



MANGALORE INSTITUTE OF TECHNOLOGY AND ENGINEERING
(An ISO 9001:2015 Certified Institution)

1.3.2. Average percentage of courses that include experiential learning through project work/field work/internship during last five years

ACADEMIC YEAR 2018-19

MECHANICAL ENGINEERING

Documents contains list and syllabus of courses that includes experiential learning through project works, internships and field work for the department.

Documents Enclosed

Sl. No	Particulars	Page Nos
1.	List of course that include experiential learning through project works, internships and field work	1-3
2.	Syllabus of the courses mapped	4-192

Subjects List of 2018-2019 Mapped Project/ Internship/Industrial Visit

15MAT11	Engineering maths-I
15PHY12	Engineering physics
15CIV13	Elements of civil Engg. & Mechanics
15EME14	Elements of mechanical engg
15ELE15	Basic electrical engg
15WSL16	Workshop practice
15PHYL17	Engg. Physics lab
15CPH18	Constitution of india, professional ethics and human rights (cph)
15MAT21	Engineering maths-II
15CHE22	Engineering chemistry
15PCD23	Programming in c & data structures
15CED24	Computer aided engineering drawing
15ELN25	Basic electronics
15CPL26	Computer programming lab
15CHEL27	Engg. Chemistry lab
15CIV28	Environmental studies
15MAT31	Engineering Mathematics - III
15MAT32	Materials Science
15MAT33	Basic Thermodynamics
15MAT34	Mechanics of Materials
15ME35A	Metal Casting and Welding
15ME36B	Mechanical Measurements and Metrology
15MEL37B	Mechanical Measurements and Metrology Lab
15MEL38A	Foundry and Forging Lab
15MAT41	Engineering Mathematics - III
15ME42	Kinematics of Machinery
15ME43	Applied Thermodynamics
15ME44	Fluid mechanics
15ME45B	Machine Tools and Operations
15ME46A	Computer Aided Machine Drawing

15MEL47A	Materials Testing Lab
15MEL48B	Machine Shop
15ME51	Management and Engineering Economics
15ME52	Dynamics of Machinery
15ME53	Turbo Machines
15ME54	Design of Machine Elements - I
15MEL57	Fluid Mechanics & Machinery Lab
15MEL58	Energy Lab
15ME551	Refrigeration and Air-conditioning
15ME554	Non-Traditional Machining
15ME563	Automation and Robotics
15ME564	Project Managemet
15ME61	Finite Element Analysis
15ME62	Computer integrated Manufacturing
15ME63	Heat Transfer
15ME64	Design of Machine Elements -II
15MEL67	Heat Transfer Lab
15MEL68	Modeling and Analysis Lab (FEA)
15ME653	Metal Forming
15ME664	Total Quality Management
15ME71	Energy Engineering
15ME72	Fluid Power Systems
15ME73	Control Engineering
15MEL76	Design Lab
15MEL77	CIM Lab
15ME745	Smart Materials & MEMS
15ME754	Mechatronics
18MDE11	Mathematical Methods in Engineering
18MDE12	Advanced Theory of Vibrations
18MDE14	Dynamics and Mechanism Design
18MDE15	Fracture Mechanics
18MDEL16	Design Laboratory 1

18MEA21	Finite Element Methods
18MDE22	Advanced Machine design
18MDE23	Tribology and Bearing Design
18MDE241	Material Handling Equipment Design
18CAE251	Design Optimization
18MDEL26	Design Laboratory 2
18MDE34	Evaluation of Project phase -1
18MDE332	Composite Materials Technology
18MDE41	Project work phase -2

ENGINEERING MATHEMATICS-I

[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2015 -2016)

SEMESTER - I/II

Subject Code	15MAT11	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS - 04

Course Objectives:

To enable the students to apply the knowledge of Mathematics in various engineering fields by making them to learn the following:

- n^{th} derivatives of product of two functions and polar curves.
- Partial derivatives
- Vector calculus
- Reduction formulae of integration; To solve First order differential equations.
- Solution of system of linear equations , quadratic forms.

Module - 1

Hours - 10

Differential Calculus -1: determination of n^{th} order derivatives of Standard functions - Problems. Leibnitz's theorem (without proof) - problems.

Polar Curves - angle between the radius vector and tangent, angle between two curves, Pedal equation of polar curves. Derivative of arc length - Cartesian, Parametric and Polar forms (without proof) - problems. Curvature and Radius of Curvature – Cartesian, Parametric, Polar and Pedal forms (without proof) -problems

Module -2

<p>Differential Calculus -2</p> <p>Taylor's and Maclaurin's theorems for function of one variable(statement only)- problems. Evaluation of Indeterminate forms.</p> <p>Partial derivatives – Definition and simple problems, Euler's theorem(without proof) – problems, total derivatives, partial differentiation of composite functions-problems. Definition and evaluation of Jacobians</p>	<p>Hours - 10</p>
<p>Module – 3</p>	
<p>Vector Calculus:</p> <p>Derivative of vector valued functions, Velocity, Acceleration and related problems, Scalar and Vector point functions. Definition of Gradient, Divergence and Curl-problems. Solenoidal and Irrotational vector fields. Vector identities - $\text{div}(\phi A)$, $\text{curl}(\phi A)$, $\text{curl}(\text{grad } \phi)$, $\text{div}(\text{curl } A)$.</p>	<p>Hours - 10</p>
<p>Module-4</p>	
<p>Integral Calculus:</p> <p>Reduction formulae - $\int \text{Sin}^n x dx$, $\int \text{Cos}^n x dx$, $\int \text{Sin}^m x \text{Cos}^n x dx$, (m and n are positive integers), evaluation of these integrals with standard limits (0 to $\pi/2$) and problems.</p> <p>Differential Equations ;</p> <p>Solution of first order and first degree differential equations – Exact, reducible to exact and Bernoulli's differential equations .Orthogonal trajectories in Cartesian and polar form. Simple problems on Newton's law of cooling.</p>	<p>Hours - 10</p>
<p>Module-5</p>	

<p>Linear Algebra</p> <p>Rank of a matrix by elementary transformations, solution of system of linear equations - Gauss-elimination method, Gauss-Jordan method and Gauss-Seidel method</p> <p>Eigen values and Eigen vectors, Rayleigh's power method to find the largest Eigen value and the corresponding Eigen vector.</p> <p>Linear transformation, diagonalisation of a square matrix .</p> <p>Reduction of Quadratic form to Canonical form</p>	<p>Hours - 10</p>
<p>Course outcomes:</p> <p>On completion of this course, students are able to</p> <ul style="list-style-type: none"> • Use partial derivatives to calculate rates of change of multivariate functions. • Analyze position, velocity, and acceleration in two or three dimensions using the calculus of vector valued functions. • Recognize and solve first-order ordinary differential equations, Newton's law of cooling • Use matrices techniques for solving systems of linear equations in the different areas of Linear Algebra. 	
<p>Question paper pattern:</p> <ul style="list-style-type: none"> • The question paper will have ten questions. • Each full Question consisting of 16 marks • There will be 2 full questions(with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. • The students will have to answer 5 full questions, selecting one full question from each module. 	
<p>Text Books:</p> <ol style="list-style-type: none"> 1. B.S. Grewal, "Higher Engineering Mathematics", Khanna publishers, 42nd edition, 2013. 	

2. Erwin Kreyszig, "**Advanced Engineering Mathematics**I, Wiley, 2013

Reference Books:

1. B.V. Ramana, "**Higher Engineering Mathematics**", Tata Mc Graw-Hill, 2006
2. N.P.Bali and Manish Goyal, "**A text book of Engineering mathematics**", Laxmi publications, latest edition.
3. H.K. Dass and Er. RajnishVerma, "**Higher Engineerig Mathematics**", S.Chand publishing, 1st edition, 2011.

ENGINEERING MATHEMATICS-II

[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2015 -2016)

SEMESTER - I/II

Subject Code	15MAT21	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS - 04

Course objectives:

To enable students to apply the knowledge of Mathematics in various engineering fields by making them to learn the following'

- Ordinary differential equations
- Partial differential equations
- Double and triple integration
- Laplace transform

Module - I**Teaching Hours**

Linear differential equations with constant coefficients: Solutions of second and higher order differential equations - inverse differential operator method, method of undetermined coefficients and method of variation of parameters.

10 Hours**Module -2****Differential equations-2:****10 Hours**

Linear differential equations with variable coefficients: Solution of Cauchy's and Legendre's linear differential equations.

Nonlinear differential equations - Equations solvable for p, equations solvable for y, equations solvable for x, general and singular solutions, Clairaut's equations and equations reducible to Clairaut's form.

Module – 3	
<p>Partial Differential equations:</p> <p>Formulation of Partial differential equations by elimination of arbitrary constants/functions, solution of non-homogeneous Partial differential equations by direct integration, solution of homogeneous Partial differential equations involving derivative with respect to one independent variable only.</p> <p>Derivation of one dimensional heat and wave equations and their solutions by variable separable method.</p>	10 Hours
Module-4	
<p>Integral Calculus:</p> <p>Double and triple integrals: Evaluation of double and triple integrals. Evaluation of double integrals by changing the order of integration and by changing into polar co-ordinates. Application of double and triple integrals to find area and volume. . Beta and Gamma functions: definitions, Relation between beta and gamma functions and simple problems.</p>	10 Hours
Module-5	
<p>Laplace Transform</p> <p>Definition and Laplace transforms of elementary functions. Laplace transforms of $e^{at}f(t)$, $t^n f(t)$ and $\frac{f(t)}{t}$ (without proof) , periodic functions and unit-step function- problems</p> <p>Inverse Laplace Transform</p> <p>Inverse Laplace Transform - problems, Convolution theorem to find the inverse Laplace transforms(without proof) and problems, solution of linear differential equations using Laplace Transforms.</p>	10 Hours

Course outcomes:

On completion of this course, students are able to,

- solve differential equations of electrical circuits, forced oscillation of mass spring and elementary heat transfer.
- solve partial differential equations fluid mechanics, electromagnetic theory and heat transfer.
- Evaluate double and triple integrals to find area , volume, mass and moment of inertia of plane and solid region.
- Use curl and divergence of a vector valued functions in various applications of electricity, magnetism and fluid flows.
- Use Laplace transforms to determine general or complete solutions to linear ODE

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 16 marks
- There will be **2** full questions(with a **maximum** of **four** sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer **5** full questions, selecting one full question from each module.

Text Books:

- B. S. Grewal," Higher Engineering Mathematics", Khanna publishers, 42nd edition, 2013.
- Kreyszig, "Advanced Engineering Mathematics " - Wiley, 2013

Reference Books:

- B.V.Ramana "Higher Engineering Mathematics" Tata Mc Graw-Hill, 2006
- N P Bali and Manish Goyal, "A text book of Engineering mathematics" , Laxmi publications, latest edition.
- H. K Dass and Er. Rajnish Verma ,"Higher Engineerig Mathematics", S. Chand publishing,1st edition, 2011.

ENGINEERING PHYSICS [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2015 -2016) SEMESTER - I/II			
Subject Code	15PHY12/15PHY22	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03
CREDITS - 04			
COURSE OBJECTIVES: <p>The Objective of this course is to make students learn and understand basic concepts and principles of physics to analyze practical engineering problems and apply its solutions effectively and meaningfully. To understand building up of models, design issues, practical oriented skills and problem solving challenges are the great task of the course. To know about shock waves and practical applications is the prime motto to introduce new technology at the initial stage of Engineering.</p>			
Module - 1			Teaching Hours
Modern Physics and Quantum Mechanics <p>Black body radiation spectrum, Assumptions of quantum theory of radiation, Plank's law, Weins law and Rayleigh Jeans law, for shorter and longer wavelength limits. Wave Particle dualism, deBroglie hypothesis. Compton Effect. Matter waves and their Characteristic properties, Definition of Phase velocity and group velocity, Relation between phase velocity and group velocity, Relation between group velocity and particle velocity.</p> <p>Heisenberg's uncertainty principle and its application, (Non-existence of electron in the nucleus).Wave function, Properties and physical significance of wave function, Probability density and Normalization of wave function. Setting up of one dimensional time independent Schrodinger wave equation. Eigen values and Eigen functions. Application of Schrodinger wave equation for a particle in a potential well of infinite depth and for free particle.</p>			10 Hours

Module -2	
Electrical Properties of Materials	10 Hours
<p>Free–electron concept (Drift velocity, Thermal velocity, Mean collision time, Mean free path, relaxation time). Failure of classical free electron theory. Quantum free electron theory, Assumptions, Fermi factor, density of states (qualitative only) Fermi–Dirac Statistics. Expression for electrical conductivity based on quantum free electron theory, Merits of quantum free electron theory.</p> <p>Conductivity of Semi conducting materials, Concentration of electrons and holes in intrinsic semiconductors, law of mass action.</p> <p>Temperature dependence of resistivity in metals and superconducting materials. Effect of magnetic field (Meissner effect). Type I and Type II superconductors–Temperature dependence of critical field. BCS theory (qualitative). High temperature superconductors. Applications of superconductors –. Maglev vehicles.</p>	
Module – 3	
Lasers and Optical Fibers	10 Hours
<p>Einstein’s coefficients (expression for energy density). Requisites of a Laser system. Condition for laser action. Principle, Construction and working of CO₂ laser and semiconductor Laser. Applications of Laser – Laser welding, cutting and drilling. Measurement of atmospheric pollutants. Holography–Principle of Recording and reconstruction of images.</p> <p>Propagation mechanism in optical fibers. Angle of acceptance. Numerical aperture. Types of optical fibers and modes of propagation. Attenuation, Block diagram discussion of point to point communication, applications.</p>	
Module-4	

<p style="text-align: center;">Crystal Structure</p> <p>Space lattice, Bravais lattice–Unit cell, primitive cell. Lattice parameters. Crystal systems. Direction and planes in a crystal. Miller indices. Expression for inter – planar spacing. Co-ordination number. Atomic packing factors (SC,FCC,BCC). Bragg’s law, Determination of crystal structure using Bragg’s X–ray diffractometer. Polymorphism and Allotropy. Crystal Structure of Diamond, qualitative discussion of Pervoskites.</p>	10 Hours
Module-5	
<p style="text-align: center;">Shock waves and Science of Nano Materials</p> <p>Definition of Mach number, distinctions between- acoustic, ultrasonic, subsonic and supersonic waves. Description of a shock wave and its applications. Basics of conservation of mass, momentum and energy. Normal shock equations (Rankine-Hugonit equations). Method of creating shock waves in the laboratory using a shock tube, description of hand operated Reddy shock tube and its characteristics.</p> <p>Introduction to Nano Science, Density of states in 1D, 2D and 3D structures. Synthesis : Top–down and Bottom–up approach, Ball Milling and Sol–Gel methods.</p> <p>CNT – Properties, synthesis: Arc discharge, Pyrolysis methods, Applications.</p> <p>Scanning Electron microscope: Principle, working and applications.</p>	10 Hours

Course outcomes:

On Completion of this course, students are able to –

- Learn and understand more about basic principles and to develop problem solving skills and implementation in technology.
- Gain Knowledge about Modern physics and quantum mechanics will update the basic concepts to implement the skills.
- Study of material properties and their applications is the prime role to understand and use in engineering applications and studies.
- Study Lasers and Optical fibers and its applications are to import knowledge and to develop skills and to use modern instruments in the engineering applications.
- Understand Crystal structure and applications are to boost the technical skills and its applications.
- Expose shock waves concept and its applications will bring latest technology to the students at the first year level to develop research orientation programs at higher semester level.
- Understand basic concepts of nano science and technology.

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 16 marks
- There will be **2** full questions(with a **maximum** of **four** sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer **5** full questions, selecting one full question from each module.

Text Books:

1. Wiley precise Text, **Engineering Physics**, Wiley India Private Ltd., New Delhi.
Book series – 2014,
2. Dr. M.N. Avadhanulu, Dr. P.G.Kshirsagar, **Text Book of Engineering Physics**, S Chand Publishing, New Delhi - 2012

Reference Books:

1. S.O.Pillai, **Solid State Physics**, New Age International. Sixth Edition.
2. Chintoo S Kumar ,K Takayana and K P J Reddy, **Shock waves made simple**, Willey India Pvt. Ltd. New Delhi,2014
3. A Marikani, **Engineering Physics**, PHI Learning Private Limited, Delhi - 2013
4. Prof. S. P. Basavaraju, **Engineering Physics**, Subhas Stores, Bangalore – 2
5. V Rajendran ,**Engineering Physics**, Tata Mc.Graw Hill Company Ltd., New Delhi - 2012
6. S Mani Naidu, **Engineering Physics**, Pearson India Limited - 2014

ELEMENTS OF CIVIL ENGINEERING AND ENGINEERING MECHANICS [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2015 -2016) SEMESTER - I/II			
Subject Code	15CIV13/23	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03
CREDITS - 04			
COURSE OBJECTIVES: The objectives of this course is to make students to learn basics of Civil Engineering concepts and infrastructure development, solve problems involving Forces, loads and Moments and know their applications in allied subjects. It is a pre-requisite for several courses involving Forces, Moments, Centroids, Moment of inertia and Kinematics.			
Particulars			Hours
Module 1: Introduction to Civil Engineering &Engineering Mechanics			10
Introduction to Civil Engineering Scope of different fields of Civil Engineering - Surveying, Building Materials, Construction Technology, Geotechnical Engineering, Structural Engineering, Hydraulics, WaterResources and Irrigation Engineering, Transportation Engineering, Environmental Engineering.			01
Infrastructure: Types of infrastructure, Role of Civil Engineer in theInfrastructural Development, Effect of the infrastructural facilities onsocio-economic development of a country.			01
Roads: Classification of Roads and their functions, Comparison of Flexible and Rigid Pavements (Advantages and Limitations)			01

Bridges: Types of Bridges and Culverts, RCC, Steel and Composite Bridges	01
Dams: Different types of Dams based on Material, Structural behavior and functionality with simple sketches.	01
Introduction to Engineering Mechanics: Basic idealizations - Particle, Continuum and Rigid body; Newton's laws □ Force and its characteristics, types of forces-Gravity, Lateral and its distribution on surfaces, Classification of force systems, Principle of physical independence, superposition, transmissibility of forces, , Introduction to SI units.	02
Couple, Moment of a couple, Characteristics of couple, Moment of a force, Equivalent force - Couple system; Numerical problems on moment of forces and couples, on equivalent force - couple system.	03
Module 2: Analysis of Concurrent Force Systems	10
Concepts: Resultants and Equilibrium Composition of forces - Definition of Resultant; Composition of coplanar -concurrent force system, Parallelogram Law of forces, Principle of resolved parts;	03
Numerical problems on composition of coplanar concurrent force systems. Equilibrium of forces - Definition of Equilibrant; Conditions of static equilibrium for different force systems, Lami's theorem; Numerical problems on equilibrium of coplanar – concurrent and non-concurrent force systems.	03
Application- Static Friction in rigid bodies in contact Types of friction, Laws of static friction, Limiting friction, Angle of friction, angle of repose; Impending motion on horizontal and inclined planes; Numerical Problems on single and two blocks on inclined planes	02 02
Module - 3 Analysis of Non-Concurrent Force Systems	10

<p>Concepts: Resultants and Equilibrium Composition of coplanar - non-concurrent force system, Varignon's principle of moments; Numerical problems on composition of coplanar non-concurrent Force system.</p>	05
<p>Application-Support Reaction in beams Types of Loads and Supports, statically determinate beams, Numerical problems on support reactions for statically determinate beams with Point load (Normal and inclined) and uniformly distributed and uniformly varying loads and Moments.</p>	05
<p>Module 4 Centroids and Moments of Inertia of Engineering Sections:</p>	10
<p>Centroids Introduction to the concept, centroid of line and area, centroid of basic geometrical figures, computing centroid for – T, L, I, Z and full/quadrant circular sections and their built up sections. Numerical problems</p>	05
<p>Moment of Inertia Introduction to the concept, Radius of gyration, Parallel axis theorem, Perpendicular axis theorem, Moment of Inertia of basic planar figures, computing moment of Inertia for – T, L, I, Z and full/quadrant circular sections and their built up sections. Numerical problems</p>	05
<p>Module 5: Kinematics</p>	10
<p>Concepts and Applications Definitions – Displacement – Average velocity – Instantaneous velocity – Speed – Acceleration - Average acceleration – Variable acceleration – Acceleration due to gravity – Newton's Laws of Motion.</p>	02
Rectilinear Motion–Numerical problems.	02
Curvilinear Motion – Super elevation – Projectile Motion – Relative motion – Numerical problems.	03
Motion under gravity – Numerical problems.	03
<p>COURSE OUTCOMES After a successful completion of the course, the student will be able to: 1. Know basics of Civil Engineering, its scope of study, knowledge about Roads, Bridges and Dams;</p>	

2. Comprehend the action of Forces, Moments and other loads on systems of rigid bodies;
3. Compute the reactive forces and the effects that develop as a result of the external loads;
4. Locate the Centroid and compute the Moment of Inertia of regular cross-sections.
5. Express the relationship between the motion of bodies and
6. Equipped to pursue studies in allied courses in Mechanics.

Question Paper Pattern:

- 10 Questions are to be set such that 2 questions are selected from each module.
- 2 Questions are to be set under respective modules.
- Intra module questions are to be set such that the questions should cover the entire module and further, should be answerable for the set marks.
- Each question should be set for 16 marks (Preferably 8 marks each)
- Not more than 3 sub questions are to be set under any main question
- Students should answer 5 full questions selecting at least 1 from each module.

TEXT BOOKS

1. Elements of Civil Engineering and Engineering Mechanics by M.N. Shesha Prakash and Ganesh. B. Mogaveer, PHI Learning, 3rd Revised edition (2014)
2. Engineering Mechanics-Statics and Dynamics by A Nelson, Tata McGraw Hill Education Private Ltd, New Delhi, 2009.
3. Elements of Civil Engineering (IV Edition) by S.S. Bhavikatti, New Age International Publisher, New Delhi, 3rd edition 2009.

