of units (Numerical). **Economic Analysis of Power Plant:** Cost of energy production, selection of plant and generating equipment, performance and operating characteristics of power plants, tariffs for electrical energy (Numerical).	11 Hours

Question paper pattern:

1. Total of Ten Questions with two from each MODULE to be set covering the entire syllabus.
2. Five full questions are to be answered choosing at least one from each MODULE.
3. Each question should not have more than 4 sub divisions.

Text books:

1. Power plant Engineering, P.K Nag, Tata Mc Graw Hill.
2. Power Plant Engineering, Er.R K Rajput Laxmi Publications (P) Ltd. New Delhi.
3. Power Plant Engineering, G.R.Nagpal, Khanna Publishers, 2006

Reference Books:

1.Power plant Engineering, F.T Morse, Van Nostrand.
2. Power Plant Engineering, Dhomakundawar, Dhanpath Rai sons. 2003
3. Power Plant Technology, M.M.Wakil, Tata Mc Graw Hill Publishers, 2nd Edition

E books and online course materials:

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

CO	Course Outcomes
CO1	Identify and choose the various components needed for a steam power plant.
CO2	Interpret the various accessories and auxiliaries for steam power plants.
CO3	Choose the diesel engine and nuclear power plant fundamentals required for the geographical area.
CO4	Analyze power plant layout for a hydroelectric and gas turbine power plant.
CO5	Predict the usage of base load and peak load plant and analyze, Interpret the power plant economics and recommend solutions.

Elective-3

QUALITY ASSURANCE AND RELIABILITY

Subject Code	19ME731	Credits	03	CIE: 50
Number of Lecture Hours/Week	3 (Theory)			SEE: 50
Total Number of Lecture Hours	42			SEE Hours: 03

Prerequisite: Student should have knowledge of Industrial management, Statistics and probability, reliability.

Course Objectives:

1. To learn the fundamentals of Quality tools, techniques and quality production.
2. To have knowledge the quality and reliability tools and techniques to solving real world problems related to industry.
3. Learn to achieve reliability with cost related aspects.

Modules	Teaching Hours
MODULE-I **Basic Concepts of Quality:** Definition of Quality, Factors of quality, Quality of Design, Quality of conformance, Quality of performance. Objectives of quality control and its characteristics. **Statistical Quality Control and Cost of Quality:** Introduction to Statistical Quality control (SQC), types and its benefits. Cost of quality Categories, optimum cost of performance, Economics of quality design, specification of quality.	08 Hours
MODULE-II **Concepts in Probability :** Events, Sample space, Laws of probability (Addition law of probability, Multiplication law of probability and law of Conditional probability) Numerical. **Probability Distributions:** Discrete and Continuous Distributions, Binomial Distributions, Poisson Distributions, Normal Distributions , Weibull Distribution, Numerical.	09 Hours
MODULE-III **Statistical Aspects and Control Charts:** Statistical Tools in Quality control Control charts for Variable, Procedure, Interpretation and analysis using X-chats, R-Charts, Process capacity estimation, and Process improvement. Numerical **Control Charts for Attributes:** Practical limitation of the control charts for variables, Definition of fraction defective(p), Comparison of X and R charts with P-chart, control limits (3σ limits) on p Chart, Choice between p- chart and np-chart. Numerical.	09 Hours

MODULE-IV **Reliability:** Definition, basic elements and Achievements, Methods for improving Design Reliability and tests. **Failure Data Analysis:** Failure data, MTTF, MTBF, Bathtub curve, Mean life, life Testing, Introduction to failure Mode and effect Analysis. Numerical.	08 Hours
MODULE-V **System Reliability:** Probability of survival of series system and parallel redundant system. Numerical**.** **Maintainability and availability:** Maintainability Engineering, Designing for Maintainability, Maintainability Assurance, Availability, Equipment Availability, MTBF and MTTF trade-off, Numerical.	08 Hours

Question paper pattern:

1. Total of Ten Questions with two from each MODULE to be set covering the entire syllabus.
2. Five full questions are to be answered choosing at least one from each MODULE.
3. Each question should not have more than 4 sub divisions.

Text books:

1. Halpern, Seigmund (1978), The Assurances Sciences, Prentice Hall International, New Jersy, USA
2. M Mahajan . (2015) Statistical Quality Control.
3. Juran, I.M and Gryna, F. M (1982), Quality planning and Analysis Tata Mc GrawHill Publishing Company Ltd, New Delhi, India

Reference Books:

1 Balachandra, Benjamin S (1986), Logistics Engineering and Management prentice Hall International, New Jersey, USA

2 Kraus, John W (1988), Maintainability and Reliability Hand Book of Reliability'' Engineering and Management, Editors –Ireson .W.G. and Cooms. CF McGraw hill Books Company Inc. USA

3. Srinathm KS (1985), Concepts in Reliability Engineering Affiliated East West Press Private Limited, New Delhi, India.

E books and online course materials:

Course outcomes:
On completion of the course, the student will have the ability to:

	CO	Course Outcome (CO)
	CO1	Knowledge of production processes and assurance Science of quality products
	CO2	Implement Laws of probability and Probability Distributions
	CO3	Interpret and represent the control charts according to the Specified specialization that meet the requirements.
	CO4	Apply and analyze the appropriate technique of Reliability to understand the impact of applications in the industry.
	CO5	Evaluate of system Reliability and illustrate Maintainability Engineering.

DESIGN FOR MANUFACTURING

Subject Code	19ME732	Credits	03	CIE: 50
Number of Lecture Hours/Week	3 (Theory)			SEE: 50
Total Number of Lecture Hours	42			SEE Hours: 03

Prerequisite:

Course Objectives:

1.To educate students on factors to be considered in designing parts and components with focus on manufacturability.

2.To expose the students to dimensional tolerances, geometric tolerances and true position tolerance techniques in manufacture.

3.To impart the knowledge on design considerations for designing components produced using various machining operations like turning, drilling, milling, grinding etc.

4. To educate the students on design rules and recommendations for processes like casting, welding, forgings powder metallurgy and injection moulding.

Modules	Teaching Hours
MODULE-I **Introduction:** Definition, need for DFM and approach for cost reduction, general design guide lines of DFM, advantages, disadvantages and application of DFM. Design for Quality Manufacturability, DFQM approach and designing for economical production. Design for Excellence (DFX). Basics of dimensional tolerancing, Redundancy, tolerance allocation, Review of relationship between attainable tolerance grades and different machining processes. Geometrical tolerances. Process capability, mean, variance, skewness, kurtosis, process capability indices- Cp, and Cpk. Cumulative effect of tolerance- Sure fit law and truncated normal law with Numerical.	08 Hours
MODULE-II **True positional theory:** Comparison between coordinate and true position method of feature location. True position tolerance- virtual size concept, concepts of datum and changing datum, floating and fixed fasteners, projected tolerance zone and functional gauges. Concept of Zero true position tolerance. Simple Numerical on true position tolerancing. **Selective Assembly**: Interchangeable part manufacture and selective assembly. Deciding the number of groups -model-1: group tolerance of mating parts equal, model- 2: total and group tolerances of shaft equal. Control of axial play- introducing secondary machining operations, and laminated shims; examples.	09 Hours
MODULE-III **Datum Features:** Functional datum, datum for manufacturing, changing the datum; examples. **Component Design:** 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, economy, clampability, and accessibility. Designing for heat treatment, roller burnishing, and economical de-burring.	08 Hours

MODULE-IV **Design of components with casting considerations:** Pattern, mould, and parting line. Cored holes and machined holes. Identifying the possible and probable parting lines. Castings requiring special sand cores. Designing to obviate sand cores. **Welding considerations:** Advantages of weldments over other design concepts, design requirements and rules, redesign of components for welding; case studies.	09 Hours
MODULE-V **Forging considerations** -requirements and rules-redesign of components for forging and case studies. **Design of components for powder metallurgy**- requirements and rules-case studies. **Design of components for injection moulding**- requirements and rules-case studies.	08 Hours

Question paper pattern:

1. Total of Ten Questions with two from each MODULE to be set covering the entire syllabus.
2. Five full questions are to be answered choosing at least one from each MODULE.
3. Each question should not have more than 4 sub divisions.

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. Handbook of Products Design for Manufacturing: A Practical Guide to Low-cost Production Bralla, James G McGraw Hill, New York 1986.

Reference Books:

1 Engineering Design Eggert, R.J Pearson Education, Inc., New Jersey 2005
2. Engineering Design for Manufacture Kalandar Saheb, S.D and Prabhakar, O. SPE,1999
3. Processes and Materials of Manufacture Linberg, Roy A. Allyn and Bacon, Boston, U.S.A. 4 th ed., 1990

E books and online course materials:

CO	Course Outcomes
CO1	Select proper materials and manufacturing processes for designing products/components by applying the relevant principles for ease and economic production.
CO2	Identify faulty design factors leading to increased costs in producing mechanical components.
CO3	Apply appropriate design tolerances – dimensional, geometric and true position tolerances for the production processes of mechanical components.
CO4	Apply the concepts related to reducing machined areas, simplification by amalgamation and separation, clampability, accessibility etc., in the design of mechanical components.
CO5	Analyse the design of castings, weldments, forgings, powder metallurgy components and suggest design modifications to reduce the cost.