REFERENCES

1. Engineering Mechanics by S.Timoshenko,D.H.Young, and J.V.Rao, TATA McGraw-Hill Book Company, New Delhi
2. Beer FP and Johnson ER, “**Mechanics for Engineers- Dynamics and Statics**”- 3rd SI Metric edition, Tata McGraw Hill. - 2008
3. Shames IH, “**Engineering Mechanics – Statics & Dynamics**”- PHI – 2009

ELEMENTS OF MECHANICAL ENGINEERING [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2015 -2016) SEMESTER - I/II			
Subject Code	15EME14/15EME24	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03
CREDITS - 04			
Course objectives: Students belonging to all branches of Engineering are made to learn certain fundamental topics related to mechanical engineering so that they will have a minimum understanding of mechanical systems, equipment and process.			
Module -1			Teaching Hours
<p>Energy Resources :Non-renewable and renewable energy resources, Petroleum based solid, liquid and gaseous fuels, Calorific values of fuels, Combustion and combustion products of fuels, Solar Power : Solar Radiation,</p> <p>Solar constant (definition only), Solar Thermal energy harvesting, ex: liquid flat plate collectors, solar ponds (principle of operation only), Solar photovoltaic principle. WindPower :principle of operation of a typical windmill. Hydro Power :Principles of electric power generation from hydropowerplants, Nuclear Power : Principles of Nuclear power plants, Bio Fuels : introduction to bio fuels, examples of various biofuels used in engineering applications, Comparison of biofuels with petroleum fuels in terms of calorific value and emission. Steam Formation and Properties :</p> <p>Classification of boilers, Lancashire boiler, Babcock and Wilcox boiler, boiler mountings and accessories (No sketches for mountings and accessories), wet steam, saturated and superheated steam, specific volume, enthalpy and internal energy. (No numerical problems in this module)</p>			10 Hours

Module -2	
<p>Turbines and IC Engines and Pumps Steam turbines :Classification, Principle of operation of Impulse and reaction turbines, Delaval's turbine, Parson's turbine. (No compounding of turbines).</p> <p>Gas turbines :Classification, Working principles and Operations of Open cycle and closed cycle gas turbines.</p> <p>Water turbines :Classification, Principles and operations of Pelton wheel, Francis turbine and Kaplan turbine</p> <p>Internal Combustion Engines :Classification, I.C. Engines parts, 2 Stroke and 4 stroke Petrol engines, 4 stroke diesel engines. P-V diagrams of Otto and Diesel cycles. Problems on indicated power, brake power, indicated thermal efficiency, brake thermal efficiency, mechanical efficiency, and specific fuel consumption, [numericals on IC Engines].</p>	10 Hours
Module - 3	
<p>Machine Tools and Automation Machine Tools Operations : Turning, facing, knurling, Thread cutting, Taper Turning by swivelling the compound rest, Drilling, Boring, Reaming, Tapping, Counter Sinking, Counter Boring, -Plane milling, End milling, Slot milling. (No sketches of Machine tools, sketches to be used only for explaining operations. Students to be shown the available machine tools in the Machine Shop of the college before explaining the operations)</p> <p>Robotics and Automation :</p> <p>Robotics :Introduction, classification based on robots configuration; Polar, cylindrical, Cartesian Coordinate and spherical. Application, Advantages, and disadvantages</p> <p>Automation :Definition, types -Fixed, Programmable & Flexible automation, NC/ CNC machines: Basic elements with simple block diagrams, advantages and disadvantages.</p>	10 Hours

Module-4	
<p>Engineering materials and joining processes :</p> <p>Engineering Materials :Types and applications of Ferrous & Nonferrous metals and alloys,</p> <p>Composites :Introduction: Definition, Classification and applications (Air craft and Automobiles)</p> <p>Soldering, Brazing and Welding :</p> <p>Definitions, classification and method of soldering, Brazing and welding. Differences between soldering, Brazing and Welding. Description of Electric Arc Welding and Oxy-Acetylene Welding.</p>	10 Hours
Module-5	
<p>Refrigeration, Air-Conditioning :</p> <p>Refrigerants :properties of refrigerants, list of commonly used refrigerants. Refrigeration –Definitions – Refrigerating effect, Ton of Refrigeration, Ice making capacity, COP, Relative COP, unit of Refrigeration. Principle and working of vapor compression refrigeration and vapour absorption refrigeration: Principles and applications of air conditioners, Room air conditioner.</p>	10 Hours
<p>Course outcomes:</p> <p>Students shall demonstrate knowledge associated with,</p> <ol style="list-style-type: none"> 1. Various Energy sources, Boilers, Prime movers such as turbines and IC engines, refrigeration and air-conditioning systems 2. Metal removal process using Lathe, drilling, Milling Robotics and Automation. 3. Fair understanding of application and usage of various engineering materials. 	
<p>Question paper pattern:</p> <ul style="list-style-type: none"> • The question paper will have ten questions. • Each full Question consisting of 16 marks • There will be 2 full questions(with a maximum of four sub questions) 	

from each module.

- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer **5** full questions, selecting one full question from each module.
- Each full question will have sub questions covering all the topics under a module.

Text Books:

1. V.K.Manglik, "**Elements of Mechanical Engineering**", PHI Publications, 2013. (Module-1,2,4,5)
2. MikellP.Groover, "**Automation, Production Systems & CIM**", 3rd Edition, PHI (Module -3)
3. K.R.Gopalkrishna, "**A text Book of Elements of Mechanical Engineering**"- Subhash Publishers, Bangalore. (Module -1,2,3,4,5)

Reference Books:

1. S.TrymbakaMurthy, "**A Text Book of Elements of Mechanical Engineering**", 4th Edition 2006, Universities Press (India) Pvt Ltd, Hyderabad.
2. K.P.Roy, S.K.HajraChoudhury, Nirjhar Roy, "**Elements of Mechanical Engineering**", Media Promoters & Publishers Pvt Ltd,Mumbai,7th Edition,2012
3. Pravin Kumar, "**Basic Mechanical Engineering**", 2013 Edition, Pearson.

BASIC ELECTRICAL ENGINEERING			
[As per Choice Based Credit System (CBCS) scheme]			
(Effective from the academic year 2015 -2016)			
SEMESTER - I/II			
Subject Code	15ELE15/15ELE25	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03
Credits - 04			
Course objectives:			
<ul style="list-style-type: none"> • Impart a basic knowledge of electrical quantities such as current, voltage, power, energy and frequency to understand the impact of technology in a global and societal context. • Provide working knowledge for the analysis of basic DC and AC circuits used in electrical and electronic devices. • Develop selection skill to identify the type of generators or motors required for particular application. • Highlight the importance of transformers in transmission and distribution of electric power. • Emphasize the effects of electric shock and precautionary measures. • Improve the ability to function on multi-disciplinary teams. 			
Module -1			Teaching Hours
D C circuits: Ohm's Law and Kirchhoff's Laws, analysis of series, parallel and series- parallel circuits excited by independent voltage sources. Power and Energy. Illustrative examples.			5 Hours
Electromagnetism: Review of field around a conductor and coil, magnetic flux and flux density, magnetomotive force and magnetic field intensity, reluctance and permeability, definition of magnetic circuit and basic analogy between electric and magnetic circuits. (These topics are not to be considered for setting the examination questions). Electromagnetic induction: Definition of Electromagnetic Induction, Faradays Laws, Fleming's right hand rule, Lenz's Law, Statically and dynamically induced emf. Self-inductance, mutual inductance and coefficient of coupling. Energy stored in magnetic field. Illustrative examples. Force on current carrying conductor placed in a magnetic field, Fleming's left hand rule.			5Hours

Module -2	
<p>DC Machines: Working principle of DC machine as a generator and a motor. Types and constructional features. Types of armature windings, Emf equation of generator, relation between induced emf and terminal voltage with a mention of brush contact drop and drop due to armature reaction. Illustrative examples, neglecting armature reaction.</p> <p>Operation of DC motor, back emf, torque equation. Types of DC motors, characteristics and applications. Significance of back emf. Necessity of a starter for DC motor. Illustrative examples on back emf and torque.</p>	7 Hours
<p>Measuring Instruments: Construction and Principle of operation of dynamometer type wattmeter and single phase induction type energy meter.</p>	3 Hours
Module - 3	
<p>Single-phase AC circuits: Generation of sinusoidal voltage, frequency of generated voltage, definition and numerical values of average value, root mean square value, form factor and peak factor of sinusoidally varying quantities, phasor representation of alternating quantities. Analysis, with phasor diagrams, of R, L, C, R-L, R-C and R-L-C circuits and, parallel and series- parallel circuits. Real power, reactive power, apparent power and power factor. Illustrative examples.</p>	7 Hours
<p>Domestic wiring:</p> <p>Service mains, meter board and distribution board. Brief discussion on concealed conduit wiring. Two-way and three-way control. Elementary discussion on Circuit protective devices: fuse and Miniature Circuit Breaker (MCB's). Electric shock, precautions against shock, Objectives of Earthing, types of earthing; pipe and plate earthing, Residual current circuit breaker (RCCB).</p>	3 Hours
Module-4	
<p>Three Phase Circuits: Necessity and advantages of three phase systems, generation of three phase power. Definition of Phase sequence, balanced supply and balanced load. Relationship between line and phase values of balanced star and delta connections. Power in balanced three-phase circuits, measurement of power by two-wattmeter method. Determination power factor using wattmeter readings. Illustrative examples.</p>	6 Hours

<p>Three Phase Synchronous Generators: Principle of operation, Types and constructional features, Advantages of rotating field type alternator, Synchronous speed, Frequency of generated voltage, Emf equation. Concept of winding factor (excluding the derivation of distribution and pitch factors). Illustrative examples on calculation of distribution factor, pitch factor and emf equation.</p>	<p>4 Hours</p>
<p>Module-5</p>	
<p>Single Phase Transformers:</p> <p>Necessity of transformer, Principle of operation and construction of single-phase transformers (core and shell types). Emf equation, losses, variation losses with respect to load, efficiency, Condition for maximum efficiency, Voltage regulation and its significance (Open Circuit and Short circuit tests, equivalent circuit and phasor diagrams are excluded). Illustrative problems on emf equation and efficiency only.</p>	<p>6 Hours</p>
<p>Three Phase Induction Motors: Principle of operation, Concept and production of rotating magnetic field, Synchronous speed, rotor speed, Slip, Frequency of the rotor induced emf, Types and Constructional features. Slip and its significance. Applications of squirrel - cage and slip - ring motors. Necessity of a starter, starting of motor using stars-delta starter. Illustrative examples on slip calculations.</p>	<p>4 Hours</p>
<p>Course outcomes:</p> <p>After the completion of the course, the student should be able</p> <ul style="list-style-type: none"> • To predict the behaviour of electrical and magnetic circuits. • Select the type of generator / motor required for a particular application. • Realize the requirement of transformers in transmission and distribution of electric power and other applications. • Practice Electrical Safety Rules & standards. • To function on multi-disciplinary teams. 	
<p>Question paper pattern:</p> <ul style="list-style-type: none"> • The question paper will have ten questions. • Each full Question consisting of 16 marks • There will be 2 full questions (with a maximum of four sub questions) from 	

each module.

- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer **5** full questions, selecting one full question from each module.

Text Books

1	Basic Electrical Engineering	D. C. Kulshreshtha	TMH	1 st Edition, Revised
2	Electrical Technology	Edward Hughes	Pearson	10th Edition, 2014
Reference Books				
3	Fundamentals of Electrical Engineering	Rajendra Prasad	PHI	Third Edition 2014
4	Basic Electrical Engineering	Abhijit Chakrabarti, Chandan Kumar Chanda, Sudiptanath	TMH,	1st Edition 2010
5	Fundamentals of Electrical Engineering and Electronics	B. L. Theraja	S. Chand & Company Ltd	Reprint Edition 2013

WORKSHOP PRACTICE

[As per Choice Based Credit System (CBCS) scheme]

(Effective from the academic year 2015 -2016)

SEMESTER - I/II

Subject Code	15WSL16/15WSL26	IA Marks	20
Labs / Tutorial Hours/Week	3 (1 hr Tut +2 hrs lab)	Exam Marks	80
Total Number of Lecture Hours	42	Exam Hours	03

CREDITS - 02

Course objectives:

- To impart knowledge and skill to use tools, machines, equipment, and measuring instruments.
- Educate students of Safe handling of machines and tools.

Module -1

Teaching Hours

1. Demonstration on use of Hand Tools: V-block, Marking Gauge, Files, Hack Saw, Drills, Taps. Minimum 3 models involving Dove tail joint, Triangular joint and Semicircular joint.
2. Welding: Study of electric arc welding tools & equipments, Models: Butt Joint, Lap Joint, T joint & L-joint.
3. Sheet Metal & Soldering Work: Development & Soldering of the models: Tray, Frustum of cone, Prism (Hexagon & Pentagon), Truncated Square Pyramid, Funnel.

3 Hours

Course outcomes:

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

1. Demonstrate and produce different types of fitting models.
2. Gain knowledge of development of sheet metal models with an understanding of their applications.
3. Perform soldering and welding of different sheet metal & welded joints.
4. Understand the Basics of Workshop practices.

Ref Books:

1. Elements of Workshop Technology:Vol I:Manufacturing Processes, S K Hajra.

Choudhury, A K. Hajra Choudhury,15th Edition Reprinted 2013,Media Promoters &Publishers Pvt Ltd., Mumbai.

Note: No mini drafters and drawing boards required. Drawings (Developments) can be done on sketch sheets using scale , pencil and Geometrical Instruments

ENGINEERING PHYSICS LAB

Laboratory Code	15PHYL17 / 15PHYL27	IA Marks	20
Labs / Instructions Hours/Week	3 (1 hr Tutorial +2 hrs lab)	Exam Marks	80
Total Number of Lecture Hours	48	Exam Hours	03

CREDITS - 02

Course Objectives:

- The Objective of this course is to make the students gain practical knowledge to co-relate with the theoretical studies. To achieve perfectness in experimental skills and the study of practical applications will bring more confidence and ability to develop and fabricate engineering and technical equipments.
- Design of circuits using new technology and latest components and to develop practical applications of engineering materials and use of principle in the right way to implement the modern technology.

EXPERIMENTS:

1. Black box experiment; Identification of unknown passive electrical components and determine the value of Inductance and Capacitance
2. Series and parallel LCR Circuits (Determination of resonant frequency and quality factor)
3. I-V Characteristics of Zener Diode. (determination of knee voltage, zener voltage and forward resistance)
4. Characteristics of Transistor (Study of Input and Output characteristics and calculation of input resistance, output resistance and amplification factor)
5. Photo Diode Characteristics (Study of I-V characteristics in reverse bias and variation of photocurrent as a function of reverse voltage and intensity).
6. Dielectric constant (Measurement of dielectric constant).
7. Diffraction (Measurement of wavelength of laser source using diffraction grating).
8. Torsional pendulum (Determination of M.I. of wire and Rigidity modulus).
9. Determination of Fermi energy. (Measurement of Fermi energy in copper).
10. Uniform Bending Experiment (Determination of Youngs modulus of material bar).
11. Newtons Rings, (Determination of radius of curvature of plano convex lens).

12. Verification of Stefan's Law.

Course Outcomes:

On Completion of this course, students are able to –

- Develop skills to impart practical knowledge in real time solution.
- Understand principle, concept, working and application of new technology and comparison of results with theoretical calculations.
- Design new instruments with practical knowledge.
- Gain knowledge of new concept in the solution of practical oriented problems and to understand more deep knowledge about the solution to theoretical problems.
- Understand measurement technology, usage of new instruments and real time applications in engineering studies.

Note: 1) All the above twelve experiments are to be conducted

2) Two experiments are to be performed by the students in the examination

CONSTITUTION OF INDIA, PROFESSIONAL ETHICS & HUMAN RIGHTS

Subject Code	15CPH18/15CPH28	IA Marks	20
Number of Lecture Hours/Week	02	Exam Marks	80
Total Number of Lecture Hours	25	Exam Hours	03
CREDITS - 01			

Course objectives:

1. To provide basic information about Indian constitution.
2. To identify individual role and ethical responsibility towards society.
3. To understand human rights and its implications

Module 1

Introduction to the Constitution of India, The Making of the Constitution and Salient features of the Constitution. **2 Hours**

Preamble to the Indian Constitution Fundamental Rights & its limitations. **3 Hours**

Module 2

Directive Principles of State Policy & Relevance of Directive Principles State Policy Fundamental Duties. **2 Hours**

Union Executives – President, Prime Minister Parliament Supreme Court of India. **3 Hours**

Module 3

State Executives – Governor Chief Minister, State Legislature High Court of State. **2 Hours**

Electoral Process in India, Amendment Procedures, 42nd, 44th, 74th, 76th, 86th & 91st Amendments. **3 Hours**

Module 4

Special Provision for SC & ST Special Provision for Women, Children & Backward Classes Emergency Provisions. Human Rights –Meaning and Definitions, Legislation Specific Themes in Human Rights- Working of National Human Rights Commission in India **3 Hours**

Powers and functions of Municipalities, Panchyats and Co - Operative Societies. **2 Hours**

Module 5

Scope & Aims of Engineering Ethics, Responsibility of Engineers Impediments to Responsibility. **2 Hours**

Risks, Safety and liability of Engineers, Honesty, Integrity & Reliability in Engineering.

3 Hours

Course outcomes:

After study of the course, the students are able to

- Have general knowledge and legal literacy and thereby to take up competitive examinations
- Understand state and central policies, fundamental duties
- Understand Electoral Process, special provisions
- Understand powers and functions of Municipalities, Panchayats and Co-operative Societies, and
- Understand Engineering ethics and responsibilities of Engineers.
- Have an awareness about basic human rights in India

Text Books:

1. Durga Das Basu: **“Introduction to the Constitution on India”**, (Students Edn.) Prentice –Hall EEE, 19th / 20th Edn., 2001
2. Charles E. Haries, Michael S Pritchard and Michael J. Robins **“Engineering Ethics”** Thompson Asia, 2003-08-05.

Reference Books:

1. M.V.Pylee, **“An Introduction to Constitution of India”**, Vikas Publishing, 2002.
2. M.Govindarajan, S.Natarajan, V.S.Senthilkumar, **“Engineering Ethics”**, Prentice –Hall of India Pvt. Ltd. New Delhi, 2004
3. Brij Kishore Sharma, **“Introduction to the Constitution of India”**, PHI Learning Pvt. Ltd., New Delhi, 2011.
4. Latest Publications of Indian Institute of Human Rights, New Delhi.

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ENGINEERING CHEMISTRY

[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2015 -2016)

SEMESTER - I/II

Subject Code	15CHE12/15CHE22	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS - 04

Course objectives:

To provide students with knowledge of engineering chemistry for building technical competence in industries, research and development in the following fields

- Electrochemistry & Battery Technology.
- Corrosion & Metal Finishing.
- Fuels & Solar energy.
- Polymers.
- Water Technology & Nano Materials.

Module - 1**Teaching Hours****Electrochemistry and Battery Technology****10 hours**

Electrochemistry: Introduction, Derivation of Nernst equation for electrode potential. Reference electrodes: Introduction, construction, working and applications of calomel and Ag / AgCl electrodes. Measurement of electrode potential using calomel electrode. Ion selective electrode: Introduction; Construction and working of glass electrode, determination of pH using glass electrode. Concentration cells: Electrolyte concentration cells, numerical problems.

Battery Technology: Introduction, classification - primary, secondary and reserve batteries. Characteristics - cell potential, current, capacity, electricity storage density, energy efficiency, cycle

life and shelf life. Construction, working and applications of Zinc-Air, Nickel- metal hydride batteries. Lithium batteries: Introduction, construction, working and applications of Li-MnO₂ and Li-ion batteries.

Fuel Cells: Introduction, difference between conventional cell and fuel cell, limitations & advantages. Construction, working & applications of methanol-oxygen fuel cell with H₂SO₄ electrolyte.

Module -2

Corrosion and Metal Finishing:**10hours**

Corrosion: Introduction, electrochemical theory of corrosion, galvanic series. Factors affecting the rate of corrosion: ratio of anodic to cathodic areas, nature of metal, nature of corrosion product, nature of medium – pH, conductivity, and temperature. Types of corrosion- Differential metal, differential aeration (Pitting and water line) and stress. Corrosion control: Inorganic coatings- Anodizing of Al and phosphating; Metal coatings-Galvanization and Tinning. Cathodic protection (sacrificial anodic and impressed current methods).

Metal Finishing: Introduction, Technological importance. Electroplating: Introduction, principles governing-Polarization, decomposition potential and overvoltage. Factors influencing the nature of electro deposit-current density, concentration of metal ion & electrolyte; pH, temperature & throwing power of plating bath; additives- brighteners, levellers, structure modifiers & wetting agents. Electroplating of Nickel (Watt's Bath) and Chromium(decorative and hard). Electro less plating: Introduction, distinction between electroplating and electro less plating, electro less plating of copper & manufacture of double sided Printed Circuit Board with copper.

Module - 3

<p>Fuels and Solar Energy:</p> <p>Fuels: Introduction, classification, calorific value- gross and net calorific values, determination of calorific value of fuel using bomb calorimeter, numerical problems. Cracking: Introduction, fluidized catalytic cracking, synthesis of petrol by Fishcher-Tropsch process, reformation of petrol, octane and cetane numbers. Gasoline and diesel knocking and their mechanism, anti knocking agents, power alcohol & biodiesel.</p> <p>Solar Energy: Introduction, utilization and conversion, photovoltaic cells- construction and working. Design of PV cells: modules, panels & arrays. Advantages & disadvantages of PV cells. Production of solar grade silicon: Union carbide process, purification of silicon (zone refining), doping of silicon-diffusion technique (n&p types).</p>	<p>10 hours</p>
<p>Module - 4</p>	

<p>Polymers:</p> <p>Introduction, types of polymerization: addition and condensation, mechanism of polymerization- free radical mechanism taking vinyl chloride as an example. Molecular weight of polymers: number average and weight average, numerical problems. Glass transition temperature (T_g): Factors influencing T_g-Flexibility, inter molecular forces, molecular mass, branching & cross linking and stereo regularity. Significance of T_g. Structure property relationship: crystallinity, tensile strength, elasticity & chemical resistivity. Synthesis, properties and applications of PMMA (plexi glass), Polyurethane and polycarbonate. Elastomers: Introduction, synthesis, properties and applications of Silicone rubber. Adhesives: Introduction, synthesis, properties and applications of epoxy resin. Polymer Composites: Introduction, synthesis, properties and applications of Kevlar. Conducting polymers: Introduction, mechanism of conduction in Poly aniline and applications of conducting poly aniline.</p>	<p>10 hours</p>
<p>Module-5</p>	

<p>Water Technology and Nanomaterials:</p> <p>Water Technology: Introduction, boiler troubles with disadvantages & prevention methods-scale and sludge formation, priming and foaming, boiler corrosion(due to dissolved O₂, CO₂ and MgCl₂). Determination of DO, BOD and COD, numerical problems on COD. Sewage treatment: Primary, secondary (activated sludge method) and tertiary methods. Softening of water by ion exchange process. Desalination of sea water by reverse osmosis & electro dialysis (ion selective)..</p> <p>Nano Materials: Introduction, properties (size dependent). Synthesis-bottom up approach (sol-gel, precipitation, gas condensation & chemical vapour condensation processes). Nano scale materials- carbon nano tubes, nano wires, fullerenes, dendrimers, nano rods, & nano composites.</p>	<p>10 hours</p>
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Course outcomes:

On completion of this course, students will have knowledge in:

- Electrochemical and concentration cells. Classical & modern batteries and fuel cells.
- Causes & effects of corrosion of metals and control of corrosion. Modification of surface properties of metals to develop resistance to corrosion, wear, tear, impact etc. by electroplating and electroless plating.
- Production & consumption of energy for industrialization of country and living standards of people. Utilization of solar energy for different useful forms of energy.
- Replacement of conventional materials by polymers for various applications.
- Boiler troubles; sewage treatment and desalination of sea water, and
- Over viewing of synthesis, properties and applications of nanomaterials.

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 16 marks
- There will be **2** full questions (with a **maximum** of **four** sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer **5** full questions, selecting one full question from each module.

Text Books:

1. B.S.Jai Prakash, R.Venugopal, Sivakumaraiah & Pushpa Iyengar., **“Chemistry for Engineering Students”**, Subhash Publications, Bangalore.

2. R.V.Gadag & A.Nityananda Shetty., **“Engineering Chemistry”**, I K International Publishing House Private Ltd. New Delhi.
3. P.C.Jain & Monica Jain.,**“Engineering Chemistry”**, Dhanpat Rai Publications, New Delhi.

Reference Books:

1. O.G.Palanna,**“Engineering Chemistry”**,Tata McGraw Hill Education Pvt. Ltd. New Delhi, Fourth Reprint.
2. G.A.Ozin & A.C. Arsenault, **“Nanochemistry A Chemical Approach to Nanomaterials”**, RSC publishing, 2005.
3. **“Wiley Engineering Chemistry”**, Wiley India Pvt. Ltd. New Delhi. Second Edition.
4. V.R.Gowariker, N.V.Viswanathan & J.Sreedhar., **“Polymer Science”**, Wiley-Eastern Ltd.
5. M.G.Fontana., **“Corrosion Engineering”**, Tata McGraw Hill Publishing Pvt. Ltd. New Delhi.

PROGRAMMING IN C AND DATA STRUCTURES [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2015 -2016) SEMESTER - I/II			
Subject Code	15PCD13/23	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03
CREDITS - 04			
Course objectives: The objectives of this course is to make students to learn basic principles of Problem solving, implementing through C programming language and to design & develop programming skills. To gain knowledge of data structures and their applications.			
Module -1 : INTRODUCTION TO C LANGUAGE			Teaching Hours
Pseudo code solution to problem, Basic concepts in a C program, Declaration, Assignment & Print statements, Data Types, operators and expressions etc, Programming examples and exercise. Text 1: Chapter 2, and Text 2: 1.1, 1.2, 1.3			10Hours
Module -2: BRANCHING AND LOOPING			
Two way selection (if, if-else, nested if-else, cascaded if-else), switch statement, ternary operator? Go to, Loops (For, while-do, do-while) in C, break and continue, Programming examples and exercises. Text 1: Chapter 3. & Text 2: 4.4.			10 Hours
Module – 3: FUNCTIONS, ARRAYS AND STRINGS			
ARRAYS AND STRINGS: Using an array, Using arrays with Functions, Multi-Dimensional arrays. String: Declaring, Initializing, Printing and reading strings, string manipulation functions, String input and output functions, array of strings, Programming examples and Exercises. Text 1: 5.7, & Text 2: 7.3, 7.4, chapter 9 FUNCTIONS: Functions in C, Argument Passing – call by value, call by reference, Functions and program structure, location of functions, void and parameter less Functions, Recursion, Programming examples and exercises. Text 1: 1.7, 1.8, Chapter 4. Text 2: 5.1 to 5.4.			10 Hours

Module-4: STRUCTURES AND FILE MANAGEMENT	
<p>Basic of structures, structures and Functions, Array of structures, structure Data types, type definition, Defining, opening and closing of files, Input and output operations, Programming examples and exercises.</p> <p>Text 1: 6.1 to 6.3. Text 2: 10.1 to 10.4, Chapter 11.</p>	10 Hours
Module-5: POINTERS AND PREPROCESSORS & Data Structures	
<p>Pointers and address, pointers and functions (call by reference) arguments, pointers and arrays, address arithmetic, character pointer and functions, pointers to pointer ,Initialization of pointer arrays, Dynamic memory allocations methods, Introduction to Preprocessors, compiler control Directives, Programming examples and exercises.</p> <p>Text 1: 5.1 to 5.6, 5.8. Text 2: 12.2, 12.3, 13.1 to 13.7.</p> <p>Introduction to Data Structures: Primitive and non primitive data types, Abstract data types, Definition and applications of Stacks, Queues, Linked Lists and Trees.</p> <p>Text 2 : 14.1, 14.2, 14.11, 14.12, 14.13, 14.15, 14.16, 14.17, 15.1.</p>	10 Hours
<p>Course outcomes: On completion of this course, students are able to</p> <ul style="list-style-type: none"> • Achieve Knowledge of design and development of C problem solving skills. • Understand the basic principles of Programming in C language • Design and develop modular programming skills. • Effective utilization of memory using pointer technology • Understands the basic concepts of pointers and data structures. 	
<p>Question paper pattern:</p> <ul style="list-style-type: none"> • The question paper will have ten questions. • Each full Question consisting of 16 marks • There will be 2 full questions(with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. • The students will have to answer 5 full questions, selecting one full question from each module. 	

Text Books:

1. Brian W. Kernighan and Dennis M. Ritchie: The C Programming Language, 2nd Edition, PHI, 2012.
2. Jacqueline Jones & Keith Harrow: Problem Solving with C, 1st Edition, Pearson 2011.

Reference Books:

1. Vikas Gupta: Computer Concepts and C Programming, Dreamtech Press 2013.
2. R S Bichkar, Programming with C, University Press, 2012.
3. V Rajaraman: Computer Programming in C, PHI, 2013.

COMPUTER AIDED ENGINEERING DRAWING

[As per Choice Based Credit System (CBCS) scheme]

(Effective from the academic year 2015 -2016)

SEMESTER - I/II

Subject Code	15CED14/15CED24	IA Marks	20
Number of Lecture Hours/Week	6 (2T + 4L)	Exam Marks	80
Total Number of Lecture Hours	84	Exam Hours	03

CREDITS - 04

Course objectives:

Engineering drawing is an important tool for all Engineers and for many others professionals. It is the language of Engineers. Engineering Drawing communicates all needed information from the engineer who designed a part to the workers who will manufacture it.

The aim of the subject is to equip students with the fundamentals of Computer Aided Engineering Drawing and to further the ability to communicate information by graphical means.

Module -1

Teaching Hours

<p>Introduction to Computer Aided Sketching</p> <p>Introduction, Drawing Instruments and their uses, BIS conventions, Lettering, Dimensioning and free hand practicing. Computer screen, layout of the software, standard tool bar/menus and description of most commonly used tool bars, navigational tools. Co-ordinate system and reference planes. of HP, VP, RPP & LPP. of 2D/3D environment. Selection of drawing size and scale. Commands and creation of Lines, Co-ordinate points, axes, poly-lines, square, rectangle, polygons, splines, circles, ellipse, text, move, copy, off-set, mirror, rotate, trim, extend, break, chamfer, fillet, curves, constraints viz. tangency, parallelism, inclination and perpendicularity. Dimensioning, line conventions, material conventions and lettering.</p>	<p>06 Hours</p>
<p>Module -2</p>	<p>Teaching Hours</p>
<p>Orthographic projections</p> <p>Introduction, Definitions - Planes of projection, reference line and conventions employed, Projections of points in all the four quadrants, Projections of straight lines (located in First quadrant/first angle only), True and apparent lengths, True and apparent inclinations to reference planes (No application problems).</p> <p>Orthographic Projections of Plane Surfaces (First Angle Projection Only)</p> <p>Introduction, Definitions–projections of plane surfaces–triangle, square, rectangle, rhombus, pentagon, hexagon and circle, planes in different positions by change of position method only (No problems on punched plates and composite plates).</p>	<p>20Hours</p>
<p>Module-3</p>	

<p>Projections of Solids (First angle Projection only)</p> <p>Introduction, Definitions – Projections of right regular tetrahedron, hexahedron (cube), prisms, pyramids, cylinders and cones in different positions (No problems on octahedrons and combination solid).</p>	<p>28 Hours</p>
<p>Module-4</p>	
<p>Sections And Development of Lateral Surfaces of Solids</p> <p>Introduction, Section planes, Sections, Section views, Sectional views, Apparent shapes and True shapes of Sections of right regular prisms, pyramids, cylinders and cones resting with base on HP. (No problems on sections of solids)</p> <p>Development of lateral surfaces of above solids, their frustums and truncations. (No problems on lateral surfaces of trays, tetrahedrons, spheres and transition pieces).</p>	<p>15Hours</p>
<p>Module-5</p>	
<p>Isometric Projection (Using Isometric Scale Only)</p> <p>Introduction, Isometric scale, Isometric projection of simple plane figures, Isometric projection of tetrahedron, hexahedron(cube), right regular prisms, pyramids, cylinders, cones, spheres, cut spheres and combination of solids (Maximum of three solids).</p>	<p>15 Hours</p>
<p>Course outcomes:</p> <p>After studying this course,</p> <ol style="list-style-type: none"> 1. Students will be able to demonstrate the usage of CAD software. 2. Students will be able to visualize and draw Orthographic projections, Sections of solids and Isometric views of solids. 3. Students are evaluated for their ability in applying various concepts to solve practical problems related to engineering drawing. 	

Question paper pattern:

1. Module -1 is only for practice and Internal Assessment and not for examination.
2. Question paper for each batch of students will be sent online by VTU and has to be downloaded before the commencement of Examination of each batch. The answer sheets will have to be jointly evaluated by the Internal & External examiners.
3. A maximum of **THREE** questions will be set as per the following pattern (*No mixing of questions from different Modules*).

Q. No.	From Chapters	Marks Allotted
1	Module 2(Choice between (Points+Lines or Planes)	25
2	Module 3	30
3	Module 4 or Module 5	25
Total		80

Q. No.	Solutions and Sketching in the Graph Book	Computer Display and Printout	Total Marks
1	10	15	25
2	12	18	30
3	13	12	25
Total Marks	35	45	80

Students have to submit the computer printouts and the sketches drawn on the graph sheets at the end of the examination. Both Internal & External examiners have to jointly evaluate the solutions (sketches) and computer display & printouts of each student for 80 marks (35 marks for solutions & sketches + 45 marks for computer display and printouts) and submit the marks list along with the solution (sketches) on graph sheets & computer printouts in separate covers.

4. Each batch must consist of a minimum of 10 students and a maximum of 12 students.
5. Examination can be conducted in parallel batches, if necessary.

Text Books:

1) **Engineering Drawing** - N.D. Bhatt & V.M. Panchal, 48th edition, 2005-Charotar Publishing House, Gujarat.

2) "**Computer Aided Engineering Drawing**" by Dr. M H Annaiah, Dr C N Chandrappa and Dr B Sudheer Premkumar Fifth edition, New Age International Publishers.

Reference Books:

1) Computer Aided Engineering Drawing - S. Trymbaka Murthy, - I.K. International Publishing House Pvt. Ltd., New Delhi, 3rd revised edition- 2006.

2) Engineering Graphics - K.R. Gopalakrishna, 32nd edition, 2005- Subash Publishers Bangalore.

3) Fundamentals of Engineering Drawing with an Introduction to Interactive Computer Graphics for Design and Production- Luzadder Warren J., Duff John M., Eastern Economy Edition, 2005- Prentice-Hall of India Pvt. Ltd., New Delhi.

4) A Primer on Computer Aided Engineering Drawing-2006, Published by VTU, Belgaum.

BASIC ELECTRONICS			
[As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2015 -2016)			
SEMESTER - I/II			
Subject Code	15ELN15 / 15ELN25	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03
CREDITS - 04			
Course objectives: The course objective is to make students of all the branches of Engineering to understand the efficacy of Electronic principles which are pervasive in engineering applications			
Module -1			Teaching Hours
Semiconductor Diodes and Applications (Text-1): p-n junction diode, Characteristics and Parameters, Diode approximations, DC load line analysis, Half-wave rectifier, Two-diode Full-wave rectifier, Bridge rectifier, Capacitor filter circuit (only qualitative approach), Zener diode voltage regulators: Regulator circuit with no load, Loaded Regulator. Numerical examples as applicable.			06 Hours
Bipolar Junction Transistors: BJT operation, BJT Voltages and Currents, BJT amplification, Common Base, Common Emitter and Common Collector Characteristics, Numerical examples as applicable.			04 Hours
Module -2			
BJT Biasing (Text-1): DC Load line and Bias Point, Base Bias, Voltage divider Bias, Numerical examples as applicable.			04 Hours
Introduction to Operational Amplifiers (Text-2): Ideal OPAMP, Inverting and Non Inverting OPAMP circuits, OPAMP applications: voltage follower, addition, subtraction, integration, differentiation; Numerical examples as applicable.			06 Hours

Module – 3	
Digital Electronics (Text-2): Introduction, Switching and Logic Levels, Digital Waveform (Sections 9.1 to 9.3). Number Systems: Decimal Number System, Binary Number System, Converting Decimal to Binary, Hexadecimal Number System: Converting Binary to Hexadecimal, Hexadecimal to Binary, Converting Hexadecimal to Decimal, Converting Decimal to Hexadecimal, Octal Numbers: Binary to Octal Conversion. Complement of Binary Numbers. Boolean Algebra Theorems, De Morgan's theorem. Digital Circuits: Logic gates, NOT Gate, AND Gate, OR Gate, XOR Gate, NAND Gate, NOR Gate, X-NOR Gate. Algebraic Simplification, NAND and NOR Implementation (Sections 11.7 and 11.8): NAND Implementation, NOR Implementation. Half adder, Full adder.	10 Hours
Module-4	
Flip-Flops (Text-2): Introduction to Flip-Flops (Section 12.1), NAND Gate Latch/ NOR Gate Latch, RS Flip-Flop, Gated Flip-Flops: Clocked RS Flip-Flop (Sections 12.3 to 12.5).	05 Hours
Microcontrollers (Ref.1): Introduction to Microcontrollers, 8051 Microcontroller Architecture and an example of Microcontroller based stepper motor control system (only Block Diagram approach).	05 Hours
Module-5	
Communication Systems (Text-2): Introduction, Elements of Communication Systems, Modulation: Amplitude Modulation, Spectrum Power, AM Detection (Demodulation), Frequency and Phase Modulation. Amplitude and Frequency Modulation: A comparison.	06 Hours
Transducers (Text-2): Introduction, Passive Electrical Transducers, Resistive Transducers, Resistance Thermometers, Thermistor. Linear Variable Differential Transformer (LVDT). Active Electrical Transducers, Piezoelectric Transducer, Photoelectric Transducer.	04 Hours

Course outcomes:

After studying this course, students will be able to:

- Appreciate the significance of electronics in different applications,
- Understand the applications of diode in rectifiers, filter circuits and wave shaping,
- Apply the concept of diode in rectifiers, filters circuits
- Design simple circuits like amplifiers (inverting and non inverting), comparators, adders, integrator and differentiator using OPAMPS,
- Compile the different building blocks in digital electronics using logic gates and implement simple logic function using basic universal gates, and
- Understand the functioning of a communication system, and different modulation technologies, and
- Understand the basic principles of different types of Transducers.

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 16 marks
- There will be **2** full questions(with a **maximum** of **four** sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer **5** full questions, selecting one full question from each module.

Text Books:

1. David A. Bell, "**Electronic Devices and Circuits**", Oxford University Press, 5th Edition, 2008.
2. D.P. Kothari, I. J. Nagrath, "**Basic Electronics**", McGraw Hill Education (India) Private Limited, 2014.

Reference Books: MuhammadAli Mazidi, "**The 8051 Microcontroller and Embedded. Systems. Using Assembly and C.**" Second Edition, 2011, Pearson India.

COMPUTER PROGRAMMING LABORATORY [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2015 -2016) SEMESTER - I/II			
Laboratory Code	15CPL 16 / 15CPL26	IA Marks	20
Number of Lecture Hours/Week	01Hr Tutorial (Instructions) + 02 Hours Laboratory	Exam Marks	80
Total Number of Lecture Hours	48	Exam Hours	03
CREDITS - 02			
<p>Course objectives: To provide basic principles C programming language. To provide design & develop of C programming skills. To provide practical exposures like designing flowcharts, algorithms, how to debug programs etc.</p>			
<p>Descriptions (if any):</p> <p>Demonstration of Personal Computer and its Accessories: Demonstration and Explanation on Disassembly and Assembly of a Personal Computer by the faculty-in-charge. Students have to prepare a write-up on the same and include it in the Lab record and evaluated.</p> <p>Laboratory Session-1: Write-up on Functional block diagram of Computer, CPU, Buses, Mother Board, Chip sets, Operating System & types of OS, Basics of Networking & Topology and NIC.</p> <p>Laboratory Session-2: Write-up on RAM, SDRAM, FLASH memory, Hard disks, Optical media, CD-ROM/R/RW, DVDs, Flash drives, Keyboard, Mouse, Printers and Plotters. Introduction to flowchart, algorithm and pseudo code.</p> <p>Note: These TWO Laboratory sessions are used to fill the gap between theory classes and practical sessions. Both sessions are to be evaluated as lab experiments.</p>			

Laboratory Experiments:

Implement the following programs with WINDOWS / LINUX platform using appropriate C compiler.

1. Design and develop a flowchart or an algorithm that takes three coefficients (a , b , and c) of a Quadratic equation ($ax^2+bx+c=0$) as input and compute all possible roots. Implement a C program for the developed flowchart/algorithm and execute the same to output the possible roots for a given set of coefficients with appropriate messages.
2. Design and develop an algorithm to find the *reverse* of an integer number **NUM** and check whether it is **PALINDROME** or **NOT**. Implement a C program for the developed algorithm that takes an integer number as input and output the reverse of the same with suitable messages. Ex: Num: **2014**, Reverse: **4102**, Not a Palindrome
3.
 - 3a. Design and develop a flowchart to find the square root of a given number N . Implement a C program for the same and execute for all possible inputs with appropriate messages. Note: **Don't use library function $\text{sqrt}(n)$.**
 - 3b. Design and develop a C program to read a *year* as an input and find whether it is *leap year* or not. Also consider end of the centuries.
4. Design and develop an algorithm to evaluate polynomial $f(x) = a_4x^4 + a_3x^3 + a_2x^2 + a_1x + a_0$, for a given value of x and its coefficients using Horner's method. Implement a C program for the same and execute the program with different set of values of coefficients and x .
5. Draw the flowchart and Write a C Program to compute **Sin(x)** using Taylor series approximation given by **Sin(x) = x - (x³/3!) + (x⁵/5!) - (x⁷/7!) +**
Compare your result with the built- in Library function. Print both the results with appropriate messages.
6. Develop an algorithm, implement and execute a C program that reads N integer numbers and arrange them in ascending order using **Bubble Sort**.
7. Develop, implement and execute a C program that reads two matrices **A (m x n)** and **B (p x q)** and Compute product of matrices **A** and **B**. Read matrix **A** and matrix **B** in row major order and in column major order respectively. Print both the input matrices and resultant matrix with suitable headings and output should be in matrix format only. Program must check the compatibility of orders of the matrices for multiplication. Report appropriate message in case of incompatibility.
8. Develop, implement and execute a C program to search a Name in a list of names using **Binary searching** Technique.
9. Write and execute a C program that

- i. Implements string copy operation **STRCOPY**(str1,str2) that copies a string *str1* to another string *str2* without using library function.
- ii. Read a *sentence* and print frequency of vowels and total count of consonants.

10.

a. Design and develop a C function **RightShift**(*x* ,*n*) that takes two integers *x* and *n* as input and returns value of the integer *x* rotated to the right by *n* positions. Assume the integers are unsigned. Write a C program that invokes this function with different values for *x* and *n* and tabulate the results with suitable headings.

b. Design and develop a C function **isprime**(num) that accepts an integer argument and returns 1 if the argument is prime, a 0 otherwise. Write a C program that invokes this function to generate prime numbers between the given range.

11. Draw the flowchart and write a **recursive C** function to find the factorial of a number, ***n!***, defined by $fact(n)=1$, if $n=0$. Otherwise $fact(n)=n*fact(n-1)$. Using this function, write a C program to compute the binomial coefficient ${}_nC_r$. Tabulate the results for different values of ***n*** and ***r*** with suitable messages.

12. Given two university information files “**studentname.txt**” and “**usn.txt**” that contains students Name and USN respectively. Write a C program to create a new file called “**output.txt**” and copy the content of files “studentname.txt” and “usn.txt” into output file in the sequence shown below . Display the contents of output file “output.txt” on to the screen.

Student Name	USN	← Heading
Name 1	USN1	
Name 2	USN2	
....	
....	

13. Write a C program to maintain a record of ***n*** student details using an array of structures with four fields (Roll number, Name, Marks, and Grade). Assume appropriate data type for each field. Print the marks of the student, given the student name as input.

14. Write a C program using pointers to compute the sum, mean and standard deviation of all elements stored in an array of ***n*** real numbers.