FINITE ELEMENT METHODS				
Subject Code	19ME733	Credits	03	CIE: 50
Number of Lecture Hours/Week	3 (Theory)			SEE: 50
Total Number of Lecture Hours	42			SEE Hours: 03
Prerequisite: Should have knowledge of physics, mechanics, strength of materials, linear algebra, mechanical properties of materials.				
Course Objectives: The course aims to provide an introductory approach to finite element method as a basic numerical tool for solving mechanical engineering problems.				
Modules				**Teaching Hours**
MODULE-I **INTRODUCTION TO FEM:** Need, Advantages and disadvantages of FEM, Engineering Applications, Steps involved in FEM, Discretization process – types of elements (1D,2D,3D), size of the elements, location of nodes, node numbering scheme, Method of solution of linear algebraic equations – Gauss elimination method. Numerical integration by Gaussian quadrature (one point and two point formula). Basic elastic equations – body force and traction force, strain-displacement relations. Principle of minimum potential energy and derivation of potential energy functional for a 3D elastic body, concept of plane stress and plane strain and their stress-strain relations.				10 Hours
MODULE-II **INTERPOLATION MODELS:** Displacement function, selection of the order of displacement function, convergence criteria, geometric isotropy, Pascal's triangle for 2D polynomial, Different co-ordinate systems used in FEM, Interpolation or shape functions for 1D linear and quadratic bar elements and 2D linear triangular (CST) element in cartesian and natural co-ordinate systems. Lagrangian polynomial – Shape functions for linear quadrilateral element (QUAD 4) and quadratic quadrilateral element (9-noded), Iso-parametric, subparametric and super-parametric elements, Concept of Jacobian matrix, Jacobian matrix for CST.				08 Hours
MODULE-III **ELEMENT STIFFNESS MATRIX AND LOAD VECTORS:** Strain displacement matrix, Stiffness matrix and load vector for linear and quadratic bar element and CST element. Assembly of elements by direct stiffness method, special characteristics of stiffness matrix, Treatment of boundary conditions- elimination and penalty methods. Analysis of axially loaded uniformly tapered and stepped bars.				08 Hours
MODULE-IV **ANALYSIS OF PLANE TRUSSES AND BEAMS:** Local and global coordinate systems, stiffness matrix for plane truss element, analysis of truss members. Hermite shape function for beam element in Cartesian coordinates, Stiffness matrix and load vector for beam element, element shear force and bending moment, analysis of beams.				08 Hours
MODULE-V **ANALYSIS OF HEAT TRANSFER PROBLEMS:** Steady state heat transfer, 1D heat conduction- governing equation, boundary conditions, one-dimensional element, Galerkin's approach to heat conduction, heat flux boundary condition. 1D heat transfer in thin finsFormulation of equations. Simple numerical of 1D heat transfer problems on composite walls and fins with conduction and convection.				08Hours

Question paper pattern:

1. Total of Ten Questions with two from each MODULE to be set covering the entire syllabus.
2. Five full questions are to be answered choosing at least one from each MODULE.
3. Each question should not have more than 4 sub divisions.

Text books:

1 Chandrakanth S Desai and J.F. Abel, "Introduction to the Finite Element Method," CBS, 1st edition, 2005, ISBN: 978-8123908953.

2 T R Chandrupatla and A D Belegundu, "Introduction to Finite Elements in engineering," Pearson, 4th edition, 19th October 2011, ISBN: 978-0132162746.

3 Singiresu S Rao, "The Finite Element Method in engineering," Elsevier Publisher, 5th edition, 2008 ISBN: 978-9380931555.

Reference Books:

1 O.C.Zienkiewicz, "The FEM its basics and fundamentals," Elsevier Publisher, 6th edition, 2007, ISBN: 978-8131211182.

2 J.N.Reddy, "Finite Element Method," McGraw Hill International Edition, 2005, ISBN: 9780072466850.

3 Daryl. L. Logon, "Finite Element Methods," Thomson Learning 5th edition, 1st Jan 2011, ISBN: 978-0495668251.

4 David V. Hutton, "Fundamentals of Finite Element Analysis," Tata McGraw Hill Publishing Co. Ltd, New Delhi, 10th June 2005, ISBN: 978-0070601222.

E books and online course materials:

Course outcomes:
On completion of the course, the student will have the ability to:

Course Code	CO #	Course Outcome (CO)
	CO1	Understand the basic concepts and mathematical preliminaries of FEM required to solve basic field problems.
	CO2	Develop interpolation models for 1D and 2D elements that satisfy convergence criteria and geometric isotropy and use isoparametric concept in the finite element analysis.
	CO3	Formulate element stiffness matrices and load vectors for different elements using variational principle and analyze axially loaded bars.
	CO4	Use finite element formulations in the determination of stresses, strains and reactions of trusses and transversely loaded beams.
	CO5	Formulate finite element equations for heat transfer problems using Variational and Galerkin techniques and apply these models to analyze conduction and convection heat transfer problems.

EXPERIMENTAL STRESS ANALYSIS

Subject Code	19ME734	Credits	03	CIE: 50
Number of Lecture Hours/Week	3 (Theory)			SEE: 50
Total Number of Lecture Hours	42			SEE Hours: 03

Prerequisite: Student should have the basic knowledge of physics and behavior of materials.

Course Objectives:

1. To use the method of electrical strain gauges to study and characterize the elastic behavior of solid bodies.
2. To measure displacement and perform stress strain analysis of mechanical systems using electrical resistance strain gauges.
3. To describe the photo elastic method to study and characterize the elastic behavior of solid bodies.
4. To determine stress strain behavior of solid bodies using methods of coating
5. To conduct stress strain analysis of solid bodies using the methods Holography

Modules	Teaching Hours
MODULE-I **Introduction:** Definition of terms, Calibration, Standards, Dimension and units generalized measurement system. Basic concepts in dynamic measurements, system response, distortion, impedance matching, Analysis of experimental data, cause and types of experimental errors. General consideration in data analysis. **Electrical Resistance Strain Gages:** Strain sensitivity in metallic alloys, Gage construction, Adhesives and mounting techniques, Gage sensitivity and gage factor, Performance Characteristics, Environmental effects, Strain Gage circuits. Potentiometer, Whetstone's bridges, Constant current circuits.	08 Hours
MODULE-II **Strain Analysis Methods:** Two element, three element rectangular and delta rosettes, Correction for transverse strain effects, Stress gage, Plane shear gauge, stress intensity factor. Force, **Torque and strain measurements:** Mass balance measurement, Elastic element for force measurements, torque measurement.	08 Hours
MODULE-III **Photoelasticity:** Nature of light, Wave theory of light - optical interference, Stress optic law – effect of stressed model in plane and circular polariscopes, Isoclinic's & Isochromatics, Fringe order determination Fringe multiplication techniques , Calibration photoelastic model materials. **Two Dimensional Photoelasticity:** Separation methods: Shear difference method, Analytical separation methods, Model to prototype scaling, Properties of 2D photoelastic model materials, Materials for 2D photoelasticity.	08 Hours
MODULE-IV **Three Dimensional Photo elasticity:** Stress freezing method, Scattered light photoelasticity, Scattered light as an interior analyzer and polarizer, Scattered light polariscope and stress data Analyses. **Photoelastic (Birefringent) Coatings:** Birefringence coating stresses, Effects of coating thickness: Reinforcing effects, Poisson's, Stress separation techniques: Oblique incidence.	10 Hours

MODULE-V	
Brittle Coatings: Coatings stresses, Crack patterns, Refrigeration techniques, Load relaxation techniques, Crack detection methods, Types of brittle coatings, Calibration of coating. Advantages and brittle coating applications. **Moire Methods:** Moire fringes produced by mechanical interference .Geometrical approach, Displacement field approach to Moire fringe analysis, 0ut of plane displacement measurements, Out of plane slope measurements .Applications and advantages.	08 Hours

Question paper pattern:

1. Total of Ten Questions with two from each MODULE to be set covering the entire syllabus.
2. Five full questions are to be answered choosing at least one from each MODULE.
3. Each question should not have more than 4 sub divisions.

Text books:

1. Experimental Stress Analysis, Dally and Riley, McGraw Hill.
2. Experimental Stress Analysis, Sadhu Singh, Khanna publisher.
3. Experimental stress Analysis, Srinath L.S TaTa Mc Graw Hill.

Reference Books:

1. Photoelasticity Vol I and Vol II, M.M.Frocht, John Wiley & sons.
2. Strain Gauge Primer, Perry and Lissner,
3. Photo Elastic Stress Analysis, Kuske, Albrecht & Robertson John Wiley & Sons.
4. Motion Measurement and Stress Analysis, Dave and Adams,
5. Holman, Experimental Methods for Engineers, Tata McGraw-Hill Companies, 7th Edition, New York, 2007.
6. B. C. Nakra and K. K. Chaudhry, Instrumentation, Measurement and Analysis, Tata McGraw-Hill Companies, Inc, New York, 7th Edition, 2006.

E books and online course materials:

Course outcomes: On completion of the course, the student will have the ability to:

	CO	Course Outcome (CO)
	CO1	Impart basic knowledge of the elastic behavior of solid bodies
	CO2	Ability to understand the stress and strain gauges.
	CO3	Apply photo-elastic methods in whole field stress analysis of solids
	CO4	Discuss experimental investigations by predictions by other methods.
	CO5	Describe various coating techniques

NANOTECHNOLOGY				
Subject Code	19ME735	Credits	03	CIE: 50
Number of Lecture Hours/Week	3 (Theory)			SEE: 50
Total Number of Lecture Hours	42			SEE Hours: 03
Prerequisite: Material science.				
Course Objectives: In this course students will learn about the basics of nanoscale science, types of materials, and their engineering applications and hazards.				