Course outcomes:

- **Gaining Knowledge on various parts of a computer.**
- **Able to draw flowcharts and write algorithms**
- **Able design and development of C problem solving skills.**
- **Able design and develop modular programming skills.**
- **Able to trace and debug a program**

Conduction of Practical Examination:

- 1 . All laboratory experiments (nos) are to be included for practical examination.
- 2 . Students are allowed to pick one experiment from the lot.
- 3 . Strictly follow the instructions as printed on the cover page of answer script for breakup of marks
- 4 . **Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.**

ENGINEERING CHEMISTRY LABORATORY
[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2015 -2016)

SEMESTER - I/II

Laboratory Code	15CHEL17/15CHEL27	IA Marks	20
Number of Lecture Hours/Week	3 (1 hr Tutorial +2 hrs lab)	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS - 02

Course objectives:

- To provide students with practical knowledge of quantitative analysis of materials by classical and instrumental methods for developing experimental skills in building technical competence.

Instrumental Experiments

1. Estimation of FAS potentiometrically using standard $K_2Cr_2O_7$ solution.
2. Estimation of Copper colorimetrically.
3. Estimation of Acids in acid mixture conductometrically.
4. Determination of pKa of weak acid using pH meter.
5. Determination of Viscosity co-efficient of the given liquid using Ostwald's viscometer.
6. Estimation of Sodium and Potassium in the given sample of water using Flame Photometer.

Volumetric Experiments

1. Estimation of Total hardness of water by EDTA complexometric method.
2. Estimation of CaO in cement solution by rapid EDTA method.
3. Determination of percentage of Copper in brass using standard sodium thiosulphate solution.
4. Estimation of Iron in haematite ore solution using standard $K_2Cr_2O_7$ solution by External Indicator method.
5. Estimation of Alkalinity (OH^- , CO_3^{2-} & HCO_3^-) of water using standard HCl solution.
6. Determination of COD of waste water.

Course outcomes:

On completion of this course, students will have the knowledge in,

- Handling different types of instruments for analysis of materials using small quantities of materials involved for quick and accurate results, and
- Carrying out different types of titrations for estimation of concerned in materials using comparatively more quantities of materials involved for good results

Conduction of Practical Examination:

1. All experiments are to be included for practical examination.
2. One instrumental and another volumetric experiments shall be set.
3. Different experiments shall be set under instrumental and a common experiment under volumetric.
4. **Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.**

Reference Books:

1. G.H.Jeffery, J.Bassett, J.Mendham and R.C.Denney, **“Vogel’s Text Book of Quantitative Chemical Analysis”**
2. O.P.Vermani & Narula, **“Theory and Practice in Applied Chemistry”**, New Age International Publisers.
3. Gary D. Christian, **“Analytical chemistry”**, 6th Edition, Wiley India.

ENVIRONMENTAL STUDIES

[As per Choice Based Credit System (CBCS) scheme]

(Effective from the academic year 2015 -2016)

SEMESTER - I/II

Subject Code	15CIV18/15CIV28	IA Marks	10
Number of Lecture Hours/Week	02	Exam Marks	40
Total Number of Lecture Hours	25	Exam Hours	02

Course Objectives:

1. To identify the major challenges in environmental issues and evaluate possible solutions.
2. Develop analytical skills, critical thinking and demonstrate socio-economic skills for sustainable development.
3. To analyze an overall impact of specific issues and develop environmental management plan.

Module - 1

Introduction: Environment - Components of Environment Ecosystem: Types & Structure of Ecosystem, Balanced ecosystem Human Activities – Food, Shelter, And Economic & Social Security. **2 Hours**

Impacts of Agriculture & Housing Impacts of Industry, Mining & Transportation Environmental Impact Assessment, Sustainable Development. **3 Hours**

Module - 2

Natural Resources, Water resources – Availability & Quality aspects, Water borne diseases & water induced diseases, Fluoride problem in drinking water Mineral resources, Forest Wealth Material Cycles – Carbon Cycle, Nitrogen Cycle & Sulphur Cycle. **2 Hours**

Energy – Different types of energy, Conventional sources & Non Conventional sources of energy Solar energy, Hydro electric energy, Wind Energy, Nuclear energy, Biomass & Biogas Fossil Fuels, Hydrogen as an alternative energy. **3 Hours**

Module -3

Environmental Pollution – Water Pollution, Noise pollution, Land Pollution, Public Health Aspects. **2 Hours**

Global Environmental Issues: Population Growth, Urbanization, Land Management, Water & Waste Water Management. **3 Hours**

Module -4

Air Pollution & Automobile Pollution: Definition, Effects – Global Warming, Acid rain & Ozone layer depletion, controlling measures. **3 Hours**

Solid Waste Management, E - Waste Management & Biomedical Waste Management - Sources, Characteristics & Disposal methods. **2 Hours**

Module - 5

Introduction to GIS & Remote sensing, Applications of GIS & Remote Sensing in Environmental Engineering Practices. **2 Hours**

Environmental Acts & Regulations, Role of government, Legal aspects, Role of Non-governmental Organizations (NGOs) , Environmental Education & Women Education. **3 Hours**

Course Outcome:

Students will be able to,

1. Understand the principles of ecology and environmental issues that apply to air, land, and water issues on a global scale,
2. Develop critical thinking and/or observation skills, and apply them to the analysis of a problem or question related to the environment,
3. Demonstrate ecology knowledge of a complex relationship between biotic and abiotic components
4. Apply their ecological knowledge to illustrate and graph a problem and describe the realities that managers face when dealing with complex issues

Text Books:

1. Benny Joseph (2005), **“Environmental Studies”**, Tata McGraw – Hill Publishing Company Limited.
2. R.J.Ranjit Daniels and Jagadish Krishnaswamy, (2009), **“Environmental Studies”**, Wiley India Private Ltd., New Delhi.
3. R Rajagopalan, **“Environmental Studies – From Crisis to Cure”**, Oxford University Press, 2005,
4. Aloka Debi, **“Environmental Science and Engineering”**, Universities Press (India) Pvt. Ltd. 2012.

Reference Books:

1. Raman Sivakumar, **“Principals of Environmental Science and Engineering”**, Second Edition, Cengage learning Singapore, 2005
2. P. Meenakshi, **“Elements of Environmental Science and Engineering”**, Prentice Hall of India Private Limited, New Delhi, 2006
3. S.M. Prakash, **“Environmental Studies”**, Elite Publishers Mangalore, 2007
4. Erach Bharucha, **“Text Book of Environmental Studies”**, for UGC, University press, 2005
5. G.Tyler Miller Jr., **“Environmental Science – working with the Earth”**, Tenth Edition, Thomson Brooks /Cole, 2004
6. G.Tyler Miller Jr., **“Environmental Science – working with the Earth”**, Eleventh Edition, Thomson Brooks /Cole, 2006
7. Dr.Pratiba Sing, Dr.AnoopSingh and Dr.Piyush Malaviya, **“Text Book of Environmental and Ecology”**, Acme Learning Pvt. Ltd. New Delhi.

MATERIAL SCIENCE
[AS PER CHOICE ASED CREDIT SYSTEM (CBCS) SCHEME]
SEMESTER – III

Subject Code	15 ME 32	IA Marks	20
Number of Lecture Hrs / Week	04	Exam Marks	80
Total Number of Lecture Hrs	50	Exam Hours	03
CREDITS – 04			

COURSE OBJECTIVES:

This course provides

1. The foundation for understanding the structure and various modes of failure in materials common in mechanical engineering.
2. Topics are designed to explore the mechanical properties of metals and their alloys, polymers, ceramics, smart materials and composites.
3. The means of modifying such properties, as well as the processing and failure of materials.
4. Concepts of use of materials for various applications are highlighted.

COURSE OUTCOMES:

The student shall be able to

1. Describe the mechanical properties of metals, their alloys and various modes of failure.
2. Understand the microstructures of ferrous and non-ferrous materials to mechanical properties.
3. Explain the processes of heat treatment of various alloys.
4. Understand the properties and potentialities of various materials available and material selection procedures.
5. Know about composite materials and their processing as well as applications.

MODULE 1

Basics, Mechanical Behavior, Failure of Materials

Introduction to Crystal Structure – Coordination number, atomic packing factor, Simple Cubic, BCC, FCC and HCP Structures, Crystal imperfections – point, line, surface and volume imperfections, Atomic Diffusion: Phenomenon, Fick's laws of diffusion; Factors affecting diffusion.

Mechanical Behavior:

Stress-strain diagrams showing ductile and brittle behavior of materials, Engineering and true strains, Linear and non-linear elastic behavior and properties, Mechanical properties in plastic range. Stiffness, Yield strength, Offset Yield strength, Ductility, Ultimate Tensile strength, Toughness, Plastic deformation of single crystal by slip and twinning, Mechanisms of strengthening in metals

Fracture: Type I, Type II and Type III,

Fatigue: Types of fatigue loading with examples, Mechanism of fatigue, Fatigue properties, S-N diagram, Fatigue testing.

Creep: Description of the phenomenon with examples, three stages of creep, creep properties, Stress relaxation. Concept of fracture toughness, numerical on diffusion, strain and stress relaxation 10 Hours

MODULE 2

Alloys, Steels, Solidification

Concept of formation of alloys: Types of alloys, solid solutions, factors affecting solid solubility (Hume Rothery rules), Binary phase diagrams: Eutectic, and Eutectoid systems, Lever rule, Substitutional and interstitial solid solutions, Intermediate phases, Gibbs phase rule Effect of non- equilibrium cooling, Coring and Homogenization Iron-Carbon (Cementite) diagram: description of phases, Effect of common alloying elements in steel, Common alloy steels, Stainless steel, Tool steel, Specifications of steels. Solidification: Mechanism of solidification, Homogenous and Heterogeneous nucleation, Crystal growth, Cast metal structures Solidification of Steels and Cast irons. Numerical on lever rule

10 Hours

MODULE 3

Heat Treatment, Ferrous and Non-Ferrous Alloys

Heat treating of metals: Time-Temperature-Transformation (TTT) curves, Continuous Cooling Transformation (CCT) curves, Annealing: Recovery, Recrystallization and Grain growth, Types of annealing, Normalizing, Hardening, Tempering, Martempering, Austempering, Concept of hardenability, Factors affecting it hardenability, surface hardening methods: carburizing, cyaniding, nitriding, flame hardening and induction hardening, Age hardening of aluminum-copper alloys and PH steels. Ferrous materials: Properties, Compositions and uses of Grey cast iron, Malleable iron, SG iron and steel, 10 Hours

MODULE 4

Other Materials, Material Selection

Ceramics: Structure types and properties and applications of ceramics. Mechanical / Electrical behavior and processing of Ceramics.

Plastics: Various types of polymers/plastics and their applications. Mechanical behaviors and processing of plastics, Failure of plastics.

Other materials: Brief description of other materials such as optical and thermal materials Smart materials – fiber optic materials, piezo-electrics, shape memory alloys Shape Memory Alloys – Nitinol, superelasticity, Biological applications of smart materials - materials used as implants in human Body, Selection of Materials, Performance of materials in service Residual life assessment – use of non-destructive testing, Economics, Environment and Sustainability 10 Hours

MODULE 5

Composite Materials

Composite materials - Definition, classification, types of matrix materials & reinforcements, Metal Matrix Composites (MMCs), Ceramic Matrix Composites (CMCs) and Polymer Matrix Composites (PMCs), Particulate-reinforced and fiber-reinforced composites, Fundamentals of production of composites, Processes for production of composites, Characterization of composites, Constitutive relations of composites, Determination of composite properties from component properties, Hybrid composites, Applications of composite materials, Numericals on determining properties of composites 10 Hours

TEXT BOOKS:

1. Smith, Foundations of Materials Science and Engineering, 4th Edition, McGraw Hill, 2009.
2. William D. Callister, Material science and Engineering and Introduction, Wiley, 2006.

REFERENCE BOOKS

1. V.Raghavan, Materials Science and Engineering, , PHI, 2002
2. Donald R. Asklund and Pradeep.P. Phule, The Science and Engineering of Materials, Cengage Learning, 4th Ed., 2003.
3. George Ellwood Dieter, Mechanical Metallurgy, McGraw-Hill.
4. ASM Handbooks, American Society of Metals.

Scheme of Examination:

Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.

BASIC THERMODYNAMICS
[AS PER CHOICE ASED CREDIT SYSTEM (CBCS) SCHEME]
SEMESTER – III

Subject Code	15 ME 33	IA Marks	20
Number of Lecture Hrs / Week	04	Exam Marks	80
Total Number of Lecture Hrs	50	Exam Hours	03
CREDITS – 04			

COURSE OBJECTIVES

1. Learn about thermodynamic systems and boundaries
2. Study the basic laws of thermodynamics including, conservation of mass, conservation of energy or first law , second law and Zeroth law.
3. Understand various forms of energy including heat transfer and work
4. Identify various types of properties (e.g., extensive and intensive properties)
5. Use tables, equations, and charts, in evaluation of thermodynamic properties
6. Apply conservation of mass, first law, and second law in thermodynamic analysis of systems (e.g., turbines, pumps, compressors, heat exchangers, etc.)
7. Enhance their problem solving skills in thermal engineering

COURSE OUTCOMES

The student will be able to

	Course Outcomes	PO's	Course Level
CO 1	Explain thermodynamic systems, properties, Zeroth law of thermodynamics, temperature scales and energy interactions.	PO1	U
CO 2	Determine heat, work, internal energy, enthalpy for flow & non flow process using First and Second Law of Thermodynamics.	PO1, PO2	Ap
CO3	Interpret behavior of pure substances and its applications to practical problems.	PO1,PO2	U
CO4	Determine change in internal energy, change in enthalpy and change in entropy using TD relations for ideal gases.	PO1,PO2	Ap
CO 5	Calculate Thermodynamics properties of real gases at all ranges of pressure, temperatures using modified equation of state including Vander Waals equation, Redlich Wong equation and Beattie-Bridgeman equation.	PO1,PO2	Ap
Total Number Lecture hours			50

MODULE 1

Fundamental Concepts & Definitions: Thermodynamic definition and scope, Microscopic and Macroscopic approaches. Some practical applications of engineering thermodynamic Systems, Characteristics of system boundary and control surface, examples. Thermodynamic properties; definition and units, intensive , extensive properties, specific properties, pressure, specific volume Thermodynamic state, state point, state diagram, path and process, quasi-static process, cyclic and non-cyclic; processes; Thermodynamic equilibrium; definition, mechanical equilibrium; diathermic wall, thermal equilibrium, chemical equilibrium, Zeroth law of thermodynamics, Temperature; concepts, scales, international fixed points and measurement of temperature. Constant volume gas thermometer, constant pressure gas thermometer, mercury in glass thermometer

Work and Heat: Mechanics, definition of work and its limitations. Thermodynamic definition of work; examples, sign convention. Displacement work; as a part of a system boundary, as a whole of a system boundary, expressions for displacement work in various processes through p-v diagrams. Shaft work; Electrical work. Other types of work. Heat; definition, units and sign convention. Problems

10 Hours

MODULE 2

First Law of Thermodynamics: Joules experiments, equivalence of heat and work. Statement of the First law of thermodynamics, extension of the First law to non - cyclic processes, energy, energy as a property, modes of energy, Extension of the First law to control volume; steady flow energy equation(SFEE), important applications.

Second Law of Thermodynamics: limitations of first law of thermodynamics Devices converting heat to work; (a) in a thermodynamic cycle, (b) in a mechanical cycle. Thermal reservoir, Direct heat engine; schematic representation and efficiency. Devices converting work to heat in a thermodynamic cycle; reversed heat engine, schematic representation, coefficients of performance. Kelvin - Planck statement of the Second law of Thermodynamics; PMM I and PMM II, Clausius statement of Second law of Thermodynamics, Equivalence of the two statements; Carnot cycle, Carnot principles. Problems

10 Hours

MODULE 3

Reversibility: Definitions of a reversible process, reversible heat engine, importance and superiority of a reversible heat engine and irreversible processes; factors that make a process irreversible, reversible heat engines. Unresisted expansion, remarks on Carnot's engine, internal and external reversibility, Definition of the thermodynamic temperature scale. Problems

Entropy: Clausius inequality, Statement- proof, Entropy- definition, a property, change of entropy, entropy as a quantitative test for irreversibility, principle of increase in entropy, , calculation of entropy using Tds relations, entropy as a coordinate.

10 Hours

MODULE 4

Availability, Irreversibility and General Thermodynamic relations. Introduction, Availability (Exergy), Unavailable energy (anergy), Relation between increase in unavailable energy and increase in entropy. Maximum work, maximum useful work for a system and control volume, irreversibility, second law efficiency (effectiveness). Gibbs and Helmholtz functions, Maxwell relations, Clapeyron equation, Joule Thomson coefficient, general relations for change in entropy, enthalpy , internal energy and specific heats.

Pure Substances: P-T and P-V diagrams, triple point and critical points. Sub-cooled liquid, saturated liquid, mixture of saturated liquid and vapor, saturated vapor and superheated vapor states of pure substance with water as example. Enthalpy of change of phase (Latent heat). Dryness fraction (quality), T-S and H-S diagrams, representation of various processes on these diagrams. Steam tables and its use. Throttling calorimeter, separating and throttling calorimeter.

10 Hours

MODULE 5

Ideal gases: Ideal gas mixtures, Daltons law of partial pressures, Amagat's law of additive volumes, evaluation of properties of perfect and ideal gases,

Air- Water mixtures and related properties, Psychrometric properties, Construction and use of Psychrometric chart.

Real gases – Introduction , Air water mixture and related properties, Van-der Waal's Equation of state, Van-der Waal's constants in terms of critical properties, Redlich and Kwong equation of state Beattie-Bridgeman equation , Law of corresponding states, compressibility factor; compressibility chart. Difference between Ideal and real gases.

10 Hours

TEXT BOOKS:

1. Basic Engineering Thermodynamics, A.Venkatesh, Universities Press, 2008
2. Basic and Applied Thermodynamics, P.K.Nag, 2nd Ed., Tata McGraw Hill Pub. 2002

REFERENCE BOOKS:

1. Thermodynamics, An Engineering Approach, Yunus A.Cengel and Michael A.Boles, Tata McGraw Hill publications, 2002
2. Engineering Thermodynamics, J.B.Jones and G.A.Hawkins, John Wiley and Sons..
3. Fundamentals of Classical Thermodynamics, G.J.Van Wylen and R.E.Sonntag, Wiley Eastern.
4. An Introduction to Thermodynamics, Y.V.C.Rao, Wiley Eastern, 1993,
5. B.K Venkanna, Swati B. Wadavadagi "Basic Thermodynamics, PHI, New Delhi, 2010

Scheme of Examination: Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.

MECHANICS OF MATERIALS
[AS PER CHOICE ASED CREDIT SYSTEM (CBCS) SCHEME]
SEMESTER – III

Subject Code	15 ME 34	IA Marks	20
Number of Lecture Hrs / Week	04	Exam Marks	80
Total Number of Lecture Hrs	50	Exam Hours	03
CREDITS – 04			

COURSE OBJECTIVES:

1. Classify the stresses into various categories and define elastic properties of materials and compute stress and strain intensities caused by applied loads in simple and compound sections and temperature changes.
2. Derive the equations for principal stress and maximum in-plane shear stress and calculate their magnitude and direction. Draw Mohr circle for plane stress system and interpret this circle.
3. Determine the shear force, bending moment and draw shear force and bending moment diagrams, describe behavior of beams under lateral loads.
4. Explain the structural behavior of members subjected to torque, Calculate twist and stress induced in shafts subjected to bending and torsion.
5. Understand the concept of stability and derive crippling loads for columns.
6. Understand the concept of strain energy and compute strain energy for applied loads.

COURSE OUTCOMES:

The student shall be able to

	Course Outcomes	POs	CL
CO1	Understand simple, compound, thermal stresses and strains their relations, Poisson's ratio, Hooke's law, mechanical properties including elastic constants and their relations	PO1	U
CO2	Determine stresses, strains and deformations in bars with varying circular and rectangular cross-sections subjected to normal and temperature loads	PO1,	Ap
CO3	Determine plane stress, principal stress, maximum shear stress and their orientations using analytical method and Mohr's circle	PO1,	Ap
CO4	Determine the dimensions of structural members including beams, bars and rods using Energy methods and also stress distribution in thick and thin cylinders	PO1,	Ap
CO5	Draw SFD and BMD for different beams including cantilever beams, simply supported beams and overhanging beams subjected to UDL, UVL, Point loads and couples	PO1,	Ap
CO6	Determine dimensions, bending stress, shear stress and its distribution in beams of circular, rectangular, symmetrical I and T sections subjected to point loads and UDL	PO1,	Ap
CO7	Determine slopes and deflections at various points on beams subjected to UDL, UVL, Point loads and couples	PO1,	Ap
CO8	Determine the dimensions of shafts based on torsional strength, rigidity and flexibility and also elastic stability of columns using Rankin's and Euler's theory	PO1,	Ap
Total Hours of instruction		50	

MODULE 1

Stress and Strain: Introduction, Hooke's law, Calculation of stresses in straight, Stepped and tapered sections, Composite sections, Stresses due to temperature change, Shear stress and strain, Lateral strain and Poisson's ratio, Generalized Hooke's law, Bulk modulus, Relationship between elastic constants. 10 Hours

MODULE 2

Analysis of Stress and Strain: Plane stress, Stresses on inclined planes, Principal stresses and maximum shear stress, Principal angles, Shear stresses on principal planes, Maximum shear stress, Mohr circle for plane stress conditions.

Cylinders: Thin cylinder: Hoop's stress, maximum shear stress, circumferential and longitudinal strains, Thick cylinders: Lames equations. 10 Hours

MODULE 3

Shear Forces and Bending Moments: Type of beams, Loads and reactions, Relationship between loads, shear forces and bending moments, Shear force and bending moments of cantilever beams, Pin support and roller supported beams subjected to concentrated loads and uniformly distributed constant / varying loads.