Modules	Teaching Hours
MODULE-I **INTRODUCTION TO NANOSCIENCE AND NANOTECHNOLOGY:** History, background and interdisciplinary nature of nano-science and nanotechnology, challenges of Rechard Feynman, scientific revolutions. Nano-size effect on surface to volume ratio. Atomic structure, Bohr atomic model, molecules and phases. Introduction to classical physics and quantum mechanics and importance of nanoscale materials and their devices.	08 Hours
MODULE-II **CLASSIFICATION OF NANOSTRUCTURES :** Zero dimensional, one-dimensional and two dimensional nanostructure materials - classification of solids: conductor, semiconductors, insulator, types of semiconductor, doping, diodes, current flow in semiconductors, ceramics and nanocomposites, quantum size effect(QSE) in 1D, 2D, 3D nanomaterials, quantum dots, nanowires, nanotubes, nanosheets, top down and bottom up approach.	08 Hours
MODULE-III **BIOMIMETICS AND BIOMATERIALS:** **Biomimetics**: Introduction, Industrial significance, Lessons from nature and applications, overview of various objects from nature and their selected functions, Lotus effect, Velcro effect, biologically inspired mechanisms, Biologically inspired structures and tools, biological materials. **Biomaterials:** Introduction, Classification of Biomaterials, Biomaterials as implant in human body, characterization of biomaterials.	08 Hours
MODULE-IV **INTRODUCTION TO NANOMATERIALS AND DEVICES:** Types of nanomaterials: Metal nanoparticles eg Au, Ag, Cu, Pt and their application as FETs. Metal oxide nanoparticles TiO2, ZnO, SnO2 and their application in solar cells, MEMS based gas sensors, Semiconducting Cadmium and Selenide quantum dots bio imaging, Carbon based nanomaterials and their applications in FETs, MOSFETS, sensors and actuators , Silicon based nanostructures and their application in single electron electronics used as tips for AFM and Field emission microscopy, magnetic and ceramics nanomaterials and their application.	10 Hours

MODULE-V	
INTRODUCTION TO NANOTOXICOLOGY: Nanomaterials pollution – Nanomaterials in Environment - Toxicology of Airborne – Effect of Nanomaterials in the environment. Safety and pollution Control techniques-handling, storage, packaging, transportation and disposal.	08 Hours

Question paper pattern:

1. Total of Ten Questions with two from each MODULE to be set covering the entire syllabus.
2. Five full questions are to be answered choosing at least one from each MODULE.
3. Each question should not have more than 4 sub divisions.

Text books:

1. Edward L. Wolf, "Nanophysics and Nanotechnology - An Introduction to Modern Concepts in Nanoscience" Second Edition, John Wiley & Sons, 2006.
2. Foundations of Nanoscale Science and Technology,Shareefraza J. Ukkund, Prasad Puthiyillam, LAP-Lambert Academic Publishing, Mauritius, 2018. ISBN: 978-613-958649-3 Nanotechnology – Basic Science & Emerging Technologies: 2002 by Michael Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons, and Burkhard Raguse.
3. Nanoparticles technology: Masuo Hosokawa, Kiyoshi Nogi, Makio Naito, Toyokazu Yokoyama, First edition 2007, ISBN: 978-0-444-53122-3.

Reference Books:

1. Vladimir P. Torchilin (2006) Nanoparticulates as Drug Carriers, Imperial College Press.
2. M. Reza Mozafari (2007) Nanomaterials and Nanosystems for Biomedical Applications.
3. K.W. Kolasinski, “Surface Science: Foundations of Catalysis and Nanoscience”, Wiley, 2002.
4. Biomimetics: lessons from nature – an overview by Bharath bhushan
5. Biomimetics—using nature to inspire human innovation Yoseph Bar-Cohen.

E books and online course materials:

Course outcomes: On completion of the course, the student will have the ability to:

	CO	Course Outcome (CO)
	CO1	Describe fundamentals of nanoscience and nanotechnology
	CO2	Classify nano-structures;
	CO3	Develop smart materials
	CO4	Analyse biomaterials
	CO5	Explain nanotoxicology

Elective-4

ADVANCED FOUNDRY TECHNOLOGY

Subject Code	19ME741	Credits	03	CIE: 50
Number of Lecture Hours/Week	3 (Theory)			SEE: 50
Total Number of Lecture Hours	42			SEE Hours: 03

Prerequisite: Manufacturing process and materials science knowledge, basic foundry practices of metal casting.

Course Objectives:

1. To promote understanding of foundry practice and metal casting as one of the important manufacturing processes.
2. To study the various techniques used in foundry industries and their applications.
3. Understand the standard foundry practices for casting of ferrous and non-ferrous alloys elaborated according to specialization.
4. An overview of the designing of molds, casting defects, inspection and testing of castings and modernization of foundries

Modules	Teaching Hours
MODULE-I **Introduction of foundry:** History, Types of Manufacturing process, principles of foundry, Types of foundries, Different sections of foundry and its layout. Foundry materials: Types of raw materials. **Introduction and Technology of Pattern making:** Definition, pattern materials, types of patterns, pattern allowances.	08 Hours
MODULE-II **Technology of Mould making:** Mould materials, sand preparation, Properties f moulding materials, steps involved in sand mould making, Core and core prints. Green sand moulding, dry sand moulding, shell moulding, Sodium silicate molding, no-bake moulding, Plaster moulding, Vacuum sealed moulding(V process).	08 Hours
MODULE-III **Melting and Pouring :** Introduction, Melting furnaces- open hearth h furnace, acidic and basic hearth furnaces. **Metal Pouring:** Pouring temperatures, pouring equipment, pouring ladles, Gates, Risers, Chvorinov's rule, risers feeding distance, sprues and their characteristics. **Solidification of castings:** Concept of solidification of metal, solidification of pure metals-nucleation, heterogeneous-nucleation, solidification rate, time and Chvorinov's rule-progressive, directional solidification and control of solidification to obtain sound castings.	09 Hours
MODULE-IV **Special casting Techniques:** Introduction-Special casting techniques- Permanent mould casting, pressure die casting, centrifugal casting, Squeeze casting, comparison with sand casting, advantages, disadvantages and applications. **Inspection and testing:** Non- destructive testing, visual testing, liquid penetrate, ultrasonic testing.	08 Hours

MODULE-V	
Fettling technique: Introduction of shake out, modern developments, Fettling or cleaning, and finishing of castings, removal of cores, cleaning casting surfaces, blast cleaning, removal of gates, risers, fins and other unwanted projections from castings. **Casting Defects:** causes and remedial measures, porosity, Shrinkage cavity, inclusions, hot tears, rat tail, sand fusion, mis- run, cold shut, Fins.	09 Hours

Question paper pattern:

1. Total of Ten Questions with two from each MODULE to be set covering the entire syllabus.
2. Five full questions are to be answered choosing at least one from each MODULE.
3. Each question should not have more than 4 sub divisions.

Text books:

1. O.P. Khanna, *"A Text Book of Foundry Technology"*, Dhanpat Rai & Sons, 15th Edition, 2011.
2. P.N. Rao, *"Manufacturing Technology",* TMH, 5th Edition, 2013.

Reference Books:

1. Richard. W. Heine and Rosenthal, *"Principles of Metal Castings"*, TMH, 2nd Edition, 2001.
2. R.K. Jain, *"Production Technology",* Khanna Publishers, 17th Edition, 2011.

E books and online course materials:

Course outcomes: On completion of the course, the student will have the ability to:

CO	Course Outcomes
CO1	Detect the material to prepare patterns and moulds
CO2	Explain sand preparation, reclamation, control tests and various types of moulding
CO3	Design gating systems and calculate solidification time.
CO4	Select melting furnaces and ladles, non-destructive methods used in castings
CO5	Identify defects, salvage and heat treatment of castings

ADVANCED MATERIALS TECHNOLOGY

Subject Code	19ME742	Credits	03	CIE: 50
Number of Lecture Hours/Week	3 (Theory)			SEE: 50
Total Number of Lecture Hours	42			SEE Hours: 03

Prerequisite:

Course Objectives:

1.To impart knowledge on material selection methods and basics of advanced engineering materials.

2. To introduce the basics of smart materials, composite materials, ceramics and glasses and modern metallic materials and their applications in engineering.

Modules	Teaching Hours
MODULE-I **Classification and Selection of Materials:** Classification of materials, properties required in Engineering materials, Selection of Materials; Motivation for selection, cost basis and service requirements - Selection for mechanical properties, strength, toughness, fatigue and creep - Selection for surface durability corrosion and wear resistance – Relationship between materials selection and processing - Case studies in materials selection with relevance to aero, auto, marine, machinery and nuclear applications	08 Hours
MODULE-II **Composite Materials**:Fiber reinforced, laminated and dispersed materials with metallic matrix of aluminium, copper and Titanium alloys and with non-metallic matrix of unsaturated polyesters and epoxy resins. Development, Important properties and applications of these materials.	08 Hours
MODULE-III **Ceramics and Glasses - Bio-ceramics**: Nearly inert ceramics, bio-reactive glasses and glass ceramics, porous ceramics; Calcium phosphate ceramics: grafts, coatings Physico-chemical surface modification of materials used in medicine. Low & High Temperature Materials: Properties required for low temperature applications, Materials available for low temperature applications, Requirements of materials for high temperature applications, Materials available for high temperature applications, Applications of low and high temperature materials.	10 Hours
MODULE-IV **Modern Metallic Materials**: Dual Steels, Micro alloyed, High Strength Low alloy (HSLA) Steel, Transformation induced plasticity (TRIP) Steel, Maraging Steel, Inter metallics, Ni and Ti Aluminides. Non-metallic Materials: Polymeric materials and their molecular structures, Production Techniques for Fibers, Foams, Adhesives and Coatings, structure, Properties and Applications of Engineering Polymers.	08 Hours

MODULE-V	
Smart Materials: Shape Memory Alloys, Varistors and Intelligent materials for bio-medical applications. Nanomaterials: Definition, Types of nanomaterials including carbon nanotubes and nanocomposites, Physical and mechanical properties, Applications of nanomaterials.	08 Hours

Question paper pattern:

1. Total of Ten Questions with two from each MODULE to be set covering the entire syllabus.
2. Five full questions are to be answered choosing at least one from each MODULE.
3. Each question should not have more than 4 sub divisions.