Stress in Beams: Pure bending, Curvature of a beam, Longitudinal strains in beams, Normal stresses in Beams with rectangular, circular, 'I' and 'T' cross sections, Flexure Formula, Bending Stresses, Deflection of beams (Curvature). 10 Hours

MODULE 4

Torsion: Circular solid and hollow shafts, Torsional moment of resistance, Power transmission of straight and stepped shafts, Twist in shaft sections, Thin tubular sections, Thin walled sections

Columns: Buckling and stability, Critical load, Columns with pinned ends, Columns with other support conditions, Effective length of columns, Secant formula for columns. 10 Hours

MODULE 5

Strain Energy: Castigliano's theorem I and II, Load deformation diagram, Strain energy due to normal stresses, Shear stresses, Modulus of resilience, Strain energy due to bending and torsion.

Theories of Failure: Maximum Principal stress theory, Maximum shear stress theory. 10 Hours

TEXT BOOKS:

1. James M Gere, Barry J Goodno, Strength of Materials, Indian Edition, Cengage Learning, 2009.
2. R Subramanian, Strength of Materials, Oxford, 2005.

REFERENCE BOOKS:

1. S S Rattan, Strength of Materials, Second Edition, McGraw Hill, 2011.
2. Ferdinand Beer and Russell Johnston, Mechanics of materials, Tata McGraw Hill, 2003.

Scheme of Examination:

Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.

METAL CASTING AND WELDING
 [AS PER CHOICE ASED CREDIT SYSTEM (CBCS) SCHEME]
 SEMESTER – III / IV

Subject Code	15 ME 35 A	IA Marks	20
Number of Lecture Hrs / Week	04	Exam Marks	80
Total Number of Lecture Hrs	50	Exam Hours	03
CREDITS – 04			

COURSE OBJECTIVE

- To provide detailed information about the moulding processes.
- To provide knowledge of various casting process in manufacturing.
- To impart knowledge of various joining process used in manufacturing.
- To provide adequate knowledge of quality test methods conducted on welded and casted components.

COURSE OUTCOMES

CO No.	Course Outcomes	Blooms level	PO
CO1	Describe the casting process, preparation of Green, Core, dry sand molds and Sweep, Shell, Investment and plaster molds.	U	PO1
CO2	Explain the Pattern, Core, Gating, Riser system and Jolt, Squeeze, Sand Slinger Molding Machines.	U	PO1
CO3	Compare the Gas fired pit, Resistance, Coreless, Electrical and Cupola Metal Furnaces.	U	PO1
CO4	Compare the Gravity, Pressure die, Centrifugal, Squeeze, slush and Continuous Metal mold castings.	U	PO1
CO5	Explain the Solidification process and Casting of Non-Ferrous Metals.	U	PO1
CO6	Describe the Metal Arc, TIG, MIG, Submerged and Atomic Hydrogen Welding processes used in manufacturing.	U	PO1
CO7	Explain the Resistance spot, Seam, Butt, Projection, Friction, Explosive, Thermit, Laser and Electron Beam Special type of welding process used in manufacturing.	U	PO1
CO8	Describe the Metallurgical aspects in Welding and inspection methods for the quality assurance of components made of casting and joining process.	U	PO1
Total Hours of instruction		50	

MODULE -1

INTRODUCTION & BASIC MATERIALS USED IN FOUNDRY

Introduction: Definition, Classification of manufacturing processes. Metals cast in the foundry-classification, factors that determine the selection of a casting alloy.

Introduction to casting process & steps involved. Patterns: Definition, classification, materials used for pattern, various pattern allowances and their importance.

Sand molding: Types of base sand, requirement of base sand. Binder, Additives definition, need and types

Preparation of sand molds: Molding machines- Jolt type, squeeze type and Sand slinger. Study of important molding process: Green sand, core sand, dry sand, sweep mold, CO₂ mold, shell mold, investment mold, plaster mold, cement bonded mold. Cores: Definition, need, types. Method of making cores, concept of gating (top, bottom, parting line, horn gate) and risering (open, blind) Functions and types

10 Hours

MODULE -2

MELTING & METAL MOLD CASTING METHODS

Melting furnaces: Classification of furnaces, Gas fired pit furnace, Resistance furnace, Coreless induction furnace, electric arc furnace, constructional features & working principle of cupola furnace.

Casting using metal molds: Gravity die casting, pressure die casting, centrifugal casting, squeeze casting, slush casting, thixocasting, and continuous casting processes

10 Hours

MODULE -3

SOLIDIFICATION & NON FERROUS FOUNDRY PRACTICE

Solidification: Definition, Nucleation, solidification variables, Directional solidification-need and methods. Degasification in liquid metals-Sources of gas, degasification methods.

Fettling and cleaning of castings: Basic steps involved. Sand Casting defects- causes, features and remedies. Advantages & limitations of casting process

Nonferrous foundry practice: Aluminum castings - Advantages, limitations, melting of aluminum using lift-out type crucible furnace. Hardeners used, dressing, gas absorption, fluxing and flushing, grain refining, pouring temperature. Stir casting set up, procedure, uses, advantages and limitations.

10 Hours

MODULE -4

WELDING PROCESS

Welding process: Definition, Principles, Classification, Application, Advantages & limitations of welding. Arc welding: Principle, Metal arc welding (MAW), Flux Shielded Metal Arc Welding (FSMAW), Inert Gas Welding (TIG & MIG) Submerged Arc Welding (SAW) and Atomic Hydrogen Welding (AHW).

Special type of welding: Resistance welding principles, Seam welding, Butt welding, Spot welding and Projection welding. Friction welding, Explosive welding, Thermit welding, Laser welding and electron beam welding.

10 Hours

MODULE -5

SOLDERING , BRAZING AND METALLURGICAL ASPECTS IN WELDING

Structure of welds, Formation of different zones during welding, Heat Affected Zone (HAZ), Parameters affecting HAZ. Effect of carbon content on structure and properties of steel, Shrinkage in welds & Residual stresses, Concept of electrodes, filler rod and fluxes. Welding defects- Detection, causes & remedy.

Soldering, brazing, gas welding: Soldering, Brazing, Gas Welding: Principle, oxy-Acetylene welding, oxy-hydrogen welding, air-acetylene welding, Gas cutting, powder cutting.

Inspection methods: Methods used for inspection of casting and welding. Visual, magnetic particle, fluorescent particle, ultrasonic. Radiography, eddy current, holography methods of inspection.

10 Hours

TEXT BOOKS:

1. **“Manufacturing Process-I”**, Dr.K. Radhakrishna, Sapna Book House, 5th Revised Edition 2009.
2. **“Manufacturing & Technology: Foundry Forming and Welding”**, P.N. Rao, 3rd Ed., Tata McGraw Hill, 2003.

REFERENCE BOOKS:

1. **“Process and Materials of Manufacturing”**, Roy A Lindberg, 4th Ed. Pearson Edu. 2006.
2. **“Manufacturing Technology”**, Serope Kalpakjian, Steuen. R. Sechmid, Pearson Education Asia, 5th Ed. 2006.
3. **“Principles of metal casting”**, Recharad W. Heine, Carl R. Loper Jr., Philip C. Rosenthal, Tata McGraw Hill Education Private Limited Ed.1976.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consisting of 16 marks.
- There will be **2** full questions (with a **maximum** of **4** sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer **5** full questions, selecting one full question from each module.

MACHINE TOOLS AND OPERATIONS
 [AS PER CHOICE ASED CREDIT SYSTEM (CBCS) SCHEME]
 SEMESTER – III / IV

Subject Code	15 ME 35 B	IA Marks	20
Number of Lecture Hrs / Week	04	Exam Marks	80
Total Number of Lecture Hrs	50	Exam Hours	03
CREDITS – 04			

COURSE OBJECTIVES:

- To introduce students to different machine tools in order to produce components having different shapes and sizes.
- To enrich the knowledge pertaining to relative motion and mechanics required for various machine tools.
- To develop the knowledge on mechanics of machining process and effect of various parameters on economics of machining.

COURSE OUTCOMES:

- Explain the construction & specification of various machine tools.
- Describe various machining processes pertaining to relative motions between tool & work piece.
- Discuss different cutting tool materials, tool nomenclature & surface finish.
- Apply mechanics of machining process to evaluate machining time.
- Analyze tool wear mechanisms and equations to enhance tool life and minimize machining cost.

MODULE 1

MACHINE TOOLS

Introduction, Classification, construction and specifications of lathe, drilling machine, milling machine, boring machine, broaching machine, shaping machine, planing machine, grinding machine [**Simple sketches showing major parts of the machines**]
 10 hours

MODULE 2

MACHINING PROCESSES

Introduction, Types of motions in machining, turning and Boring, Shaping, Planing and Slotting, Thread cutting, Drilling and reaming, Milling, Broaching, Gear cutting and Grinding, Machining parameters and related quantities.
[Sketches pertaining to relative motions between tool and work piece only] 10 Hours

MODULE 3

CUTTING TOOL MATERIALS, GEOMETRY AND SURFACE FINISH

Introduction, desirable Properties and Characteristics of cutting tool materials, cutting tool geometry, cutting fluids and its applications, surface finish, effect of machining parameters on surface finish.
Machining equations for cutting operations: Turning, Shaping, Planing, slab milling, cylindrical grinding and internal grinding, Numerical Problems 10 Hours

MODULE 4

MECHANICS OF MACHINING PROCESSES

Introduction, Chip formation, Orthogonal cutting, Merchant's model for orthogonal cutting, Oblique cutting, Mechanics of turning process, Mechanics of drilling process, Mechanics of milling process, Numerical problems. 10 Hours

MODULE 5

TOOL WEAR, TOOL LIFE: Introduction, tool wear mechanism, tool wear equations, tool life equations, effect of process parameters on tool life, machinability, Numerical problems
ECONOMICS OF MACHINING PROCESSES: Introduction, choice of feed, choice of cutting speed, tool life for minimum cost and minimum production time, machining at maximum efficiency, Numerical problems 10 Hours

TEXT BOOKS:

1. Fundamentals of metal cutting and Machine Tools, B.L. Juneja, G.S. Sekhon and Nitin Seth, New Age International Publishers 2nd Edition, 2003
2. All about Machine Tools, Heinrich Gerling, New Age International Publishers revised 2nd Edition, 2006

REFERENCE BOOKS:

1. Fundamental of Machining and Machine Tools, Geoffrey Boothroyd and Winston A. Knight, CRC Taylor & Francis, Third Edition.
2. Metal cutting principles, Milton C. Shaw, Oxford University Press, Second Edition, 2005.

Scheme of Examination:

Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.

COMPUTER AIDED MACHINE DRAWING
 [AS PER CHOICE ASED CREDIT SYSTEM (CBCS) SCHEME]
 SEMESTER – III / IV

Subject Code	15ME36 A/46A	IA Marks	20
Number of Lecture Hrs / Week	02 L+ 04 P	Exam Marks	80
Total Number of Lecture Hrs	50	Exam Hours	03
CREDITS – 04			

COURSE OBJECTIVES

- To acquire the knowledge of CAD software and its features.
- To inculcate understanding of the theory of projection and make drawings using orthographic projections and sectional views
- To familiarize the students with Indian Standards on drawing practices.
- To impart knowledge of thread forms, fasteners, keys ,joints and couplings.
- To make the students understand and interpret drawings of machine components so as to prepare assembly drawings either manually and using CAD packages.
- To acquire the knowledge of limits fits and tolerance pertaining to machine drawings.

COURSE OUTCOMES

Having successfully completed this course, the student will be able to draw and use modelling software's to generate

	Course Outcome	Cognitive Level	POs
CO1	Sections of pyramids, prisms, cubes, cones and cylinders resting on their bases in 2D	U	PO1, PO5,
CO2	Orthographic views of machine parts with and without sectioning in 2D.	U	PO1, PO5,
CO3	Sectional views for threads with terminologies of ISO Metric, BSW, square and acme, sellers and American standard threads in 2D.	U	PO1, PO5,
CO4	Hexagonal and square headed bolt and nut with washer, stud bolts with nut and lock nut, flanged nut, slotted nut, taper and split pin for locking counter sunk head screw, grub screw, Allen screw assemblies in 2D	U	PO1, PO5,
CO5	Parallel key, Taper key, and Woodruff Key as per the ISO standards in 2D	U	PO1, PO5,
CO6	single and double riveted lap joints, butt joints with single/double cover straps, cotter and knuckle joint for two rods in 2D	U	PO1, PO5,
CO7	Sketch split muff, protected type flanged, pin type flexible, Oldham's and universal couplings in 2D	U	PO1, PO5,
CO8	assemblies from the part drawings with limits ,fits and tolerance given for Plummer block, Ram bottom safety valve, I.C. Engine connecting rod, Screw Jack, Tailstock of lathe, Machine Vice and Lathe square tool post in 2D and 3D	U	PO1, PO5, PO12
Total Hours of instruction			50

INTRODUCTION TO COMPUTER AIDED SKETCHING

Review of graphic interface of the software. Review of basic sketching commands and navigational commands.

02 Hours

PART A

UNIT I

Sections of Solids: Sections of Pyramids, Prisms, Cubes, Tetrahedrons, Cones and Cylinders resting only on their bases (No problems on, axis inclinations, spheres and hollow solids), True shape of section. 04 Hours

Orthographic views: Conversion of pictorial views into orthographic projections of simple machine parts with or without section. (Bureau of Indian Standards conventions are to be followed for the drawings), Hidden line conventions, Precedence of lines. 04 Hours

UNIT II

Thread forms: Thread terminology, sectional views of threads. ISO Metric (Internal & External), BSW (Internal and External), square, Acme and Sellers thread, American Standard thread.

Fasteners: Hexagonal headed bolt and nut with washer (assembly), square headed bolt and nut with washer (assembly) simple assembly using stud bolts with nut and lock nut. Flanged nut, slotted nut, taper and split pin for locking, counter sunk head screw, grub screw, Allen screw. 08 Hours

PART B

UNIT III

Keys and Joints: Parallel, Taper, Feather Key, Gib head key and Woodruff key

Riveted joints: Single and double riveted lap joints, Butt joints with single/double cover straps (Chain and zigzag using snap head riveters).

Joints: Cotter joint (socket and spigot), Knuckle joint (pin joint) for two rods. 08 Hours

UNIT IV

Couplings: Split muff coupling, Protected type flange coupling, Pin (bush) type flexible coupling, Oldham's coupling and Universal coupling (Hook's Joint). 06 Hours

PART C

Limits, Fits and Tolerances: Introduction, Fundamental tolerances, Deviations, Methods of placing limit dimensions, Types of fits with symbols and applications, Geometrical tolerances on drawings, Standards followed in industry. 03 Hours

Assembly Drawings: (Part drawings shall be given)

1. Plummer block (Pedestal Bearing)
2. Rams Bottom Safety Valve
3. I.C. Engine connecting rod
4. Screw jack (Bottle type)
5. Tailstock of lathe
6. Machine vice
7. Lathe square tool post

15 Hours

TEXT BOOKS:

1. 'A Primer on Computer Aided Machine Drawing-2007', Published by VTU, Belgaum.
2. 'Machine Drawing', N.D.Bhat & V.M.Panchal, Published by Charotar Publishing House, 1999.
3. 'Machine Drawing', N.Siddeshwar, P.Kannaih, V.V.S. Sastri, published by Tata Mc.Grawhill, 2006.

REFERENCE BOOK:

1. "A Text Book of Computer Aided Machine Drawing", S. Trymbakaa Murthy, CBS Publishers, New Delhi, 2007.
2. 'Machine Drawing', K.R. Gopala Krishna, Subhash publication.

Note:

Internal Assessment: 20 Marks

Sketches shall be in sketch books and drawing shall through use of software on A3/A4 sheets. Sketch book and all the drawing printouts shall be submitted.

Scheme of Evaluation for Internal Assessment (20 Marks)

- (a) Class work (Sketching and Computer Aided Machine drawing printouts in A4/A3 size sheets): 10Marks.
- (b) Internal Assessment test in the same pattern as that of the main examination (Better of the two Tests): 10 marks.

Scheme of Examination:

Two questions to be set from each Part A, part B and Part C.

Student has to answer one question each from Part A , Part B for 15 marks each and one question from Part C for 50 marks.

Part A 1 x 15	= 15 Marks
Part B 1 x 15	= 15 Marks
Part C 1 x 50	= <u>50 Marks</u>
Total	= 80 Marks

INSTRUCTION FOR COMPUTER AIDED MACHINE DRAWING (15ME36A/46A) EXAMINATION

1. No restriction of timing for sketching/ computerization of solutions. The total duration is 3 hours.
2. It is desirable to do sketching of all the solutions before computerization.
3. Drawing instruments may be used for sketching.
4. For Part A and Part B 2D drafting environment should be used.
5. For Part C 3D part environment should be used for parts assembly drawing and extract 2D views.

MECHANICAL MEASUREMENTS AND METROLOGY

[AS PER CHOICE ASED CREDIT SYSTEM (CBCS) SCHEME]

SEMESTER – III / IV

Subject Code	15 ME 36 B / 46B	IA Marks	20
Number of Lecture Hrs / Week	04	Exam Marks	80
Total Number of Lecture Hrs	50	Exam Hours	03
CREDITS – 03			

COURSE OBJECTIVES

Students are expected to –

- Understand metrology, its advancements & measuring instruments,
- Acquire knowledge on different standards of length, calibration of End Bars, linear and angular measurements, Screw thread and gear measurement & comparators.
- Equip with knowledge of limits, fits, tolerances and gauging.
- Acquire knowledge of measurement systems and methods with emphasis on different transducers, intermediate modifying and terminating devices.
- Understand the measurement of Force, Torque, Pressure, Temperature and Strain.

COURSE OUTCOMES

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

	Description	CL	POs
CO1	Understand the objectives of metrology, methods of measurement, selection of measuring instruments, standards of measurement and calibration of end bars.	U	PO1, PO6
CO2	Describe slip gauges, wringing of slip gauges and building of slip gauges, angle measurement using sine bar, sine center, angle gauges, optical instruments and straightness measurement using Autocollimator.	U	PO1, PO6
CO3	Explain tolerance, limits of size, fits, geometric and position tolerances, gauges and their design.	U	PO1, PO6
CO4	Understand the principle of Johnson Mikrokator, sigma comparator, dial indicator, LVDT, back pressure gauges, Solex comparators and Zeiss Ultra Optimeter	U	PO1, PO6
CO5	Describe measurement of major diameter, minor diameter, pitch, angle and effective diameter of screw threads by 2 – wire, 3 – wire methods, screw thread gauges and tool maker's microscope.	U	PO1, PO6
CO6	Explain measurement of tooth thickness using constant chord method, addendum comparator methods and base tangent method, composite error using gear roll tester and measurement of pitch, concentricity, run out and involute profile.	U	PO1, PO6
CO7	Understand laser interferometers and Coordinate measuring machines.	U	PO1, PO6
CO8	Explain measurement systems, transducers, intermediate modifying devices and terminating devices.	U	PO1, PO6
CO9	Describe functioning of force, torque, pressure, strain and temperature measuring devices.	U	PO1, PO6
Total Hours of Instructions			50

MODULE -1

Introduction to Metrology: Definition, objectives and concept of metrology, Need of inspection, Principles, process, methods of measurement, Classification and selection of measuring instruments and systems. Accuracy, precision and errors in measurement.

System of measurement, Material Standard, Wavelength Standards, Subdivision of standards, Line and End standards, Classification of standards and Traceability, calibration of End bars (Numericals), standardization.

Linear Measurement and angular measurements:

Slip gauges- Indian standards on slip gauge, method of selection of slip gauge, stack of slip gauge, adjustable slip gauge, wringing of slip gauge, care of slip gauge, slip gauge accessories, problems on building of slip gauges (M87, M112).

Measurement of angles- sine bar, sine center, angle gauges, optical instruments for angular measurements, Auto collimator-applications for measuring straightness and squareness. **10 Hours**

MODULE -2

System of Limits, Fits, Tolerance and Gauging:

Definition of tolerance, Specification in assembly, Principle of interchangeability and selective assembly, limits of size, Indian standards, concept of limits of size and tolerances, definition of fits, hole basis system, shaft basis system, types of fits and their designation (IS 919-1963), geometric tolerance, position-tolerances.

Classification of gauges, brief concept of design of gauges (Taylor's principles), Wear allowance on gauges, Types of gauges-plain plug gauge, ring gauge, snap gauge, limit gauge and gauge materials.

Comparators:

Functional requirements, classification, mechanical- Johnson Mikrokator, sigma comparators, dial indicator, electrical-principles, LVDT, Pneumatic- back pressure gauges, solex comparators and optical comparators- Zeiss ultra-optimizer. **10 Hours**

MODULE -3

Measurement of screw thread and gear:

Terminology of screw threads, measurement of major diameter, minor diameter, pitch, angle and effective diameter of screw threads by 2-wire and 3-wire methods, best size wire. Screw thread gauges, Tool maker's microscope.

Gear tooth terminology, tooth thickness measurement using constant chord method, addendum comparator method and base tangent method, measurement of pitch, concentricity, run out, and involute profile. Gear roll tester for composite error.

Advances in metrology:

Basic concepts of lasers, advantages of lasers, laser interferometers, types, applications. Basic concepts of Coordinate Measuring Machines-constructural features, applications. **10 Hours**

MODULE -4

Measurement systems and basic concepts of measurement methods:

Definition, significance of measurement, generalized measurement system, definitions and concept of accuracy, precision, calibration, threshold, sensitivity, hysteresis, repeatability, linearity, loading effect, system response-time delay. Errors in measurement, classification of errors. Transducers, transfer efficiency, primary and secondary transducers, electrical, mechanical, electronic transducers, advantages of each type transducers.

Intermediate modifying and terminating devices: Mechanical systems, inherent problems, electrical intermediate modifying devices, input circuitry, ballast circuit, electronic amplifiers. Terminating devices, Cathode ray oscilloscope, Oscillographs. **10 Hours**

MODULE -5

Force, Torque and Pressure Measurement:

Direct methods and indirect method, force measuring inst. Torque measuring inst., Types of dynamometers, Absorption dynamometer, Prony brake and rope brake dynamometer, and power measuring instruments. Pressure measurement, principle, use of elastic members, Bridgeman gauge, McLeod gauge, Pirani gauge.