Text books:

1. Engineering Material Technology, James A. Jacobs & Thomas F. Kilduff Prentice Hall 2018.
2. Materials Science and Engineering, WD. Callister Jr Wiley India Pvt. Ltd 2010.

Reference Books:

1. Engineering Design: A Materials and Processing Approach G.E. Dieter McGraw Hill 1991
2. Materials Selection in Mechanical Design M.F. Ashby Pergamon Press 1992
3. Introduction to Engineering Materials & Manufacturing Processes NIIT Prentice Hall of India
4. Engineering Materials Properties and Selection Kenneth G. Budinski Prentice Hall of India

E books and online course materials:

Course outcomes:
On completion of the course, the student will have the ability to:

	CO	Course Outcome (CO)
	CO1	Explain the concepts and principles of advanced materials and manufacturing processes.
	CO2	Understand the applications of all kinds of Industrial materials.
	CO3	Apply the material selection concepts to select a material for a given application.
	CO4	Define Nanotechnology, Describe nano material characterization.
	CO5	Understand the behaviour and applications of smart materials, ceramics, glasses and non-metallic materials.

ALTERNATE FUELS

Subject Code	19ME743	Credits	03	CIE: 50
Number of Lecture Hours/Week	3 (Theory)			SEE: 50
Total Number of Lecture Hours	42			SEE Hours: 03

Prerequisite: Basic concept of Engineering Chemistry, Thermodynamics and Fluid mechanics.

Course Objectives:

1. To explain the importance of alternate fuels, their availability, properties and to delineate the types of them.
2. To analyze and apply the effects of use of alcohols on Performance and Emission in SI and CI engines.
3. To modify SI and CI engines which use CNG, LPG, H2, Biogas as fuels, to analyze Performance and Emission Characteristics of them.
4. To test the Performance and Emission parameters of Vegetable oils and Bio-diesels on CI engines.
5. To examine different energy sources available for hybrid engines and to explain with sketches ECS, Fuel cell and Batteries.

Modules	Teaching Hours
MODULE-I **Introduction:** Need for alternate fuel, availability and properties of alternate fuels, LPG, hydrogen, ammonia, CNG and LNG, vegetable oils and biogas, merits and demerits of various alternate fuels, introduction to alternate energy sources. Like EV, hybrid, fuel cell and solar energy.	**08 Hours**
MODULE-II **Alcohols:** DME, DEE and their blends and their effects on performance of SI and CI engines and Combustion and Emission characteristics related numerical problems.	**08 Hours**
MODULE-III **Natural Gas, LPG, Hydrogen and Biogas:** modification required in engines, Performance and Emission Characteristics of CNG, LPG in SI and CI engines, Hydrogen as fuel, its storage, handling, performance and safety.	**10 Hours**
MODULE-IV **Vegetable Oils:** Various vegetable oils for engines, esterification, performance in engines, performance and emission characteristics, biodiesel and its characteristics.	**08 Hours**
MODULE-V **New Generation Energy Sources (NGES):** Energy sources for hybrid engines, advantages and limitations, required system components and Electronic Control Systems (ECS), for use of NGES in engines, High energy and power density batteries, fuel cell.	**08 Hours**

Question paper pattern:

1. Total of Ten Questions with two from each MODULE to be set covering the entire syllabus.
2. Five full questions are to be answered choosing at least one from each MODULE.
3. Each question should not have more than 4 sub divisions.

Text books:

1. Alternative Fuels Guide Book, Richard L. Bechfold, SAE International Warren dale - 1997
2. Energy Today & Tomorrow, Maheswar Dayal, I & B Horsier India - 1982.

Reference Books:

1. Power Plant Engineering, Nagpal, Khanna Publishers - 1991.
2. Alcohols as motor fuels progress in technology, Series No.19, SAE Publication USE - 1980.

E books and online course materials:

Course outcomes:

On completion of the course, the student will have the ability to:

Course Code	CO #	Course Outcome (CO)
	CO1	Explain the importance of alternate fuels, their availability, properties and to delineate the types of them.
	CO2	Analyze and apply the effects of use of alcohols on Performance and Emission in SI and CI engines.
	CO3	Modify SI and CI engines which use CNG, LPG, H2, Biogas as fuels, to analyze Performance and Emission Characteristics of them.
	CO4	Evaluate the Performance and Emission parameters of Vegetable oils and Bio-diesels on CI engines.
	CO5	Examine different energy sources available for hybrid engines and to explain with sketches ECS, Fuel cell and Batteries.

CRYOGENIC

Subject Code	19ME744	Credits	03	CIE: 50
Number of Lecture Hours/Week	3 (Theory)			SEE: 50
Total Number of Lecture Hours	42			SEE Hours: 03

Prerequisite:

Course Objectives:

1. To understand cryogenic system and gas liquefaction system
2. To analyze gas cycle cryogenic refrigeration system
3. To Comprehend gas separation and gas purification system
4. To have detailed knowledge of vacuum technology, insulation, storage of cryogenic liquids
5. To study applications of cryogenics and to embark on cryogenic fluid

Modules	Teaching Hours
MODULE-I **Introduction to Cryogenic Systems:** Cryogenic propellants and its applications, liquid hydrogen, liquid nitrogen, and liquid Helium. The thermodynamically Ideal system Production of low temperatures – Joule Thompson Effect, Adiabatic expansion. **Gas Liquefaction Systems:** Liquefaction systems for Air Simple Linde –Hampson System, Claude System, Heylndt System, Dual pressure, Claude. Liquefaction cycle Kapitza System. Comparison of Liquefaction Cycles Liquefaction cycle for hydrogen, helium and Neon, Critical components of liquefaction systems.	08 Hours
MODULE-II **Gas Cycle Cryogenic Refrigeration Systems:** Classification of Cryo coolers, Stirling cycle Cryo – refrigerators, Ideal cycle – working principle. Schmidt's analysis of Stirling cycle, Various configurations of Stirling cycle refrigerators, Integral piston Stirlingcryo-cooler, Free displacer split type StirlingCryo coolers, Gifford McmahonCryo- refrigerator, Pulse tube refrigerator, Solvay cycle refrigerator, Vuillimier refrigerator, Cryogenic regenerators.	08 Hours
MODULE-III **Gas Separation and Gas Purification Systems:** Thermodynamic ideal separation system, Properties of mixtures, Principles of gas separation, Linde single column air separation. Linde double column air separation, Argon and Neon separation systems. **Ultra Low Temperature Cryo – Refrigerators:** Magneto Caloric Refrigerator 3He-4He Dilution refrigerator. Pomeranchuk cooling. Measurement systems for low temperatures, Temperature measurement at low temperatures, Resistance thermometers, Thermocouples, Thermistors, Gas Thermometry. Liquid level sensors.	08 Hours

MODULE-IV **Vacuum Technology :** Vacuum Technology: Fundamental principles. Production of high vacuum, Mechanical vacuum pumps, Diffusion pumps, Cryo-pumping, Measurement of high vacuum level. Cryogenic Insulation: Heat transfer due to conduction, Evacuated porous insulation Powder & Fibers Opacified powder insulation, Gas filled powders & Fibrous materials Multilayer super-insulation, Composite insulation	08 Hours
MODULE-V **Cryogenic Fluid Storage And Transfer Systems**: Design of cryogenic fluid storage vessels, Inner vessel, Outer Insulation, Suspension system, Fill and drain lines. Cryogenic fluid transfer, External pressurization, Self pressurization, Transfer pump. **Application of Cryogenic Systems:** Cryogenic application for food preservation – Instant Quick Freezing techniques Super conductive devices, Cryogenic applications for space technology. Application of cryogenic systems, super conducting devices, space technology, cryogenic in biology and medicine.	10 Hours

Question paper pattern:

1. Total of Ten Questions with two from each MODULE to be set covering the entire syllabus.
2. Five full questions are to be answered choosing at least one from each MODULE.
3. Each question should not have more than 4 sub divisions.

Text books:

1. Cryogenic Systems – R.F. Barron
2. Cryogenic Engineering – R.B. Scott – D.VanNostrand Company, 1959

Reference Books:

1. Cryogenic Process Engineering – K.D. Timmerhaus and T.M. Flynn, Plenum Press, New York,1989
2. High Vacuum Technology – A. Guthree – New Age International Publication
3. Experimental Techniques in Low Temperature Physics – G.K. White – Osford University Press,

E books and online course materials:

Course outcomes:
On completion of the course, the student will have the ability to:

	CO	Course Outcome (CO)
	CO1	To be able to understand the cryogenic system.
	CO2	To have complete knowledge of cryogenic refrigeration system
	CO3	To be able to design gas separation and gas purification system
	CO4	To able to solve the problem in , insulation, storage of cryogenic liquids
	CO5	To be able to apply cryogenic in various areas and to be able take up research in cryogenics

MECHATRONICS

Subject Code	19ME745	Credits	03	CIE: 50
Number of Lecture Hours/Week	3 (Theory)			SEE: 50
Total Number of Lecture Hours	42			SEE Hours: 03

Prerequisite:

Course Objectives:

1. 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.
2. To understand the evolution and development of Mechatronics as a discipline.
3. To substantiate the need for interdisciplinary study in technology education
4. To understand the applications of microprocessors in various systems and to know the functions of each element.
5. To demonstrate the integration philosophy in view of Mechatronics technology
6. To be able to work efficiently in multidisciplinary teams.

Modules	Teaching Hours
MODULE-I **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.	09 Hours
MODULE-II **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 – 4-quadrant servo drives, PWM's – Pulse Width Modulation.	08 Hours

MODULE-III **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.	08 Hours
MODULE-IV **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.	09 Hours
MODULE-V **Mechatronics in Computer Numerical Control (CNC) machines**: Design of modern CNC machines - Machine Elements: Different types of guide ways, Linear Motion guideways. Bearings: anti-friction bearings, hydrostatic bearing and hydrodynamic bearing. Re-circulating 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.	08 Hours

Question paper pattern:

1. Total of Ten Questions with two from each MODULE to be set covering the entire syllabus.
2. Five full questions are to be answered choosing at least one from each MODULE.
3. Each question should not have more than 4 sub divisions.

Text books:

1. Mechatronics-Principles Concepts and Applications Nitaigour Premchand Mahalik ata McGraw Hill 1st Edition, 2003
2. Mechatronics–Electronic Control Systems in Mechanical and Electrical Engineering, W.Bolton Pearson Education 1st Edition, 2005

Reference Books:

1. Mechatronics HMT Ltd Tata Mc Graw Hill 1st Edition, 2000 ISBN:978007 4636435
2. Mechatronics: Integrated Mechanical Electronic Systems K.P. Ramachandran, G.K. Vijayaraghavan, M.S. Balasundaram. Wiley India Pvt. Ltd. New Delhi,2008
3. Introduction to Mechatronics and Measurement Systems David G. Aldatore, Michael B. Histand McGraw-Hill Inc USA,2003
4. Mechatronics System Design Devdas Shetty, Richard A. kolk Cengage publishers. second edition

Course outcomes: **On completion of the course, the student will have the ability to:**		
	CO	**Course Outcome (CO)**
	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 analyse and interpret data.
	CO4	Apply the principles of Mechatronics design to product design.
	CO5	Function effectively as members of multidisciplinary teams.

OPEN ELECTIVE - II

NON-CONVENTIONAL ENERGY SOURCES

Subject Code	19OE751M	Credits	03	CIE: 50
Number of Lecture Hours/Week	3 (Theory)			SEE: 50
Total Number of Lecture Hours	42			SEE Hours: 03

Prerequisite: Should have knowledge of energy sources and their utilization.

Course Objectives:

1. Understand energy scenario, energy sources and their utilization.
2. Learn about energy conversion methods and their analysis.
3. Study the principles of renewable energy conversion systems.
4. Understand the concept of green energy and zero energy.

Modules	Teaching Hours
MODULE-I **Introduction:** Energy Source, India's production and reserves of commercial energy sources, need for non-conventional energy sources, energy alternatives, solar, thermal, photovoltaic, water power, wind, bio-mass, ocean temperature difference, tidal and waves, geothermal, tarsands and oil shale, nuclear (Brief description); advantages and disadvantages, comparison (Qualitative and Quantitative). **Solar Radiation:** Extra – Terrestrial radiation, spectral distribution of extra terrestrial radiation, solar constant, solar radiation at the earth's surface, beam, diffuse and global radiation, solar radiation data. Measurement of solar radiation: Pyrometer, shading ring pyrheliometer, sunshine recorder, schematic diagrams and principle of working.	09 Hours
MODULE-II **Photovoltaic Conversion:** Description, principle of working and characteristics, applications. **Solar Thermal Conversion:** Collection and storage, thermal collection devices, liquid flat plate collectors, solar air heaters concentrating collectors (cylindrical, parabolic, paraboloid) sensible heat storage, latent heat storage, application of solar energy water heating. Space heating and cooling, active and passive systems, power generation, and refrigeration. Distillation solar pond, principle of working, operational problems.	09Hours
MODULE-III **Wind Energy** Properties of wing, availability of wind energy in India, wind velocity and power from wind; major problems associated with wind power, wind machines; Types of wind machines and their characteristics, horizontal and vertical axis wind mills, elementary design principles; coefficient of performance of a wind mill rotor, aerodynamic considerations of wind mill design. **Tidal Power:** Tides and waves as energy suppliers and their mechanics; fundamental characteristics of tidal power, harnessing tidel energy, limitations.	08 Hours

MODULE-IV **Ocean Thermal Energy Conversion:** Principle of working, Rankine cycle, OTEC power stations in the world, problems associated with OTEC. **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.	08Hours
MODULE-V **Energy From Bio Mass:** Photosynthesis, photosynthetic oxygen production, energy plantation, bio gas production from organic wastes by anaerobic fermentation, description of bio-gas plants, transportation of bio-gas, problems involved with bio-gas production, application of bio-gas, application of bio-gas in engines, advantages. **Hydrogen Energy:** Properties of Hydrogen with respect to its utilization as a renewable from of energy, source of hydrogen, production of hydrogen, electrolysis of water, thermal decomposition of water, thermo chemical production and bio-chemical production. Storage and Transportation Methods: Gaseous, cryogenic and metal hydrides, application of hydrogen, domestic and industrial safe burning of hydrogen.	08 Hours

Question paper pattern:

1. Total of Ten Questions with two from each MODULE to be set covering the entire syllabus.
2. Five full questions are to be answered choosing at least one from each MODULE.
3. Each question should not have more than 4 sub divisions.

Text books:

1. G.D Rai K, "Non conventional energy sources", Khanna publishers.2004, ISBN:9788174090737
2. Subhas P.Sukhatme, J K Nayak, "Solar energy", Tata Mc Graw Hill,India 3rd Edition. 2009, ISBN: 9780070142961

Reference Books:

1. N.K.Bansal, Manfred Kleeman and Mechael meliss, "Renewable energy sources and conversion technology", Tata Mcgraw Hill, 2001. ISBN:9780074600238
2.John W.Twidell, Tony Weir, "Renewable energy resources" , Routledge, 4th edition, 2014, ISBN:9780415633581
3.Solar Power Engineering: P K Nag TMH.2003

Course outcomes:

On completion of the course, the student will have the ability to:

CO	Course Outcome (CO)
CO1	Students will be able to study concepts of various renewable energy systems
CO2	Identify renewable energy sources and their utilization
CO3	Discuss the basic concepts of solar radiation and analyze the working of solar PV and thermal systems.
CO4	Explain principles of energy conversion from alternate sources including wind, geothermal, ocean, biomass, biogas.
CO5	Implement the concepts and applications of fuel cells, thermoelectric convertor and MHD generator methods of energy storage for specific applications.

SIMULATION & CIM LAB

Subject Code	19MEL75	Credits	01	CIE: 50
Number of Lecture Hours/Week	2 (Practical)			SEE: 50
Total Number of Lecture Hours	28			SEE Hours: 03

Prerequisite: 1. Students should have the knowledge of design of machine elements and computational skills.

2. Students should have the knowledge of basic computer operations and the subject knowledge of CAD/CAM, CIM and FEA.

3. Students should have the knowledge of G- codes and M- codes to be able to write the programs so as to prepare the jobs on CNC turning and Milling machines.

4. Students should have the knowledge of G- codes and M- codes to be able to write the programs to simulate turning and milling operations.

Course Objectives:

1. To impart knowledge of using FEA package for designing and analyzing the structural members under given load, material and geometric conditions.
2. To make the students understand the effect of loading in terms of magnitude and nature of stress, strain, displacement.
3. To impart knowledge about G- codes, M- codes and to prepare them write programs using G- codes and M- codes to simulate Turning and Milling operations to produce required specimen.
4. To be able to write programs using G- codes and M- codes according to the given job and to feed the program correctly into the CNC machines to produce that specimen.
5. To be able to visualize and appreciate the role of Robots in Manufacturing and understand the operation of simple PICK and PLACE.

Modules	Teaching Hours
1. Examples using Parametric Packages for FEA – Inventor,/Pro/E,Catia- 04	14 Hours
2. (01 Lathe & 01 Milling)	14 Hours

Course outcomes:
On completion of the course, the student will have the ability to:

Course Code	CO #	Course Outcome (CO)
	CO1	To be able to learn using FEA package for designing and analyzing the structural members under given load, material, geometric properties.
	CO2	To be able to understand the magnitude of stress, strain, displacement as a result of application of load.
	CO3	To be able to learn usage of G- codes and M- codes in writing the program to simulate Turning and Milling operations to produce required specimen.
	CO4	To be able to write programs using G- codes and M-codes, feed them into the CNC machines and learn to operate CNC machines to produce specimen.
	CO5	To understand the working of Pick and place Robot action.

SEMINAR

Subject Code	19ME76	Credits	01	CIE: 50
Number of Lecture Hours/Week	4			SEE:---

Prerequisite: Student should have knowledge of all the subjects of mechanical engineering

Course Outcomes:

1. To equip students for making a technical presentation based on a thorough research review on any contemporary area of Engineering and Management fields
2. Offering the student an opportunity to interact with faculty and peer group and to build the ability to making independent presentation.

Modules			Teaching Hours
		Contents	08 Hours
	1	Seminar shall be presented during 7th / 8th week of the semester in the department before the Departmental Evaluation	
	2	The seminar marks are to be awarded by the committee.	
	3	Students shall submit the seminar report in the prescribed	

Course outcomes:
On completion of the course, the student will have the ability to:

Course Code	CO #	Course Outcome (CO)
	CO1	Conduct literature survey on a current topic based on peer reviewed literature & Identify research gap in the literature
	CO2	Develop methodologies to resolve the identified problem(s)
	CO3	Develop presentation slides / report arranging the material coherently
	CO4	Present and discuss the topic with clarity and confidence and submit the report
	CO5	Summarize the presentation and identify scope for further work

PROJECT WORK PHASE-I

Subject Code	19MEP77	Credits	02	CIE: 50
Number of Lecture Hours/Week	4 (Practical)			SEE: 50
Total Number of Lecture Hours	42			SEE Hours: 03

Prerequisite: All the Subjects knowledge of mechanical engineering.