Measurement of strain and temperature:

Theory of strain gauges, types, electrical resistance strain gauge, preparation and mounting of strain gauges, gauge factor, methods of strain measurement. Temperature Compensation, Wheatstone bridge circuit, orientation of strain gauges for force and torque, Strain gauge based load cells and torque sensors.

Resistance thermometers, thermocouple, law of thermocouple, materials used for construction, pyrometer, optical pyrometer.

10 Hours

TEXT BOOKS:

1. **Mechanical Measurements**, Beckwith Marangoni and Lienhard, Pearson Education, 6th Ed., 2006.
2. **Engineering Metrology**, R.K. Jain, Khanna Publishers, Delhi, 2009.

REFERENCE BOOKS:

1. **Engineering Metrology and Measurements**, Bentley, Pearson Education.
2. **Theory and Design for Mechanical Measurements, III edition**, Richard S Figliola, Donald E Beasley, WILEY India Publishers.
3. **Engineering Metrology**, Gupta I.C., Dhanpat Rai Publications.
4. **Deoblin's Measurement system**, Ernest Deoblin, Dhanesh manick, McGraw –Hill.
5. **Engineering Metrology and Measurements**, N.V.Raghavendra and L.Krishnamurthy, Oxford University Press.

Scheme of Examination:

Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.

MATERIALS TESTING LAB
[AS PER CHOICE ASED CREDIT SYSTEM (CBCS) SCHEME]
SEMESTER – III / IV

Subject Code	15MEL37A/47A	IA Marks	20
Number of Lecture Hrs / Week	01	Exam Marks	80
No of Practical Hours / Week	02	Exam Hours	03
CREDITS – 02			

COURSE OBJECTIVES

Students are expected-

1. To learn the concept of the preparation of samples to perform characterization such as microstructure, volume fraction of phases and grain size.
2. To understand mechanical behavior of various engineering materials by conducting standard tests.
3. To learn material failure modes and the different loads causing failure.
4. To learn the concepts of improving the mechanical properties of materials by different methods like heat treatment, surface treatment etc.

COURSE OUTCOMES

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

1. Acquire experimentation skills in the field of material testing.
2. Develop theoretical understanding of the mechanical properties of materials by performing experiments.
3. Apply the knowledge to analyze a material failure and determine the failure inducing agent/s.
4. Apply the knowledge of testing methods in related areas.
5. Know how to improve structure/behavior of materials for various industrial applications.

PART – A

1. Preparation of specimen for Metallographic examination of different engineering materials.
To report microstructures of plain carbon steel, tool steel, gray C.I, SG iron, Brass, Bronze & composites.
2. Heat treatment: Annealing, normalizing, hardening and tempering of steel.
Metallographic specimens of heat treated components to be supplied and students should report microstructures of furnace cooled, water cooled, air cooled, tempered steel.
Students should be able to distinguish the phase changes in a heat treated specimen compared to untreated specimen.
3. Brinell, Rockwell and Vickers's Hardness tests on untreated and heat treated specimens.
4. To study the defects of Cast and Welded components using
Non-destructive tests like:
 - a) Ultrasonic flaw detection
 - b) Magnetic crack detection
 - c) Dye penetration testing.

PART – B

5. Tensile, shear and compression tests of steel, aluminum and cast iron specimens using Universal Testing Machine
6. Torsion Test on steel bar.
7. Bending Test on steel and wood specimens.
8. Izod and Charpy Tests on Mild steel and C.I Specimen.
9. To study the wear characteristics of ferrous and non-ferrous materials under different parameters.
10. Fatigue Test (demonstration only).

Students should make observations on nature of failure and manifestations of failure in each of the experiments apart from reporting values of mechanical properties determined after conducting the tests.

Scheme of Examination:

ONE question from part -A:	25 Marks
ONE question from part -B:	40 Marks
Viva -Voice:	15 Marks

Total :	80 Marks
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MECHANICAL MEASUREMENTS AND METROLOGY LAB

[AS PER CHOICE ASED CREDIT SYSTEM (CBCS) SCHEME]

SEMESTER – III / IV

Subject Code	15MEL 37B / 47B	IA Marks	20
Number of Lecture Hrs / Week	01	Exam Marks	80
No of Practical Hours / Week	02	Exam Hours	03
CREDITS – 02			

COURSE OBJECTIVES:

1. To illustrate the theoretical concepts taught in Mechanical Measurements & Metrology through experiments.
2. To illustrate the use of various measuring tools measuring techniques.
3. To understand calibration techniques of various measuring devices.

COURSE OUTCOMES

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

	Description	CL	POs
CO1	To calibrate pressure gauge, thermocouple, LVDT, load cell, micrometer.	U	PO1, PO6
CO2	To measure angle using Sine Center/ Sine Bar/ Bevel Protractor, alignment using Autocollimator/ Roller set.	U	PO1, PO6
CO3	To demonstrate measurements using Optical Projector/Tool maker microscope, Optical flats.	U	PO1, PO6
CO4	To measure cutting tool forces using Lathe/Drill tool dynamometer.	U	PO1, PO6
CO5	To measure Screw thread parameters using 2-Wire or 3-Wire method, gear tooth profile using gear tooth vernier/Gear tooth micrometer.	U	PO1, PO6
CO6	To measure surface roughness using Tally Surf/ Mechanical Comparator.	U	PO1, PO6

PART-A: MECHANICAL MEASUREMENTS

1. Calibration of Pressure Gauge
2. Calibration of Thermocouple
3. Calibration of LVDT
4. Calibration of Load cell
5. Determination of modulus of elasticity of a mild steel specimen using strain gauges.

PART-B: METROLOGY

1. Measurements using Optical Projector / Toolmaker Microscope.
2. Measurement of angle using Sine Center / Sine bar / bevel protractor
3. Measurement of alignment using Autocollimator / Roller set
4. Measurement of cutting tool forces using
 - a) Lathe tool Dynamometer OR
 - b) Drill tool Dynamometer.
5. Measurements of Screw thread Parameters using two wire or Three-wire methods.
6. Measurements of Surface roughness, Using Tally Surf/Mechanical Comparator
7. Measurement of gear tooth profile using gear tooth Vernier /Gear tooth micrometer
8. Calibration of Micrometer using slip gauges
9. Measurement using Optical Flats

Scheme of Examination:

ONE question from part -A:	25 Marks
ONE question from part -B:	40 Marks
Viva -Voice:	15 Marks
Total :	80 Marks

FOUNDRY AND FORGING LAB
 [AS PER CHOICE ASED CREDIT SYSTEM (CBCS) SCHEME]
 SEMESTER – III / IV

Subject Code	15MEL38A	IA Marks	20
Number of Lecture Hrs / Week	01	Exam Marks	80
No of Practical Hours / Week	02	Exam Hours	03
CREDITS – 02			

COURSE OBJECTIVES:

- To provide an insight into different sand preparation and foundry equipment's.
- To provide an insight into different forging tools and equipment's.
- To provide training to students to enhance their practical skills.
- To practically demonstrate precautions to be taken during casting and hot working.
- To develop team qualities and ethical principles.

COURSE OUTCOMES

Students will be able to

- Demonstrate various skills of sand preparation, molding.
- Demonstrate various skills of forging operations.
- Work as a team keeping up ethical principles.

PART A

1. Testing of Molding sand and Core sand

Preparation of sand specimens and conduction of the following tests:

1. Compression, Shear and Tensile tests on Universal Sand Testing Machine.
2. Permeability test
3. Sieve Analysis to find Grain Fineness Number(GFN) of Base Sand
4. Clay content determination in Base Sand.

PART B

2. Foundry Practice

1. Use of foundry tools and other equipment's.
2. Preparation of molding sand mixture.
3. Preparation of green sand molds using two molding boxes kept ready for pouring.
 - Using patterns (Single piece pattern and Split pattern)
 - Without patterns.
 - Incorporating core in the mold. (Core boxes).
 - Preparation of one casting (Aluminum or cast iron-Demonstration only)

PART C

3. Forging Operations :

Use of forging tools and other equipment's

- Calculation of length of the raw material required to prepare the model considering scale loss.
- Preparing minimum three forged models involving upsetting, drawing and bending operations.
- Demonstration of forging model using Power Hammer.

Question paper pattern:

One question is to be set from Part-A 15 Marks

One question is to be set from either Part-B or Part-C 35 Marks

Calculation of length of the raw material required for forging model is compulsory irrespective of the student preparing part-B or part-C model

Calculation of length for Forging 10 Marks

Viva – Voce 20 Marks

Total 20 Marks

MACHINE SHOP
[AS PER CHOICE ASED CREDIT SYSTEM (CBCS) SCHEME]
SEMESTER – III / IV

Subject Code	15MEL38 B	IA Marks	20
Number of Lecture Hrs / Week	01	Exam Marks	80
No of Practical Hours / Week	02	Exam Hours	03
CREDITS – 02			

COURSE OBJECTIVES

- To provide an insight to different machine tools, accessories and attachments
- To train students into machining operations to enrich their practical skills
- To inculcate team qualities and expose students to shop floor activities
- To educate students about ethical , environmental and safety standards

COURSE OUTCOMES

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

COs	Description	CL	POs
CO1	Perform turning , facing , knurling , thread cutting, tapering , eccentric turning and allied operations	A	PO1, PO6, PO9
CO2	Perform keyways / slots , grooves etc using shaper	A	PO1, PO6, PO9
CO3	Perform gear tooth cutting using milling machine	A	PO1, PO6, PO9
CO4	Understand the formation of cutting tool parameters of single point cutting tool using bench grinder / tool and cutter grinder	U	PO1, PO6
CO5	Understand Surface Milling/Slot Milling	U	PO1, PO6
CO6	Demonstrate precautions and safety norms followed in Machine Shop	U	PO8
CO7	Exhibit interpersonal skills towards working in a team	U	PO9

PART – A

Preparation of three models on lathe involving

Plain turning, Taper turning, Step turning, Thread cutting, Facing, Knurling, Drilling, Boring, Internal Thread cutting and Eccentric turning.

PART – B

Cutting of V Groove/ dovetail / Rectangular groove using a shaper

Cutting of Gear Teeth using Milling Machine

PART – C

For demonstration

Demonstration of formation of cutting parameters of single point cutting tool using bench grinder / tool & cutter grinder. Demonstration of surface milling /slot milling

One Model from Part – A	40 Marks
One Model from Part – B	20 Marks
Viva – Voce	20 Marks
<hr/>	
Total	80 Marks

KINEMATICS OF MACHINES

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Kinematics of Machines	15ME42	04	3-2-0	80	20	3Hrs

Course objectives

Students will

1. Familiarize with mechanisms and motion analysis of mechanisms.
2. Understand methods of mechanism motion analysis and their characteristics.
3. Analyse motion of planar mechanisms, gears, gear trains and cams.

MODULE - 1

Introduction: Definitions: Link, kinematic pairs, kinematic chain, mechanism, structure, degrees of freedom, Classification links, Classification of pairs based on type of relative motion, Grubler's criterion, mobility of mechanism, Grashoff's criteria, inversions of Grashoff's chain.

Mechanisms: Quick return motion mechanisms- Drag link mechanism, Whitworth mechanism and Crank and slotted lever Mechanism. Oldham's coupling, Straight line motion mechanisms Peaucellier's mechanism and Robert's mechanism. Intermittent Motion mechanisms: Geneva wheel mechanism, Ratchet and Pawl mechanism, toggle mechanism, pantograph, condition for correct steering, Ackerman steering gear mechanism.

10 Hours

MODULE -2

Velocity and Acceleration Analysis of Mechanisms (Graphical Method): Velocity and acceleration analysis of four bar mechanism, slider crank mechanism. Mechanism illustrating Coriolis component of acceleration. Angular velocity and angular acceleration of links, velocity of rubbing.

Velocity Analysis by Instantaneous Center Method: Definition, Kennedy's theorem, Determination of linear and angular velocity using instantaneous center method.

Klein's Construction: Analysis of velocity and acceleration of single slider crank mechanism.

10 Hours

MODULE – 3

Velocity and Acceleration Analysis of Mechanisms (Analytical Method): Velocity and acceleration analysis of four bar mechanism, slider crank mechanism using complex algebra method.

Freudenstein's equation for four bar mechanism and slider crank mechanism.

Function Generation for four bar mechanism.

10 Hours

Module – 4

Spur Gears: Gear terminology, law of gearing, path of contact, arc of contact, contact ratio of spur gear. Interference in involute gears, methods of avoiding interference, back lash, condition for minimum number of teeth to avoid interference, expressions for arc of contact and path of contact

Gear Trains: Simple gear trains, compound gear trains. Epicyclic gear trains: Algebraic and tabular methods of finding velocity ratio of epicyclic gear trains, torque calculation in epicyclic gear trains.

10 Hours

Cams: Types of cams, types of followers. displacement, velocity and acceleration curves for uniform velocity, Simple Harmonic Motion, Uniform Acceleration Retardation, Cycloidal motion. Cam profiles: disc cam with reciprocating / oscillating follower having knife-edge, roller and flat-face follower inline and offset.

Analysis of Cams: Analysis of arc cam with flat faced follower.

10 Hours

Graphical Solutions may be obtained either on the Graph Sheets or in the Answer Book itself.

Course outcomes

Students will be able to

1. Identify mechanisms with basic understanding of motion.
2. Comprehend motion analysis of planar mechanisms, gears, gear trains and cams.
3. Carry out motion analysis of planar mechanisms, gears, gear trains and cams.

TEXT BOOKS:

1. Rattan S.S, Theory of Machines, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 4th Edition, 2014.
2. Ambekar A. G., Mechanism and Machine Theory, PHI, 2009.

REFERENCE BOOKS:

1. Michael M Staniscic, Mechanisms and Machines-Kinematics, Dynamics and Synthesis, Cengage Learning, 2016.
2. Sadhu Singh, **Theory of Machines**, Pearson Education (Singapore) Pvt. Ltd, Indian Branch New Delhi, 2nd Edi. 2006.

APPLIED THERMODYNAMICS

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Applied Thermodynamics	15ME43	04	3-2-0	80	20	3Hrs

Courselearning objectives:

- To have a working knowledge of basic performance of Gas power cycles.
- To Calculate the forces exerted by a fluid at rest on submerged surfaces and understand the force of buoyancy
- To understand and evaluate the performance of steam power cycles their various Engineering applications
- To know how fuel burns and their thermodynamic properties.
- To Understand mechanism of power transfer through belt, rope, chain and gear drives in I C Engines
- To determine performance parameters of refrigeration and air-conditioning systems.
- Evaluate the performance parameters of reciprocating air compressor as a function of receiver pressure.

Module - I

Gas Power Cycles : Air standard cycles; Carnot, Otto, Diesel, Dual and Stirling cycles, p-v and T -s diagrams, description, efficiencies and mean effective pressures. Comparison of Otto and Diesel cycles. Gas turbine (Brayton) cycle; description and analysis. Regenerative gas turbine cycle. Inter-cooling and reheating in gas turbine cycles.

Jet propulsion: Introduction to the principles of jet propulsion, turbojet, turboprop, Ramjet and turbofan engines and their processes . Principles of rocket propulsion, Introduction to rocket engine. 10 Hours

Module –II

Vapour Power Cycles: Carnot vapour power cycle, drawbacks as a reference cycle. Simple Rankine cycle; description, T-s diagram, analysis for performance. Comparison of Carnot and Rankine cycles. Effects of pressure and temperature on Rankine cycle performance. Actual vapour power cycles. Ideal and practical regenerative Rankine cycles, open and closed feed water heaters. Reheat Rankine cycle. Characteristics of an Ideal working fluid in Vapour power cycles, Binary Vapour cycles
10 Hours

Module –III

Combustion Thermodynamics: Theoretical (Stoichiometric) air for combustion of fuels. Excess air, mass balance, Exhaust gas analysis, A/F ratio. Energy balance for a chemical reaction, enthalpy of formation, enthalpy and internal energy of combustion. Combustion efficiency. Dissociation and equilibrium, emissions.

I.C.Engines: Classification of IC engines, Combustion of SI engine and CI engine, Detonation and factors affecting detonation, Performance analysis of I.C Engines, heat balance, Morse test, IC Engine fuels, Ratings and Alternate Fuels. Automotive Pollutions and its effects on environment.

10 Hours

Module –IV

Refrigeration Cycles: Vapour compression refrigeration system; description, analysis, refrigerating effect. Capacity, power required, units of refrigeration, COP, Refrigerants and their desirable properties, alternate Refrigerants. Any one case study on cold storage or industrial refrigerator. Air cycle refrigeration; reversed Carnot cycle, reversed Brayton cycle, Vapour absorption refrigeration system. Steam jet refrigeration.

Psychrometrics and Air-conditioning Systems: Properties of Atmospheric air, and Psychometric properties of Air, Psychometric Chart, Analyzing Air-conditioning Processes; Heating, Cooling, Dehumidification and Humidification, Evaporative Cooling. Adiabatic mixing of two moist air streams. Cooling towers.

10 Hours

Module –V

Reciprocating Compressors: Operation of a single stage reciprocating compressors. Work input through p-v diagram and steady state steady flow analysis. Effect of Clearance and Volumetric efficiency. Adiabatic, Isothermal and Mechanical efficiencies. Multi-stage compressor, saving in work, Optimum intermediate pressure, Inter-cooling, Minimum work for compression.

Steam nozzles: Flow of steam through nozzles, Shape of nozzles, effect of friction, Critical pressure ratio, Supersaturated flow.

10 Hours

Course outcomes

Students will be able to

- Apply thermodynamic concepts to analyze the performance of gas power cycles including propulsion systems.
- Evaluate the performance of steam turbine components.
- Understand combustion of fuels and combustion processes in I C engines including alternate fuels and pollution effect on environment.
- Apply thermodynamic concepts to analyze turbo machines.
- Determine performance parameters of refrigeration and air-conditioning systems.
- Understand the principles and applications of refrigeration systems.
- Analyze air-conditioning processes using the principles of psychrometry and Evaluate cooling and heating loads in an air-conditioning system.
- Understand the working, applications, relevance of air and identify methods for performance improvement.

Text Books:

1. Thermodynamics an engineering approach, by Yunus A. Cengel and Michael A. Boles. Tata McGraw hill Pub. Sixth edition, 2008.

2. Basic and Applied Thermodynamics” by P .K. Nag, Tata McGraw Hill, 2nd Edi. 2009
3. Fundamentals of Thermodynamics by G.J. Van Wylen and R.E. Sonntag, Wiley Eastern. Fourth edition 1993.

Reference Books:

1. Thermodynamics for engineers, Kenneth A. Kroos and Merle C. Potter, Cengage Learning, 2016
2. Principles of Engineering Thermodynamics, Michael J,Moran, Howard N. Shapiro, Wiley, 8th Edition
3. An Introduction to Thermo Dynamics by Y.V.C.Rao, Wiley Eastern Ltd, 2003.
4. Thermodynamics by Radhakrishnan. PHI, 2nd revised edition.
5. I.C Engines by Ganeshan.V. Tata McGraw Hill, 4rth Edi. 2012.
6. I.C.Engines by M.L.Mathur & Sharma. Dhanpat Rai& sons- India

E- Learning

- Nptel.ac.in
- VTU, E- learning
- MOOCS
- Open courseware

Scheme of Examination:

Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.

FLUID MECHANICS

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Fluid Mechanics	15ME44	04	3-2-0	80	20	3Hrs

Course objectives:

- To have a working knowledge of the basic properties of fluids and understand the continuum approximation
- To Calculate the forces exerted by a fluid at rest on submerged surfaces and understand the force of buoyancy
- To understand the flow characteristic and dynamics of flow field for various Engineering applications
- To know how velocity changes and energy transfers in fluid flows are related to forces and torques and to understand why designing for minimum loss of energy in fluid flows is so **important**.
- To discuss the main properties of laminar and turbulent pipe flow and appreciate their differences and the concept of boundary layer theory.
- Understand the concept of dynamic similarity and how to apply it to experimental modeling
- To appreciate the consequences of compressibility in gas flow and understand the effects of friction and heat transfer on compressible flows

MODULE -1

Basics: Introduction, Properties of fluids-mass density, weight density, specific volume, specific gravity, viscosity, surface tension, capillarity, vapour pressure, compressibility and bulk modulus. Concept of continuum, types of fluids etc, pressure at a point in the static mass of fluid, variation of pressure, Pascal's law, Absolute, gauge, atmospheric and vacuum pressures pressure measurement by simple, differential manometers and mechanical gauges.

Fluid Statics: Total pressure and center of pressure for horizontal plane, vertical plane surface and inclined plane surface submerged in static fluid. Buoyancy, center of buoyancy, meta center and meta centric height its application in shipping, stability of floating bodies.

10Hrs

MODULE -2

Fluid Kinematics and Dynamics:

Fluid Kinematics: Types of Flow-steady , unsteady, uniform, non-uniform, laminar, turbulent, one,two and three dimensional, compressible, incompressible, rotational, irrotational, stream lines, path lines, streak lines, velocity components, convective and local acceleration, velocity potential, stream function, continuity equation in Cartesian co-ordinates. Rotation, vorticity and circulation, Laplace equation in velocity potential and Poisson equation in stream function, flow net, Problems.

Fluid Dynamics:

Momentum equation, Impacts of jets- force on fixed and moving vanes, flat and curved. Numericals.Euler's equation, Integration of Euler's equation to obtain Bernoulli's equation, Bernoulli's theorem, Application of Bernoulli's theorem such as venture meter, orifice meter, rectangular and triangular notch, pitot tube, orifices etc., related numericals.

12 Hrs

MODULE -3

Laminar and turbulent flow: Reynods Number, Entrance flow and Developed flow, Navier-Stokes Equation (no derivation), Laminar flow between parallel plates, Poiseuille equation – velocity profile, Couette flow, Fully developed laminar flow in circular pipes, Hagen - Poiseuille equation, related numericals.

Energy consideration in pipe flow, Loss of Pressure Head due to Fluid Friction, Darcy Weishach formula, major and minor losses in pipes, Commercial pipe, Colebrook equation, Moody equation/ diagram. Pipes in series, parallel, equivalent pipe, Related Numericals and simple pipe design problems.

10 Hrs

MODULE -4

Flow over bodies: Development of boundary layer, Prandtl's boundary layer equations, Blasius solution, laminar layer over a flat plate, boundary layer separation and its control.