Course Objectives:

1. To provide an amicable atmosphere for students to plan.
2. To test their learned theory knowledge in an actual working situation.
3. To discover the value of work and relish rewards of accomplishment.
4. To ensure a professional preparation to the liberal educational goals.

Modules

The project proposal shall be presented in the following form.

	Contents
1	Define the problem
2	Exhaustive literature survey
3	Methodology
4	References

The Project Proposal shall be submitted within 2 weeks from the start of the semester in the prescribed standard format (04 copies) to the HOD, after the certification of the concerned guide and HOD.

Minimum No. of students per batch: 02
Maximum No. of students per batch: 04

SCHEME OF EVALUATION

Assessment	Marks
CIE I Evaluation (6^{th} week)	**25**
CIE II Evaluation (12^{th} week)	**25**
SEE	**50**
Total	**100**

Reference Books: on line Journals, updated recent information.

Course outcomes:
On completion of the course, the student will have the ability to:

Course Code	CO #	Course Outcome (CO)
	CO1	Literature review on par with international journal standards
	CO2	Literature gap determination and definition of the problem
	CO3	Scientific Design / Numerical Analysis / Analytical model and interpret them.
	CO4	Apply advance tools / techniques for problem solving.
	CO5	Prepare a detailed project work report.

B.E VIII SEM

PROJECT MANAGEMENT

Subject Code	19ME81	Credits	04	CIE: 50
Number of Lecture Hours/Week	4 (Theory)			SEE: 50
Total Number of Lecture Hours	52			SEE Hours: 03

Prerequisites of the course: Student should have knowledge of Operations Management and Basic knowledge of Accounting

Course Objectives:

1. To make them understand the concepts of Project Management for planning to execution of projects.
2. To make them understand the feasibility analysis in Project Management and network analysis tools for cost and time estimation.
3. Make them capable to analyze, apply and appreciate contemporary project management tools and methodologies in Indian context.

MODULES	Teaching Hours
MODULE-I **CONCEPTS OF PROJECT MANAGEMENT:** concepts of project, categories of project, phase of project life cycle, role and responsibilities of project leaders, tool and techniques for project management. **PROJECT PLANNING:** feasibility report phased planning, project planning steps, objectives and the goals of the project.	10 Hours
MODULE-II **ESTIMATING**: preparation of cost estimation, evaluation of the project profitability, financial analysis. **PROJECT ORGANIZING:** project organization and types, accountability in project organization.	09 Hours
MODULE-III **STAFFING THE PROJECT TEAM:** skills /abilities required for project manager, authorities and responsibilities of project manager, tendering and selection of contractors. **PROJECT SCHEDULING:** project implementation scheduling, effective time management, and different scheduling and resources allocation methods, Machine loading and sequencing: Johnson's rule	10 Hours
MODULE-IV **TOOLS AND TECHNIQUES OF PROJECTS MANAGEMENT:** bar chart (Gantt chart), bar chart for combined activates, logic diagrams and networks, project evaluation and review techniques (PERT), planning computerizes project management. **CO-ORDINATION AND CONTROL:** Project Direction communication in a project, MIS project co-ordination, project controls requirement for project or role of MIS in project controls, performance controls, schedule control, cost controls,	11 Hours
MODULE-V **PERFORMANCE MEASURES & NETWORK ANALYSIS**: Performance Indicators, Network analysis and network diagram, Computation of project completion time (Forward pass and backward pass), CPM, Computation of float, Difference between PERT and CPM, Probabilistic time estimates, probability of project completion by a target date.	12 Hours

Question paper pattern:

- Total of Ten Questions with two from each MODULE to be set covering the entire syllabus.
- Five full questions are to be answered choosing at least one from each MODULE.
- Each question should not have more than 4 sub divisions.

Text books:

1. Chaudhary S.; Project Management, Tata Mc Graw Hill
2. Prasanna Chandra; Projects- Planning, Analysis, Selection, Financing, Implementation and Review', I Edition, Tata Mc Graw Hill, 8th Edition 2015.

Reference Books:

1. Kerzner H.; Project Management, II Edition, CBS Publishers
2. Meredith Jack R., Mantel Samuel J.; Project Management, IV Edition, John Wiley & Sons
3. Gopalakrishnan P., Ramamurthy V.E; Textbook of Project Management, MacMillan Publishers
4. Maylor Harvey, Project Management, MacMillan Publishers
5. Matheen A. Prof., Comprehensive Project Management, Laxmi Publications (P) Ltd.
6. Project Management,Gopalan, Wiley India
7. A Guide to the Project Management Body of Knowledge (PMBOK Guide), 5th Ed, Project Management Institute PA, USA
8. Project Management, Dennis Lock, 9th Edition, Gower Publishing England

E books and online course materials:

Course outcomes: On completion of the course, the student will have the ability to

COs	Course Outcomes
CO1	Describe and identify the projects of different categories, phases of product life cycle, tools and techniques for project management.
CO2	Organize the staff and prepare project teams and define the goals of the project and understand the concepts of project planning and estimation.
CO3	Schedule the project, identify the performance indicators and measure the performance of a project.
CO4	Coordinate and control the project activities.
CO5	Write work break down structure for a project and develop a schedule based on it.

Professional Elective- 5

RAPID PROTOTYPING AND MODELLING

Subject Code	19ME821	Credits	03	CIE: 50
Number of Lecture Hours/Week	3 (Theory)			SEE: 50
Total Number of Lecture Hours	42			SEE Hours: 03

Prerequisite:

Course Objectives:

1.Understand technology used in rapid prototyping and tooling.
2.Recognized importance of rapid prototyping in advance manufacturing process.
3.Acquire knowledge, techniques and skills to select relevant rapid prototyping and tooling process.
4.Comprehend the potential of rapid prototyping and tooling in different industrial sectors.
5.Illustrated 3D printing technology for Rapid prototyping and Modeling

Modules	Teaching Hours
MODULE-I **Introduction:** Evolution, basic principle, concept, procedure and need of rapid prototyping and tooling, Classification of rapid prototyping and tooling processes (Additive/Subtractive/Deformative), Classifications of materials used for Rapid prototyping and tooling, Industrial applications of rapid prototyping and tooling, Most commonly used processes for rapid prototyping.	08 Hours
MODULE-II **Processes used for rapid prototyping and modeling:** Stereolithography Apparatus (SLA), Fused Deposition Modeling (FDM), Selective Deposition Lamination (SDL), Laminated Object Manufacturing (LOM), Ultrasonic Consolidation, Laser Engineered Net Shaping (LENS), Electron Beam Free Form Fabrication (EBFFF), Selective Laser Sintering (SLS), Electron Beam Melting (EBM). Convectional Tooling vs Rapid Tooling, Classification of Rapid Tooling, Direct and Indirect rapid tooling methods.	10 Hours
MODULE-III **CAD for rapid prototyping and modeling:** Preparation of 3D-CAD model in STL format, Reverse engineering, Reconstruction of 3D CAD model using reverse engineering, Part orientation and support generation, STL Conversion, STL error diagnostics, Slicing and generation of codes for tool path.	08 Hours
MODULE-IV **Constructions of manipulator systems for rapid prototyping and modeling:** Axes, Linear motion guide ways, Ball screws, Motors, Bearings, Encoders/ Glass scales, Process Chamber, Safety interlocks, Sensors, Energy delivery systems, Material delivery systems.	08 Hours
MODULE-V **Post processing in rapid prototyping and modeling:** Support material removal, Surface texture improvement, Accuracy improvement, Aesthetic improvement, Property enhancements using non-thermal and thermal techniques. 3D printing: Introduction, process parameters involved, advantages and Disadvantages.	08 Hours

Question paper pattern:

1. Total of Ten Questions with two from each MODULE to be set covering the entire syllabus.
2. Five full questions are to be answered choosing at least one from each MODULE.
3. Each question should not have more than 4 sub divisions.

Text books:

1.Chua C.K., Leong K.F., and Lim C.S., "Rapid prototyping: Principles and applications", Third Edition, World Scientific Publishers, 2010.
2. Gebhardt A., "Rapid prototyping", Hanser Gardener Publications, 2003.
3. Ian Gibson, "Software Solutions for Rapid Prototyping", Professional Engineering Publishing Limited, UK, 2002.

Reference Books:

1. Liou L.W. and Liou F.W., "Rapid Prototyping and Engineering applications: A toolbox for prototype development", CRC Press, 2007.
2. Kamrani A.K. and Nasr E.A., "Rapid Prototyping: Theory and practice", Springer, 2006.
3. Hilton P.D. and Jacobs P.F., "Rapid Tooling: Technologies and Industrial Applications", CRC press, 2000.

E books and online course materials:

Course outcomes:
On completion of the course, the student will have the ability to:

	CO	Course Outcome (CO)
	CO1	Explain rapid prototyping and tooling for manufacturing complex geometries.
	CO2	Identify and solve problems related to rapid prototyping and modeling.
	CO3	Select suitable process and materials for rapid prototyping and modeling
	CO4	Distinguish technique of CAD and reverse engineering for geometric transformation in rapid prototyping and modeling.
	CO5	Determine part orientation, apply suitable slicing algorithm and generate tool path for minimum build time.

FLEXIBLE MANUFACTURING SYSTEMS

Subject Code	19ME822	Credits	03	CIE: 50
Number of Lecture Hours/Week	3 (Theory)			SEE: 50
Total Number of Lecture Hours	42			SEE Hours: 03

Prerequisite:

Course Objectives:

1) To impart knowledge of FMS
2) To make students to understand the Numerical control Machining centers.
3) To expose students to Industrial robotics and Tool management.
4) To expose students to FMS hardware and software systems.
5) To introduce the students to the concepts of JIT in Production system.