Basic concept of Lift and Drag, Types of drag, Co-efficient of drag and lift,streamline body and bluff body, flow around circular bodies and airfoils, Lift and drag on airfoil, Numericals.

Dimensional analysis: Need for dimensional analysis, Dimensions and units, Dimensional Homogeneity and dimensionless ratios, methods of dimensional analysis, Rayleigh's method, Buckingham Pi theorem, Similitude and Model studies. Numericals.

10 Hrs

MODULE -5

Compressible Flows: Introduction, thermodynamic relations of perfect gases, internal energy and enthalpy, speed of sound, pressure field due to a moving source, basic Equations for one-dimensional flow, stagnation and sonic Properties, normal and oblique shocks.

Introduction to CFD: Necessity, limitations, philosophy behind CFD, applications.

08 Hrs

Course outcomes:

Students will be able to

- CO1: Identify and calculate the key fluid properties used in the analysis of fluid behavior.
- CO2: Understand and apply the principles of pressure, buoyancy and floatation
- CO3: Apply the knowledge of fluid statics, kinematics and dynamics while addressing problems of mechanical and chemical engineering.
- CO4: Understand and apply the principles of fluid kinematics and dynamics.
- CO5: Understand the concept of boundary layer in fluid flow and apply dimensional analysis to form dimensionless numbers in terms of input output variables.
- CO6: Understand the basic concept of compressible flow and CFD

Text Books:

1. Fluid Mechanics (SI Units), Yunus A. Cengel John M. Cimbala, 3rd Ed., Tata McGraw Hill, 2014.
2. Fluid Mechanics, F M White, McGraw Hill Publications Eighth edition. 2016
3. Mechanics of Fluids, Merle C. Potter, Devid C. Wiggerrt, Bassem H. Ramadan, Cengage learning, Fourth editions 2016.

Reference Books:

1. Fundamentals of Fluid Mechanics by Munson, Young, Okiishi & Huebsch, John Wiley Publications. 7th edition.
2. Fluid Mechanics, Pijush.K.Kundu, IRAM COCHEN, ELSEVIER, 3rd Ed. 2005.
3. Fluid Mechanics, John F. Douglas, Janul and M. Gasiosek and John A. Swaffield, Pearson Education Asia, 5th ed., 2006.
4. Introduction to Fluid Mechanics by Fox, McDonald, John Wiley Publications, 8th edition.

E- Learning

- Nptel.ac.in
- VTU, E- learning
- MOOCS
- Open courseware

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.

MANAGEMENT AND ENGINEERING ECONOMICS

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Management And Engineering Economics	15ME51	04	3-2-0	80	20	3Hrs

MODULE – 1

Management: Introduction - Meaning - nature and characteristics of Management, Scope and Functional areas of management - Management as science, art of profession - Management & Administration - Roles of Management, Levels of Management, Development of Management Thought- early management approaches – Modern management approaches.

Planning: Nature, importance and purpose of planning process Objectives -Types of plans (Meaning Only) - Decision making Importance of planning - steps in planning & planning premises - Hierarchy of plans. **10 Hours**

MODULE - 2

Organizing And Staffing: Nature and purpose of organization Principles of organization - Types of organization - Departmentation Committees- Centralization Vs Decentralization of authority and responsibility - Span of control - MBO and MBE (Meaning Only) Nature and importance of staffing-- :Process of Selection & Recruitment (in brief).

Directing & Controlling: Meaning and nature of directing Leadership styles, Motivation Theories, Communication - Meaning and importance - coordination, meaning and importance and Techniques of Co Ordination. Meaning and steps in controlling - Essentials of a sound control system - Methods of establishing control (in brief) **10 Hours**

MODULE -3

Introduction: Engineering and economics, Problem solving and decision making, Laws of demand and supply, Difference between Microeconomics & Macroeconomics, equilibrium between demand & supply, elasticity of demand, price elasticity, income elasticity.

Law of Returns, Interest and interest factors, simple and compound interest, Cash flow diagrams, personal loans and EMI payment calculation with flexible interest rates, Discussion and problems **10 Hours**

MODULE -4

Present, future and annual worth and rate of returns: Basic present worth comparisons, Present worth-equivalence, Assets with unequal lives and infinite lives, future worth comparisons, payback comparisons, Equivalent annual worth comparisons, situations for annual worth comparisons. Asset life, Rate of return, minimum acceptable rate of return, IRR anomalies and misconceptions, Cost of capital, comparisons of all present future and annual worth with IRR, product costing, Discussions and problems **10 Hours**

MODULE -5

Costing and depreciation: Components of costs, estimation of selling price, marginal cost, first cost, all kinds of overheads, indirect cost estimation with depreciation, mensuration and estimation of material cost, cost estimation of mechanical process, idling time. Product costing (approaches to product costing), causes of depreciation, methods of computing depreciation charges, straight line method, declining balance method, sum of years method, sinking fund method, service output methods, taxation concepts, personal income taxes and corporate taxes, Discussions and problems. **10 Hours**

Course outcomes

On completion of this subject students will be able to

1. Understand needs, functions, roles, scope and evolution of Management
2. Understand importance, purpose of Planning and hierarchy of planning and also analyze its types
3. Discuss Decision making, Organizing, Staffing, Directing and Controlling
4. Select the best economic model from various available alternatives
5. Understand various interest rate methods and implement the suitable one.
6. Estimate various depreciation values of commodities
7. Prepare the project reports effectively.

TEXT BOOKS

1. Principles of Management by Tripathy and Reddy
2. Mechanical estimation and costing, T.R. Banga & S.C. Sharma, 17th edition 2015
3. Engineering Economy, Riggs J.L. McGraw Hill, 2002
4. Engineering Economy, Thuesen H.G. PHI, 2002

REFERENCE BOOKS

1. Management Fundamentals- Concepts, Application, Skill Development - RobersLusier - Thomson
2. Basics of Engineering Economy, Leland Blank & Anthony Tarquin, McGraw Hill Publication (India) Private Limited
3. Engineering Economics, R.Paneerselvam, PHI publication
4. Fundamentals of Management: Essential Concepts and Applications, Pearson Education, Robbins S.P. and Decenzo David A.
5. Economics: Principles of Economics, N Gregory Mankiw, Cengage Learning
6. Modern Economic Theory, By Dr. K. K. Dewett & M. H. Navalur, S. Chand Publications

DYNAMICS OF MACHINERY

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Dynamics of Machinery	15ME52	04	3-2-0	80	20	3Hrs

Course Objectives

1. To gain the knowledge static and dynamic equilibrium conditions of mechanisms subjected forces and couple, with and without friction.
2. Analyse the mechanisms for static and dynamic equilibrium.
3. To understand the balancing principles of rotating and reciprocating masses, governors and gyroscopes.
4. Analyse the balancing of rotating and reciprocating masses, governors and gyroscopes.
5. To understand vibrations characteristics of single degree of freedom systems.
6. Characterise the single degree freedom systems subjected to free and forced vibrations with and without damping.

MODULE 1

Static force Analysis: Static equilibrium. Equilibrium of two and three force members. Members with two forces and torque, Free body diagrams, Static force analysis of four bar mechanism and Slider-crank mechanism with and without friction.

Dynamic force Analysis: D'Alembert's principle, Inertia force, Inertia torque. Dynamic force analysis of four-bar mechanism and Slider crank mechanism without friction, numerical problems. **10 Hours**

MODULE 2

Balancing of Rotating Masses: Static and dynamic balancing, balancing of single rotating mass by balancing masses in same plane and in different planes. Balancing of several rotating masses by balancing masses in same plane and in different planes.

Balancing of Reciprocating Masses: Inertia effect of crank and connecting rod, Single cylinder engine, balancing in multi cylinder-inline engine (primary and secondary forces), numerical problems. **10 Hours**

MODULE 3

Governors: Types of governors, force analysis of Porter and Hartnell governors. Controlling force, Stability, Sensitiveness, Isochronism, Effort and Power.

Gyroscope: Vectorial representation of angular motion, Gyroscopic couple. Effect of gyroscopic couple on plane disc, aeroplane, ship, stability of two wheelers and four wheelers, numerical problems. **10 Hours**

MODULE - 4

Introduction & Undamped free Vibrations (Single Degree of Freedom)

Types of vibrations, Definitions, Simple Harmonic Motion (SHM), Work done by harmonic force, Principle of super position applied to SHM. Methods of analysis – (Newton's, Energy & Rayleigh's methods). Derivations for spring mass systems, Natural frequencies of simple systems, Springs in series and parallel, Torsional and transverse vibrations, Effect of mass of spring and problems. **10 Hours**

MODULE – 5

Damped free Vibrations (Single Degree of Freedom)

Types of damping, Analysis with viscous damping - Derivations for over, critical and under damped systems, Logarithmic decrement and numerical problems.

Forced Vibrations (Single Degree of Freedom):

Analysis of forced vibration with constant harmonic excitation, Magnification factor (M.F.), Vibration isolation - Transmissibility ratio, Excitation of support (absolute and relative), Numerical problems. **10 Hours**

Course outcomes

On completing the course the student will be able to

1. Determine the forces and couples for static and dynamic conditions of four bar and slider crank mechanisms to keep the system in equilibrium.
2. Determine magnitude and angular position of balancing masses under static and dynamic condition of rotating masses in same and different planes.
3. Determine unbalanced primary, secondary forces and couples in single and multi-cylinder engine.
4. Determine sensitiveness, isochronism, effort and power of porter and hartnell governors.
5. Determine gyroscopic couple and effects related to 2, 4 wheeler, plane disc, ship and aeroplanes.
6. Understand types of vibration, SHM and methods of finding natural frequencies of simple mechanical systems.
7. Determine equation of motion, natural frequency, damping factor, logarithmic decrement of damped free vibration (SDOF) systems.
8. Determine the natural frequency, force and motion transmissibility of single degree freedom systems.
9. Determine equation of motion of rotating and reciprocating unbalance systems, magnification factor, and transmissibility of forced vibration (SDOF) systems.

Text Books:

1. Theory of Machines, Sadhu Singh, Pearson Education, 2nd Edition. 2007.
2. Mechanism and Machine Theory, A. G. Ambekar PHI, 2007
3. Mechanical Vibrations, V. P. Singh, Dhanpat Rai and Company,
4. Mechanical Vibrations, G. K. Grover, Nem Chand and Bros.

Reference Books:

1. Theory of Machines, Rattan S.S. Tata McGraw Hill Publishing Company Ltd., New Delhi, 3rd Edition, 2009.
2. Mechanical Vibrations, S. S. Rao, Pearson Education Inc, 4th edition, 2003.

TURBO MACHINES

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Turbo Machines	15ME53	04	3-2-0	80	20	3Hrs

Course Objectives:

- The course aims at giving an overview of different types of turbomachinery used for energy transformation, such as pumps, fans, compressors, as well as hydraulic and steam turbines.
- Explain the working principles of turbomachines and apply it to various types of machines
- It will focus on application of turbo machinery in power generation, power absorption and transportation sectors.

Module 1

Introduction: Definition of turbo machine, parts of turbo machines, Comparison with positive displacement machines, Classification, Dimensionless parameters and their significance, Effect of Reynolds number, Unit and specific quantities, model studies.

(Note: Since dimensional analysis is covered in Fluid Mechanics subject, questions on dimensional analysis may not be given. However, dimensional parameters and model studies may be given more weightage.)

Thermodynamics of fluid flow: Application of first and second law of thermodynamics to turbo machines, Efficiencies of turbo machines, Static and Stagnation states, Incompressible fluids and perfect gases, overall isentropic efficiency, stage efficiency (their comparison) and polytropic efficiency for both compression and expansion processes. Reheat factor for expansion process **(10 Hours)**

Module 2

Energy exchange in Turbo machines: Euler's turbine equation, Alternate form of Euler's turbine equation, Velocity triangles for different values of degree of reaction, Components of energy transfer, Degree of Reaction, utilization factor, Relation between degree of reaction and Utilization factor, Problems.

General Analysis of Turbo machines: Radial flow compressors and pumps – general analysis, Expression for degree of reaction, velocity triangles, Effect of blade discharge angle on energy transfer and degree of reaction, Effect of blade discharge angle on performance, Theoretical head – capacity relationship, General analysis of axial flow pumps and compressors, degree of reaction, velocity triangles, Problems.

(10 Hours)

Module 3

Steam Turbines: Classification, Single stage impulse turbine, condition for maximum blade efficiency, stage efficiency, Need and methods of compounding, Multi-stage impulse turbine, expression for maximum utilization factor.

Reaction turbine – Parsons's turbine, condition for maximum utilization factor, reaction staging. Problems.

(10 Hours)

Module 4

Hydraulic Turbines: Classification, various efficiencies. **Pelton turbine** – velocity triangles, design parameters, Maximum efficiency.

Francis turbine - velocity triangles, design parameters, runner shapes for different blade speeds. Draft tubes- Types and functions. **Kaplan and**

Propeller turbines - velocity triangles, design parameters. Problems.

(10 Hours)

Module 5

Centrifugal Pumps: Classification and parts of centrifugal pump, different heads and efficiencies of centrifugal pump, Minimum speed for starting the flow, Maximum suction lift, Net positive suction head, Cavitation, Need for priming, Pumps in series and parallel. Problems.

Centrifugal Compressors: Stage velocity triangles, slip factor, power input factor, Stage work, Pressure developed, stage efficiency and surging and problems. Axial flow Compressors: Expression for pressure ratio developed in a stage, work done factor, efficiencies and stalling. Problems.

(10 Hours)

Course Outcomes:

- Able to give precise definition of turbomachinery
- Identify various types of turbo machinery
- Apply the Euler's equation for turbomachinery to analyse energy transfer in turbomachines
- Understand the principle of operation of pumps, fans, compressors and turbines.
- Perform the preliminary design of turbomachines (pumps, rotary compressors and turbines)
- Analyze the performance of turbo machinery.

TEXT BOOKS:

1. An Introduction to Energy Conversion, Volume III, Turbo machinery, V. Kadambi and Manohar Prasad, New Age International Publishers, reprint 2008.
2. Turbines, Compressors & Fans, S. M. Yahya, Tata McGraw Hill Co. Ltd., 2nd edition, 2002

REFERENCE BOOKS:

1. Principals of Turbo machines, D. G. Shepherd, The Macmillan Company (1964).
2. Fluid Mechanics & Thermodynamics of Turbo machines, S. L. Dixon, Elsevier (2005).

3. Text Book of Turbo machines, M. S. Govindgouda and A. M. Nagaraj, M. M. Publications, 4Th Ed, 2008.

DESIGN OF MACHINE ELEMENTS – I

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Design of Machine Elements	15ME54	04	3-2-0	80	20	3Hrs

Course Objectives

1. Able to understand mechanical design procedure, materials, codes and use of standards
2. Able to design machine components for static, impact and fatigue strength.
3. Able to design fasteners, shafts, joints, couplings, keys, threaded fasteners riveted joints, welded joints and power screws.

Module-1

Fundamentals of Mechanical Engineering Design

Mechanical engineering design, Phases of design process, Design considerations, Engineering Materials and their Mechanical properties, Standards and Codes, Factor of safety, Material selection.

Static Stresses: Static loads .Normal, Bending, Shear and Combined stresses. Stress concentration and determination of stress concentration factor.

10 Hours

Module -2

Design for Impact and Fatigue Loads

Impact stress due to Axial, Bending and Torsional loads.

Fatigue failure: Endurance limit, S-N Diagram, Low cycle fatigue, High cycle fatigue, modifying factors: size effect, surface effect. Stress concentration effects, Notch sensitivity, fluctuating stresses, Goodman and Soderberg relationship, stresses due to combined loading, cumulative fatigue damage.

10Hours

Module -3

Design of Shafts, Joints, Couplings and Keys

Torsion of shafts, design for strength and rigidity with steady loading, ASME codes for power transmission shafting, shafts under combined loads.

Design of Cotter and Knuckle joints, Rigid and flexible couplings, Flange coupling, Bush and Pin type coupling and Oldham's coupling. Design of keys-square, saddle, flat and father.

10 Hours

Module - 4

Riveted Joints and Weld Joints

Rivet types, rivet materials, failures of riveted joints, Joint Efficiency, Boiler Joints, Lozanze Joints, Riveted Brackets, eccentrically loaded joints.

Types of welded joints, Strength of butt and fillet welds, welded brackets with transverse and parallel fillet welds, eccentrically loaded welded joints.

10 Hours

Module -5

Threaded Fasteners and Power Screws

Stresses in threaded fasteners, Effect of initial tension, Design of threaded fasteners under static loads, Design of eccentrically loaded bolted joints.

Types of power screws, efficiency and self-locking, Design of power screw, Design of screw jack: (Complete Design).

10 Hours

Course outcomes

On completion of the course the student will be able to

1. Describe the design process, choose materials.
2. Apply the codes and standards in design process.
3. Analyze the behavior of machine components under static, impact, fatigue loading using failure theories.
4. Design shafts, joints, couplings.
5. Design of riveted and welded joints.
6. Design of threaded fasteners and power screws

Text Books:

1. Design of Machine Elements, V.B. Bhandari, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2nd Edition 2007.
2. Mechanical Engineering Design, Joseph E Shigley and Charles R. Mischke. McGraw Hill International edition, 6th Edition, 2009.

Design Data Handbook:

1. Design Data Hand Book, K. Lingaiah, McGraw Hill, 2nd Ed.
2. Data Hand Book, K. Mahadevan and Balaveera Reddy, CBS Publication
3. Design Data Hand Book, S C Pilli and H. G. Patil, I. K. International Publisher, 2010.

Reference Books:

1. Machine Design, Robert L. Norton, Pearson Education Asia, 2001.
2. Engineering Design, George E. Dieter, Linda C Schmidt, McGraw Hill Education, Indian Edition, 2013.
3. Design of Machined Elements, S C Pilli and H. G. Patil, I. K. International Publisher, 2017.
4. Machine Design, Hall, Holowenko, Laughlin (Schaum's Outline series) adapted by S.K Somani, tata McGraw Hill Publishing company Ltd., New Delhi, Special Indian Edition, 2008

REFRIGERATION AND AIR-CONDITIONING
(Professional Elective-I)

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Refrigeration And Air-Conditioning	15ME551	03	3-0-0	80	20	3Hrs

Pre-requisites: Basic and Applied Thermodynamics

Course objectives

1. Study the basic definition, ASHRAE Nomenclature for refrigerating systems
2. Understand the working principles and applications of different types of refrigeration systems
3. Study the working of air conditioning systems and their applications
4. Identify the performance parameters and their relations of an air conditioning system

Module – I

Introduction to Refrigeration –Basic Definitions, ASHRAE Nomenclature, Air Refrigeration Cycles-reversed Carnot cycle, Bell-Coleman cycle analysis, Air Refrigeration systems-merits and demerits and applications:Aircraft refrigeration cycles, Joule Thompson coefficient and Inversion Temperature, Linde, Claude and Stirling cycles for liquefaction of air.

Industrial Refrigeration-Chemical and process industries, Dairy plants, Petroleum refineries, Food processing and food chain, Miscellaneous
8 Hours

Module – II

Vapour Compression Refrigeration System(VCRS): Comparison of Vapour Compression Cycle and Gas cycle,Vapour Compression Refrigeration system Working and analysis, Limitations, Superheat horn and throttling loss for various refrigerants, efficiency,Modifications to standard cycle – liquid-suction heat exchangers, Grindlay cycle and Lorenz cycle, Optimum suction condition for optimum COP – Ewing’s construction and Gosney’s method.Actual cycles with pressure drops, Complete Vapour Compression Refrigeration System, Multi-Pressure,Multi-evaporator systems or Compound Vapour Compression Refrigeration Systems – Methods like Flash Gas removal, Flash inter cooling and water Inter cooling.

10 Hours

Module – III

Vapour Absorption Refrigeration Systems: Absorbent – Refrigerant combinations, Water-Ammonia Systems,Practical problems, Lithium- Bromide System, Contrast between the two systems, Modified Version of Aqua-Ammonia System with Rectifier and Analyzer Assembly.Practical problems – crystallization and air leakage, Commercial systems

Other types of Refrigeration systems: Brief Discussion on (i) Steam-Jet refrigeration system and (ii) Thermoelectric refrigeration, pulse tube refrigeration, thermo acoustic refrigeration systems

8

Hours

Module – IV

Refrigerants:Primary and secondary refrigerants, Designation of Refrigerants, Desirable properties of refrigerants including solubility in water and lubricating oil, material compatibility, toxicity, flammability, leak detection, cost, environment and performance issues Thermodynamic properties of refrigerants, Synthetic and natural refrigerants, Comparison between different refrigerants vis a vis applications, Special issues and practical implications Refrigerant mixtures – zeotropic and azeotropic mixtures

Refrigeration systems Equipment: Compressors, Condensers, Expansion Devices and Evaporators, A brief look at other components of the system.

8 Hours

Module – V

Air-Conditioning: Introduction to Air-Conditioning, Basic Definition, Classification, power rating, ASHRAE Nomenclature pertaining to Air-Conditioning, Applications of Air-Conditioning, Mathematical Analysis of Air-Conditioning Loads, Related Aspects, Different Air-Conditioning Systems-Central – Station Air-Conditioning System, Unitary Air-Conditioning System, Window Air-Conditioner and Packaged Air-Conditioner, Components related to Air-Conditioning Systems.

Transport air conditioning Systems: Air conditioning systems for automobiles (cars, buses etc.), Air conditioning systems for trains, Air conditioning systems for ships.