Modules	Teaching Hours
MODULE-I **INTRODUCTION** :- Definition, Basic components of FMS , Levels of manufacturing flexibility, Different types of FMS , FMS Layout configurations, Objectives of FMS , Advantages and disadvantages of FMS.FMS Planning and Design Issues and operational issues.	08 Hours
MODULE-II **MANUFACTURING CELL**: - Introduction, classification of cell, Unattended machining, Differences between FMC AND FMS. **MACHINING CENTERS**: - Introduction to machining centers, classification, numerical control machining centers, NC Turning center. Deburring, types of Automated Deburring, wash stations, classification of wash stations.	09 Hours
MODULE-III **INDUSTRIAL ROBOTICS**: - Robot anatomy, Robot control systems, sensors in robotics, industrial robot applications. **CUTTING TOOLS AND TOOL MANAGEMENT**: - Introduction to cutting tools, control of cutting tools, Role of Tool management in FMS, Tool monitoring and fault detection.	09 Hours
MODULE-IV **FMS SYSTEM HARDWARE AND SOFTWARE STRUCTURE**: - General structure and requirements, Introduction to PLC, components of PLC and PLC programming. FMS installation and implementation, acceptance testing.	08 Hours
MODULE-V **JIT AND KANBAN SYSTEM**: - Lean production system, Introduction to Just-in-Time (JIT) Production system, Goals of JIT, Benefits of JIT, Principal Objectives of JIT, Error Prevention, Introduction to Kanban system, types of Kanban.	08 Hours

Question paper pattern:

1. Total of Ten Questions with two from each MODULE to be set covering the entire syllabus.
2. Five full questions are to be answered choosing at least one from each MODULE.
3. Each question should not have more than 4 sub divisions.

Text books:

1. 1.Shivanand H.K., Benal MM, Koti V, "Flexible Manufacturing System", New age international (P)Limited, New Delhi, 2006

Reference Books:

1. Mikell P. Groover "Automation, Production Systems and Computer Integrated Manufacturing", PHI, 2008.
2. Kalpakjin, "Manufacturing Engineering and Technology ", AddisonWesley Publishing Co., 1995.

Course outcomes:
On completion of the course, the student will have the ability to:

	CO	Course Outcome (CO)
	CO1	Discuss the role of FMS in manufacturing systems.
	CO2	Describe the concept of NC machining centers and Automated Deburring operations.
	CO3	Role of Industrial robotics in manufacturing systems and tool management.
	CO4	Recognize various FMS Hardware and software systems.
	CO5	Understand the importance JIT methods in Manufacturing systems.

VEHICLE DYNAMICS

Subject Code	19ME823	Credits	03	CIE: 50
Number of Lecture Hours/Week	3 (Theory)			SEE: 50
Total Number of Lecture Hours	42			SEE Hours: 03

Prerequisite:

Course Objectives:

1. To develop the basic knowledge of the students in automotive field in the areas of vehicle vibrations.
2. To develop the skills of the students in stability of vehicles and their effects, related with longitudinal, vertical & lateral dynamics.

Modules	Teaching Hours
MODULE-I **CONCEPT OF VIBRATION:** Definitions, Modeling and Simulation, Global and Vehicle Coordinate System, Free, Forced, Undamped and Damped Vibration, Response Analysis of Single DOF, Two DOF, Multi DOF, Magnification Factor, Transmissibility, Vibration Absorber, Vibration Measuring Instruments, Torsional Vibration, Critical Speed.	08 Hours
MODULE-II **TIRE DYNAMICS:** Tire Forces and Moments, Tire Structure, Longitudinal and Lateral Force at Various Slip Angles, Rolling Resistance, Tractive and Cornering Property of Tire. Performance of Tire on Wet Surface. Ride Property of Tires. Magic Formulae Tire Model, Estimation of Tire Road Friction. Test on Various Road Surfaces. Tire Vibration.	08 Hours
MODULE-III **VERTICAL DYNAMICS:** Human Response to Vibration, Sources of Vibration. Design and Analysis of Passive, Semi-Active and Active Suspension Using Quarter Car, Half Car and Full Car Model. Influence of Suspension Stiffness, Suspension Damping, and Tire Stiffness. Control Law for LQR, H-Infinite, Skyhook Damping. Air Suspension System and Their Properties	08 Hours
MODULE-IV **LONGITUDINAL DYNAMICS:** Aerodynamic Forces and Moments. Equation of Motion. Resistance, Rolling Resistance, Load Distribution for Three Wheeler and Four Wheeler. Calculation of Maximum Acceleration, Reaction Forces for Different Drives. Braking and Driving Torque. Prediction of Vehicle Performance.	08 Hours
MODULE-V **LATERAL DYNAMICS:** Steady State Handling Characteristics. Steady State Response to Steering Input. Testing of Handling Characteristics. Transient Response Characteristics, Direction Control Of Vehicles Roll Center, Roll Axis, Vehicle Under Side Forces. Stability of Vehicle Running on Slope, Banked Road and During Turn, Effect of Suspension on Cornering, Latest Trends in Vehicle Dynamic Testing Like Four Poster, Multi Axis Simulator, etc.	10 Hours

Question paper pattern:

1. Total of Ten Questions with two from each MODULE to be set covering the entire syllabus.
2. Five full questions are to be answered choosing at least one from each MODULE.
3. Each question should not have more than 4 sub divisions.

Text books:

1. Singiresu S. Rao, "Mechanical Vibrations", 5th Edition, Prentice Hall, 2010
2. Wong. J. Y., "Theory of Ground Vehicles", 3rd Edition, Wiley-Interscience, 2001
3. Rajesh Rajamani, "Vehicle Dynamics and Control", 1st edition, Springer, 2005
4. Thomas D. Gillespie, "Fundamentals of Vehicle Dynamics", Society of Automotive Engineers Inc, 1992

Reference Books:

1. Dean Karnopp, "Vehicle Stability", 1st edition, Marcel Dekker, 2004
2. Nakhaie Jazar. G., "Vehicle Dynamics: Theory and Application", 1st edition, Springer, 2008
3. Michael Blundell & Damian Harty, "The Multibody Systems Approach to Vehicle Dynamics", Elsevier Limited 2004 3. Hans B Pacejka, "Tire and Vehicle Dynamics", 2nd edition, SAE International, 2005
4. John C. Dixon," Tires, Suspension, and Handling", 2nd edition, Society of Automotive Engineers Inc, 1996 6. Jan Zuijdijk, 'Vehicle dynamics and damping", Author House, 2009

E books and online course materials:

Course outcomes:

On completion of the course, the student will have the ability to:

	CO	Course Outcome (CO)
	CO1	Understand the basics of vibration, when the vehicle is at dynamic condition
	CO2	Understand the tyre dynamics with respect to force & moments.
	CO3	Derive the effective cornering stiffness when considering the elastic elements in the wheel suspension and be able to analyze effect on the dynamic characteristics of the vehicle
	CO4	Understand the aerodynamic forces & moments, load distribution in the various vehicles.
	CO5	Test the effective steering geometry, vehicle handling & directional control of vehicle

COMPUTATIONAL FLUID DYNAMICS

Subject Code	19ME824	Credits	03	CIE: 50
Number of Lecture Hours/Week	3 (Theory)			SEE: 50
Total Number of Lecture Hours	42			SEE Hours: 03

Prerequisite: Should have fundamentals of physics, fluid mechanics and fluid dynamics mathematics.

Course Objectives:

1. This course will prepare students in the fundamentals of the computational approach to study fluid flow and heat transfer problems, and will provide a deeper understanding of the physical models and governing equations of fluid dynamics.
2. It will also impart the knowledge of numerical techniques to the solution of fluid dynamics and heat transfer problems.

Modules	Teaching Hours
MODULE-I **GOVERNING EQUATIONS:** Basics of computational fluid dynamics, Comparison of experimental, theoretical and computational approaches, 3-D general mass conservation, momentum and energy equations in differential form, integral form and vector representation (no derivations) Cartesian and curvilinear co-ordinates. Forms of the governing equations particularly suited for CFD work: Generic form of equations.	10 Hours
MODULE-II **PARTIAL DIFFERENTIAL EQUATIONS (PDE):** Classification of PDE - physical & mathematical classification of PDE – equilibrium problems, marching problems, Cramer rule and Eigen value method, hyperbolic, parabolic and elliptic forms of equations and their physical behavior. Physical boundary conditions.	07 Hours
MODULE-III **FINITE DIFFERENCE METHOD:** Derivation of finite difference equations for first and second order accuracy,- different numerical schemes –Explicit and Implicit approach - upwind, downwind, FTCS, etc.,truncation error, Round-off and discretization errors and analysis of stability, Error propagation, Stability properties of Explicit and Implicit methods, numerical dissipation and numerical dispersion. Application of numerical methods to selected model Equations : Wave equation, Heat equation, Laplace equation.	09 Hours
MODULE-IV **FINITE VOLUME METHOD FOR DIFFUSION :** Finite volume formulation of steady state One dimensional diffusion problems. Simple problem solving, Finite volume methods for diffusion equation. One dimensional unsteady heat conduction through Explicit, Crank – Nicolson and fully implicit.	08 Hours
MODULE-V **FINITE VOLUME METHOD FOR CONVECTION – DIFFUSION:** Finite volume formulation of steady state One dimensional convection-diffusion problems – Central, upwind, Hybrid, Power-law, QUICK differencing schemes. properties of discretization schemes – Conservativeness, Boundedness, Trasnportiveness.	08 Hours

Question paper pattern:

1. Total of Ten Questions with two from each MODULE to be set covering the entire syllabus.
2. Five full questions are to be answered choosing at least one from each MODULE.
3. Each question should not have more than 4 sub divisions.

Text books:

1. John C. Tannehill, Dule A Anderson, Richard H Pletcher, "Computational fluid mechanics and Heat transfer", CRC press, 3rd edition, April 15, 2011, ISBN-13: 9781591690375
2. Suhas.V Patankar " Numerical Heat Transfer and Fluid Flow", CRC Press 1980,ISBN-13:9780891165224
3. Versteeg, H.K., and Malalasekera, W. "An Introduction to Computational Fluid Dynamics-The finite volume Method", Pearson, 2ND edition, 2007. ISBN13:9780131274983

Reference Books:

1. T.J. Chung, "Computational Fluid Dynamics", Cambridge University Press, 2nd edition, 2010, ISBN-13:9780521769693
2. John D.Anderson, Jr. "Computational fluid Dynamics- The basics with applications" McGraw-Hill, Inc.1995, ISBN-13:9780070016859
3. Muralidhar, K., and Sundararajan, T. "Computationsl Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 2ndedition, 2009, , ISBN13:9788173195228

E books and online course materials:

Course outcomes:

On completion of the course, the student will have the ability to:

Course Code	CO #	Course Outcome (CO)
	CO1	Apply the differential equations governing fluid flow and heat transfer.
	CO2	Classify and discribe behaviour of partial differential equations
	CO3	Discuss and develop finite difference discretizations schemes and implement them to solve engineering problems.
	CO4	Importance and implications of analytical issues: consistency, stability, convergence, error analysis.
	CO5	Specify and develop finite volume discretization schemes and implement them to solve engineering problems

MICRO ELECTRO-MECHANICAL SYSTEMS (MEMS)				
Subject Code	19ME825	Credits	03	CIE: 50
Number of Lecture Hours/Week	3 (Theory)			SEE: 50
Total Number of Lecture Hours	42			SEE Hours: 03
Prerequisite:				
Course Objectives: · Understand overview of microsystems, their fabrication and application areas. · Working principles of several MEMS devices. · Develop mathematical and analytical models of MEMS devices. · Know methods to fabricate MEMS devices. · Various application areas where MEMS devices can be used.				
Modules				**Teaching Hours**
MODULE-I **Overview of MEMS and Microsystems:** MEMS and Microsystem, Typical MEMS and Microsystems Products, Evolution of Microfabrication, Microsystems and Microelectronics, Multidisciplinary Nature of Microsystems, Miniaturization. Applications and Markets.				08 Hours
MODULE-II **Working Principles of Microsystems:** Introduction, Microsensors, Microactuation, MEMS with Microactuators, Microaccelerometers, Microfluidics. **Engineering Science for Microsystems Design and Fabrication:** Introduction, Molecular Theory of Matter and Intermolecular Forces, Plasma Physics, Electrochemistry.				10 Hours
MODULE-III **Engineering Mechanics for Microsystems Design:** Introduction, Static Bending of Thin Plates, Mechanical Vibration, Thermomechanics, Fracture Mechanics, Thin Film Mechanics, Overview on Finite Element Stress Analysis.				08 Hours
MODULE-IV **Scaling Laws in Miniaturization:** Introduction, Scaling in Geometry, Scaling in Rigid-Body Dynamics, Scaling in Electrostatic Forces, Scaling in Fluid Mechanics, Scaling in Heat Transfer.				08 Hours
MODULE-V **Overview of Micromanufacturing:** Introduction, Bulk Micromanufacturing, Surface Micromachining, The LIGA Process, Summary on Micromanufacturing.				08 Hours
Question paper pattern: 1. Total of Ten Questions with two from each MODULE to be set covering the entire syllabus. 2. Five full questions are to be answered choosing at least one from each MODULE. 3. Each question should not have more than 4 sub divisions.				
Text books: 1. Tai-Ran Hsu, MEMS and Micro systems: Design, Manufacture and Nanoscale Engineering, 2nd Ed, Wiley.				

Reference Books:

1. Hans H. Gatzen, Volker Saile, JurgLeuthold, Micro and Nano Fabrication: Tools and Processes, Springer, 2015.
2. Dilip Kumar Bhattacharya, Brajesh Kumar Kaushik, Microelectromechanical Systems (MEMS), Cenage Learning.

E books and online course materials:

Course outcomes:
On completion of the course, the student will have the ability to:

Course Code	CO #	Course Outcome (CO)
	CO1	Appreciate the technologies related to Micro Electro Mechanical Systems.
	CO2	Understand design and fabrication processes involved with MEMS devices.
	CO3	Analyse the MEMS devices and develop suitable mathematical models
	CO4	Know various application areas for MEMS device
	CO5	Learn various application areas for micromanufacturing

OPEN ELECTIVE - III **TOTAL QUALITY MANAGEMENT**				
Subject Code	19OE831	Credits	03	CIE: 50
Number of Lecture Hours/Week	3 (Theory)			SEE: 50
Total Number of Lecture Hours	42			SEE Hours: 03
Prerequisite: Student should have knowledge of production process, utilization of men, machine, materials.				
Course Objectives: 1. The aim of course to provides the knowledge of TQM, Benefits of TQM, and Contribution of Gurus. 2. Students learn role and characteristics of leaders. 3. Selectively choose Tools & Techniques of TQM. 4. To study product acceptance plan and supply. 5. To study the concept of supply chain management and Experimental design.				
Modules				**Teaching Hours**
MODULE-I **Overview of Total Quality Management:** Introduction, Definition, Basic Approach, Contribution Of quality Gurus,TQM frame work , Historical review, benefits of TQM, TQM organization.				08 Hours
MODULE-II **Tools and techniques of TQM:** Basic tools of TQM, Bench marking definition, types of benchmarking, processes of bench marking, advantages and pitfalls of benchmarking quality management systems .ISO-9000 series of standards, implementation and documentation of ISO_9000. Introduction of QFD and QFD process.				09 Hours
MODULE-III **Product acceptance control:** Design of single sampling, double sampling and multiple sampling plan. Military STD 105, OC curve, AQL, LTPD, AOQL, Problems.(Intensive coverage with numerical problems). **Dodge roming system**: Single sampling lot tolerance, Double sampling lot tolerance tables. **Preventive techniques**: Design of Failure Mode and Effect analysis [FMEA], process of FMEA.				10 Hours
MODULE-IV **Quality Circles:** Introduction, origin**,** Definition, Concept, Philosophical Basis of quality circles, Theory X, Theory Y, Characteristics, scope organization structure, Process of operation of quality circle, (for Knowledge of 7 basic problem solving tools or techniques)**.**				07 Hours

MODULE-V	
Experimental Design: Introduction, Design Matrix, Design matrix for two level(lower and Upper) or three level (Middle), Basics statistics, One factor design, two factor designs, t-test, F-test, Analysis of variance (Note: $F_{model} > F_{table}$ hence the model is adequate from table $F_{14,6,0.05} = 4.07$) **Team Development :** Synergy, Team building ,types of teams, characteristics of successful teams, team members roles, effective team meetings, common team problems.	08 Hours

Question paper pattern:

1. Total of Ten Questions with two from each MODULE to be set covering the entire syllabus.
2. Five full questions are to be answered choosing at least one from each MODULE.
3. Each question should not have more than 4 sub divisions.

Text books:

1. Total quality Management Dale H Berster field(etal) Pears education , Third edition Indian Reprint - 2004
2. TQM by K. Shridhar Bhat,pearson Education III, Edn I 2004,Himalya publishing
3. Statistical quality Control by Grant Levenworth (2000).
4. Statistical quality Control by M. Mahajan (2015)

Reference Books:

1.Stastical quality control by Douglos C Mantego third editon Pearson Education - 2006
2. A new American TQM for revolution in management:Sho- shiba, Alan Graham and, David walder Productivity press Oregon-1990
3. Organizational excellence through TQM H Lal, New Age Publishers
4. Quality control and Total quality management-PL Jain TMH Publications company Ltd - 2001 New Delhi
5.Cocran WG, Cox GM, 'Experiment Design' 2nd edition, John Wiley & Sons, Inc.India 2000

Course outcomes:

On completion of the course, the student will have the ability to:

Course Code	CO #	Course Outcome (CO)
	CO1	Able to apply the knowledge of TQM and contribution of TQM gurus and strong
	CO2	Identify and implement the tools and techniques like QFD, QFD process and
	CO3	Design solutions of acceptance sampling plan solving problems of AOQL and percent defective.
	CO4	Function effectively individual and team work to supply chain management activities coordination and communication is very important.
	CO5	Demonstrate the knowledge of design of experiments, consistent development and improvement.

MOOC's Certification Course(Online NPTEL Course)				
Subject Code	19MENPTEC	Credits	01	CIE: ---
				SEE: ---

PROJECT WORK PHASE-II

Subject Code	19MEP84	Credits	08	CIE: 50
Number of Lecture Hours/Week	4 (Practical)			SEE: 50
Total Number of Lecture Hours	52			SEE Hours: 03

Prerequisite: Project Work Phase-I

Course Objectives:

The students should be able to apply acquired knowledge of courses studied in engineering to identify, formulate, analyze, evaluate and provide solution to a technical problem in the field of mechanical engineering

Modules	Teaching Hours
SCHEME OF EVALUATION **Assessment** / **Marks** CIE I Evaluation (7th week) – 25 CIE II Evaluation (12th week) – 25 SEE – 50 **Total** – 100	08 Hours

Course outcomes:
On completion of the course, the student will have the ability to:

CO #	Course Outcome (CO)
CO1	Identify a problem from the available literature and societal needs.
CO2	Apply principles of mechanical engineering in designing and conducting experiments, date acquisition and interpretation towards meaningful analysis of identified problem.
CO3	Use their analytical, teamwork and leadership skills in designing and development of products and find solution
CO4	Apply advanced tools / techniques for solving the problem.
CO5	Prepare a detailed quality project report and present the work.