8 Hours

Course Outcomes

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

1. Illustrate the principles, nomenclature and applications of refrigeration systems.
2. Explain vapour compression refrigeration system and identify methods for performance improvement
3. Study the working principles of air, vapour absorption, thermoelectric and steam-jet and thermo-acoustic refrigeration systems
4. Estimate the performance of air-conditioning systems using the principles of psychometry.
5. Compute and Interpret cooling and heating loads in an air-conditioning system
6. Identify suitable refrigerant for various refrigerating systems

TEXT BOOKS

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

REFERENCE BOOKS

1. Dossat, Principles of Refrigeration Pearson-2006.
2. McQuiston, Heating, Ventilation and Air Conditioning, Wiley Students edition, 5th edition 2000.
3. PITA, Air conditioning 4th edition, Pearson-2005
4. Refrigeration and Air-Conditioning' by Manoharprasad
5. S C Arora & S Domkundwar, Refrigeration and Air-Conditioning Dhanpat Rai Publication
6. <http://nptel.ac.in/courses/112105128/#>

Data Book:

1. Shan K. Wang, Handbook of Air Conditioning and Refrigeration, 2/e, 2001 McGraw-Hill Education
2. Mathur M.L. & Mehta, Refrigerant and Psychrometric Properties (Tables & Charts) SI Units, F.S., Jain Brothers, 2008

E- Learning

- VTU, E- learning, MOOCS, Open courseware

**NON TRADITIONAL MACHINING
(Professional Elective-I)**

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Non Traditional Machining	15ME554	03	3-0-0	80	20	3Hrs

MODULE 1

INTRODUCTION

Introduction to Non-traditional machining, Need for Non-traditional machining process, Comparison between traditional and non-traditional machining, general classification Non-traditional machining processes, classification based on nature of energy employed in machining, selection of non-traditional machining processes, Specific advantages, limitations and applications of non-traditional machining processes. **08 hours**

MODULE 2

Ultrasonic Machining (USM): Introduction, Equipment and material process, Effect of process parameters: Effect of amplitude and frequency, Effect of abrasive grain diameter, effect of slurry, tool & work material. Process characteristics: Material removal rate, tool wear, accuracy, surface finish, applications, advantages & limitations of USM.

Abrasive Jet Machining (AJM): Introduction, Equipment and process of material removal, process variables: carrier gas, type of abrasive, work material, stand-off distance (SOD). Process characteristics- Material removal rate, Nozzle wear, accuracy & surface finish. Applications, advantages & limitations of AJM.

Water Jet Machining (WJM): Equipment & process, Operation, applications, advantages and limitations of WJM.

08 hours

MODULE 3

ELECTROCHEMICAL MACHINING (ECM)

Introduction, Principle of electro chemical machining: ECM equipment, elements of ECM operation, Chemistry of ECM. ECM Process characteristics: Material removal rate, accuracy, surface finish.

Process parameters: Current density, Tool feed rate, Gap between tool & work piece, velocity of electrolyte flow, type of electrolyte, its concentration temperature, and choice of electrolytes. ECM Tooling: ECM tooling technique & example, Tool & insulation materials.

Applications ECM: Electrochemical grinding and electrochemical honing process. Advantages, disadvantages and application of ECG, ECH.

CHEMICAL MACHINING (CHM)

Elements of the process: Resists (maskants), Etchants. Types of chemical machining process-chemical blanking process, chemical milling process.

Process characteristics of CHM: material removal rate, accuracy, surface finish, advantages, limitations and applications of chemical machining process.

10 hours

MODULE 4

ELECTRICAL DISCHARGE MACHINING (EDM)

Introduction, mechanism of metal removal, EDM equipment: spark erosion generator (relaxation type), dielectric medium-its functions & desirable properties, electrode feed control system. Flushing types; pressure flushing, suction flushing, side flushing, pulsed flushing. EDM process parameters: Spark frequency, current & spark gap, surface finish, Heat Affected Zone. Advantages, limitations & applications of EDM, Electrical discharge grinding, Traveling wire EDM.

PLASMA ARC MACHINING (PAM)

Introduction, non-thermal generation of plasma, equipment mechanism of metal removal, Plasma torch, process parameters, process characteristics. Safety precautions. Safety precautions, applications, advantages and limitations.

08 hours

MODULE 5

LASER BEAM MACHINING (LBM)

Introduction, generation of LASER, Equipment and mechanism of metal removal, LBM parameters and characteristics, Applications, Advantages & limitations.

ELECTRON BEAM MACHINING (EBM)

Introduction, Principle, equipment and mechanism of metal removal, applications, advantages and limitations.

08 hours

Course Outcomes

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

1. Understand the compare traditional and non-traditional machining process and recognize the need for Non-traditional machining process.
2. Understand the constructional features, performance parameters, process characteristics, applications, advantages and limitations of USM, AJM and WJM.
3. Identify the need of Chemical and electro-chemical machining process along with the constructional features, process parameters, process characteristics, applications, advantages and limitations.
4. Understand the constructional feature of the equipment, process parameters, process characteristics, applications, advantages and limitations EDM & PAM.
5. Understand the LBM equipment, LBM parameters, and characteristics. EBM equipment and mechanism of metal removal, applications, advantages and limitations LBM & EBM.

Text Books:

1. Modern Machining Process by P.C Pandey and H S Shah, McGraw Hill Education India Pvt. Ltd. 2000
2. Production technology, HMT, McGraw Hill Education India Pvt. Ltd. 2001

Reference Books

1. New Technology, Dr. Amitabha Bhattacharyya, The Institute of Engineers (India), 2000
2. Modern Machining process, Aditya, 2002.

AUTOMATION AND ROBOTICS
(OPEN ELECTIVE – I)

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Automation And Robotics	15ME563	03	3-0-0	80	20	3Hrs

Module - 1

Automation

History of Automation, Reasons for automation, Disadvantages of automation, Automation systems, Types of automation – Fixed, Programmable and Flexible automation, Automation strategies

Automated Manufacturing Systems: Components, classification and overview of manufacturing Systems, Flexible Manufacturing Systems (FMS), Types of FMS, Applications and benefits of FMS. **08 Hours**

Module - 2

Robotics

Definition of Robot, History of robotics, Robotics market and the future prospects, Robot Anatomy, Robot configurations: Polar, Cartesian, cylindrical and Jointed-arm configuration.

Robot motions, Joints, Work volume, Robot drive systems, Precision of movement – Spatial resolution, Accuracy, Repeatability, End effectors – Tools and grippers. **08 Hours**

Module - 3

Controllers and Actuators

Basic Control System concepts and Models, Transfer functions, Block diagrams, characteristic equation, Types of Controllers: on-off, Proportional, Integral, Differential, P-I, P-D, P-I-D controllers. Control system and analysis.

Robot actuation and feedback components

Position sensors – Potentiometers, resolvers, encoders, velocity sensors. Actuators - Pneumatic and Hydraulic Actuators, Electric Motors, Stepper motors, Servomotors, Power Transmission systems. **09 Hours**

Module - 4

Robot Sensors and Machine vision system

Sensors in Robotics - Tactile sensors, Proximity and Range sensors, use of sensors in robotics.

Machine Vision System: Introduction to Machine vision, the sensing and digitizing function in Machine vision, Image processing and analysis, Training and Vision systems. **08 Hours**

Module - 5

Robots Technology of the future: Robot Intelligence, Advanced Sensor capabilities, Telepresence and related technologies, Mechanical design features, Mobility, locomotion and navigation, the universal hand, system integration and networking.

Artificial Intelligence: Goals of AI research, AI techniques – Knowledge representation, Problem representation and problem solving, LISP programming, AI and Robotics, LISP in the factory. **09 Hours**

Course Outcomes

On completion of the course student will be able to

1. Classify various types of automation & manufacturing systems
2. Discuss different robot configurations, motions, drive systems and its performance parameters.
3. Describe the basic concepts of control systems, feedback components, actuators and power transmission systems used in robots.
4. Explain the working of transducers, sensors and machine vision systems.
5. Discuss the future capabilities of sensors, mobility systems and Artificial Intelligence in the field of robotics.

Text Books

1. Automation, Production Systems and Computer Integrated Manufacturing M.P. Groover, Pearson Education.5th edition, 2009
2. Industrial Robotics, Technology, Programming and Applications by M.P. Groover, Weiss, Nagel, McGraw Hill International, 2nd edition, 2012.

Reference Books

1. Robotics, control vision and intelligence-Fu, Lee and Gonzalez. McGraw Hill International, 2nd edition, 2007. .
2. Robotic Engineering - An Integrated approach, Klafter, Chmielewski and Negin, PHI, 1st edition, 2009.

PROJECT MANAGEMENT
(OPEN ELECTIVE – I)

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Project Management	15ME564	03	3-0-0	80	20	3Hrs

MODULE – 1

Introduction: Definition of project, characteristics of projects, understand projects, types of projects, scalability of project tools, project roles

Project Selection And Prioritization – Strategic planning process, Strategic analysis, strategic objectives, portfolio alignment – identifying potential projects, methods of selecting projects, financial mode / scoring models to select projects, prioritizing projects, securing and negotiating projects.
08 Hours

MODULE – 2

Planning Projects: Defining the project scope, Project scope checklist, Project priorities, Work Breakdown Structure (WBS), Integrating WBS with organisation, coding the WBS for the information system.

Scheduling Projects: Purpose of a project schedule, historical development, how project schedules are limited and created, develop project schedules, uncertainty in project schedules, Gantt chart.
08 Hours

MODULE – 3

Resourcing Projects: Abilities needed when resourcing projects, estimate resource needs, creating staffing management plan, project team composition issues, Budgeting Projects: Cost planning, cost estimating, cost budgeting, establishing cost control.

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

MODULE – 4

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

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

08 Hours

MODULE - 5

Network Analysis

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

10 Hours

Course Outcomes

On completion of the course the student will be able to

1. Understand the selection, prioritization and initiation of individual projects and strategic role of project management.
2. Understand the work breakdown structure by integrating it with organization.
3. Understand the scheduling and uncertainty in projects.
4. Students will be able to understand risk management planning using project quality tools.
5. Understand the activities like purchasing, acquisitions, contracting, partnering and collaborations related to performing projects.
6. Determine project progress and results through balanced scorecard approach
7. Draw the network diagram to calculate the duration of the project and reduce it using crashing.

TEXT BOOKS

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

REFERENCE BOOKS

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

FLUID MECHANICS & MACHINERY LAB

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Fluid Mechanics & Machinery Lab	15MEL57	02	1-0-2	80	20	3Hrs

Co-requisite Courses: Turbo Machines

Prerequisites : Fluid Mechanics and Thermodynamics

Course Objectives:

1. This course will provide a basic understanding of flow measurements using various types of flow measuring devices, calibration and losses associated with these devices.
2. Energy conversion principles, analysis and understanding of hydraulic turbines and pumps will be discussed. Application of these concepts for these machines will be demonstrated. Performance analysis will be carried out using characteristic curves.

PART – A

1. Lab layout, calibration of instruments and standards to be discussed
2. Determination of coefficient of friction of flow in a pipe.
3. Determination of minor losses in flow through pipes.
4. Application of momentum equation for determination of coefficient of impact of jets on flat and curved blades
5. Calibration of flow measuring devices.
6. Orifice meter
 - o Nozzle
 - o Venturimeter
 - o V-notch

PART – B

7. Performance on hydraulic Turbines
 - a. Pelton wheel
 - b. Francis Turbine
 - c. Kaplan Turbines
8. Performance hydraulic Pumps
 - d. Single stage and Multi stage centrifugal pumps
 - e. Reciprocating pump
9. Performance test on a two stage Reciprocating Air Compressor
10. Performance test on an Air Blower

PART – C (Optional)

11. Visit to Hydraulic Power station/ Municipal Water Pump House and Case Studies
12. Demonstration of cut section models of Hydraulic turbines and Pumps.

Course Outcomes:

At the end of this course students are able to,

1. Perform experiments to determine the coefficient of discharge of flow measuring devices.
2. Conduct experiments on hydraulic turbines and pumps to draw characteristics.
3. Test basic performance parameters of hydraulic turbines and pumps and execute the knowledge in real life situations.
4. Determine the energy flow pattern through the hydraulic turbines and pumps
5. Exhibit his competency towards preventive maintenance of hydraulic machines

Reading:

1. K.L.Kumar. “Engineering Fluid Mechanics” Experiments, Eurasia Publishing House, 1997
2. Jagdish Lal, Hydraulic Machines, Metropolitan Book Co, Delhi, 1995
3. [George E. Totten](#) , [Victor J. De Negri](#) “Handbook of Hydraulic Fluid Technology, Second Edition, 2011.

Scheme of Examination:

ONE question from part -A: 25 Marks
ONE question from part -B: 40 Marks
Viva –Voice : 15 Marks
Total: 80 Marks

ENERGY LAB

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Energy Lab	15MEL58	02	1-0-2	80	20	3Hrs

Prerequisites: Basic and Applied Thermodynamics

Course Objectives:

1. This course will provide a basic understanding of fuel properties and its measurements using various types of measuring devices
2. Energy conversion principles, analysis and understanding of I C Engines will be discussed. Application of these concepts for these machines will be demonstrated. Performance analysis will be carried out using characteristic curves.
3. Exhaust emissions of I C Engines will be measured and compared with the standards.

PART – A

1. Lab layout, calibration of instruments and standards to be discussed
2. Determination of Flash point and Fire point of lubricating oil using Abel Pensky and Marten's (closed) / Cleveland's (Open Cup) Apparatus.
3. Determination of Calorific value of solid, liquid and gaseous fuels.
4. Determination of Viscosity of a lubricating oil using Redwoods, Saybolt and Torsion Viscometers.
5. Analysis of moisture, volatile matter, ash content and fixed carbon of solid and liquid fuel samples
6. Valve Timing/port opening diagram of an I.C. Engine.

PART - B

7. Performance Tests on I.C. Engines, Calculations of IP, BP, Thermal efficiency, Volumetric efficiency, Mechanical efficiency, SFC, FP, A:F Ratio, heat balance sheet for
 - a. Four stroke Diesel Engine
 - b. Four stroke Petrol Engine
 - c. Multi Cylinder Diesel/Petrol Engine, (Morse test)
 - d. Two stroke Petrol Engine
 - e. Variable Compression Ratio I.C. Engine.
8. Measurements of Exhaust Emissions of Petrol engine.
9. Measurements of Exhaust Emissions of Diesel engine.
10. Measurement of $p\theta$, pV plots using Computerized IC engine test rig

PART – C (Optional)

11. Visit to Automobile Industry/service stations.
12. CFD Analysis of design, development, performance evaluation and process optimization in I C Engines.

Course Outcomes: At the end of this course students are able to,

1. Perform experiments to determine the properties of fuels and oils.
2. Conduct experiments on engines and draw characteristics.
3. Test basic performance parameters of I.C. Engine and implement the knowledge in industry.
4. Identify exhaust emission, factors affecting them and report the remedies.
5. Determine the energy flow pattern through the I C Engine
6. Exhibit his competency towards preventive maintenance of IC engines.

References

1. E.F.Obert, Internal combustion engines and air pollution intext educational publishers (1973). John Heywood, Internal combustion engine fundamentals, McGraw- Hill (1988) - USA.
2. Colin R Ferguson and Allan T. Kirkpatrick Internal combustion engines Applied Thermodynamics, John Wiley & sons – 2001.
3. Richard stone, Introduction to internal combustion engines, MacMillan (1992) – USA
4. M. L. Mathur And R.P. Sharma A course in internal combustion engines, Dhanpat Rai& sons- India.
5. C. F. Taylor The internal combustion engines in theory and practice, 2 vols. by:, pub.: Wily.
6. C. F. Taylor The internal combustion engines in theory and practice, 2 vols. by:, pub.: Wily.
7. Ganesan, V., Fundamentals of IC Engines, Tata McGraw Hill, 2003
8. Bosch, Automotive hand book, 9th edition.

Scheme of Examination:

ONE question from part -A: 25 Marks
ONE question from part -B: 40 Marks
Viva –Voice : 15 Marks
Total: 80 Marks

FINITE ELEMENT ANALYSIS

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Finite Element Analysis	15ME61	04	3-2-0	80	20	3Hrs

Course Objectives:

- 1.To learn basic principles of finite element analysis procedure .
- 2.To learn the theory and characteristics of finite elements that represent engineering structures.
- 3.To learn and apply finite element solutions to structural, thermal, dynamic problem to develop the knowledge and skills needed to effectively evaluate finite element analyses.

Module I

Introduction to Finite Element Method :General description of the finite element method. Engineering applications of finite element method. Boundary conditions: homogeneous and nonhomogeneous for structural, heat transfer and fluid flow problems.Potential energy method, Rayleigh Ritz method, Galerkin's method, Displacement method of finite element formulation. Convergence criteria, Discretisation process, Types of elements: 1D, 2D and 3D, Node numbering, Location of nodes. Strain displacement relations, Stress strain relations, Plain stress and Plain strain conditions, temperature effects.

Interpolation models: Simplex, complex and multiplex elements, Linear interpolation polynomials in terms of global coordinates 1D, 2D, 3D Simplex Elements.

10 Hours

Module II

One-Dimensional Elements-Analysis of Bars and Trusses,

Linear interpolation polynomials in terms of localcoordinate's for1D, 2Delements. Higher order interpolation functions for 1D quadratic and cubic elements in natural coordinates, , , Constant strain triangle, Four-Nodded Tetrahedral Element (TET 4), Eight-Nodded Hexahedral Element (HEXA

8), 2D isoparametric element, Lagrange interpolation functions, Numerical integration: Gaussian quadrature one point, two point formulae, 2D integrals. Fore terms: Body force, traction force and point loads,

Numerical Problems: Solution for displacement, stress and strain in 1D straight bars, stepped bars and tapered bars using elimination approach and penalty approach, Analysis of trusses.

10 Hours

Module III

Beams and Shafts: Boundary conditions, Load vector, Hermite shape functions, Beam stiffness matrix based on Euler-Bernoulli beam theory, Examples on cantilever beams, propped cantilever beams, Numerical problems on simply supported, fixed straight and stepped beams using direct stiffness method with concentrated and uniformly distributed load.

Torsion of Shafts: Finite element formulation of shafts, determination of stress and twists in circular shafts.

08 Hours

Module IV

Heat Transfer: Basic equations of heat transfer: Energy balance equation, Rate equation: conduction, convection, radiation, energy generated in solid, energy stored in solid, 1D finite element formulation using vibrational method, Problems with temperature gradient and heat fluxes, heat transfer in composite sections, straight fins.

Fluid Flow: Flow through a porous medium, Flow through pipes of uniform and stepped sections, Flow through hydraulic net works.

10 Hours

Module V

Axi-symmetric Solid Elements: Derivation of stiffness matrix of axisymmetric bodies with triangular elements, Numerical solution of axisymmetric triangular element(s) subjected to surface forces, point loads, angular velocity, pressure vessels.

Dynamic Considerations: Formulation for point mass and distributed masses, Consistent element mass matrix of one dimensional bar element, truss element, axisymmetric triangular element, quadrilateral element, beam element. Lumped mass matrix of bar element, truss element, Evaluation of eigen values and eigen vectors, Applications to bars, stepped bars, and beams.

Course outcomes:

Upon successful completion of this course you should be able to:

1. Understand the concepts behind formulation methods in FEM.
2. Identify the application and characteristics of FEA elements such as bars, beams, plane and iso-parametric elements.
3. Develop element characteristic equation and generation of global equation.
4. Able to apply suitable boundary conditions to a global equation for bars, trusses, beams, circular shafts, heat transfer, fluid flow, axi symmetric and dynamic problems and solve them displacements, stress and strains induced.

12Hours

Text Books:

1. Logan, D. L., A first course in the finite element method, 6th Edition, Cengage Learning, 2016.
2. Rao, S. S., Finite element method in engineering, 5th Edition, Pergaman Int. Library of Science, 2010.
3. Chandrupatla T. R., Finite Elements in engineering, 2nd Edition, PHI, 2013.

Reference Books:

1. J.N.Reddy, “**Finite Element Method**”- McGraw -Hill International Edition. Bathe K. J. Finite Elements Procedures, PHI.
2. Cook R. D., et al. “**Concepts and Application of Finite Elements Analysis**”- 4th Edition, Wiley & Sons, 2003.

Computer Integrated Manufacturing

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Computer Integrated Manufacturing	15ME62	04	3-2-0	80	20	3Hrs

Course Objectives:

CLO1	To impart knowledge of CIM and Automation and different concepts of automation by developing mathematical models.
CLO2	To make students to understand the Computer Applications in Design and Manufacturing [CAD / CAM) leading to Computer integrated systems. Enable them to perform various transformations of entities on display devices.
CLO3	To expose students to automated flow lines, assembly lines, Line Balancing Techniques, and Flexible Manufacturing Systems.
CLO4	To expose students to computer aided process planning, material requirement planning, capacity planning etc.
CLO5	To expose the students to CNC Machine Tools, CNC part programming, and industrial robots.
CLO6	To introduce the students to concepts of Additive Manufacturing, Internet of Things, and Industry 4.0 leading to Smart Factory.

Module - 1

1. Introduction to CIM and Automation:

Automation in Production Systems, automated manufacturing systems- types of automation, reasons for automating, Computer Integrated Manufacturing, computerized elements of a CIM system, CAD/CAM and CIM.

Mathematical models and matrices: production rate, production capacity, utilization and availability, manufacturing lead time, work-in-process, numerical problems. **5 Hours**

2. Automated Production Lines and Assembly Systems: Fundamentals, system configurations, applications, automated flow lines, buffer storage, control of production line, analysis of transfer lines, analysis of flow lines without storage, partial automation, analysis of automated flow lines with storage buffer, fundamentals of automated assembly systems, numerical problems. **5 Hours**

Module – 2

- 3. CAD and Computer Graphics Software:**The design process, applications of computers in design, software configuration, functions of graphics package, constructing the geometry.

Transformations: 2D transformations, translation, rotation and scaling, homogeneous transformation matrix, concatenation, numerical problems on transformations.

5 Hours

- 4. Computerized Manufacture Planning and Control System:** Computer Aided Process Planning, Retrieval and Generative Systems, benefits of CAPP, Production Planning and Control Systems, typical activities of PPC System, computer integrated production management system, Material Requirement Planning, inputs to MRP system, working of MRP, outputs and benefits, Capacity Planning, Computer Aided Quality Control, Shop floor control.

5 Hours

Module- 3

- 5. Flexible Manufacturing Systems:** Fundamentals of Group Technology and Flexible Manufacturing Systems, types of FMS, FMS components, Material handling and storage system, applications, benefits, computer control systems, FMS planning and design issues, Automated Storage and Retrieval Systems, AS/RS and Automatic parts identification systems and data capture.

5 Hours

- 6. Line Balancing:** Linebalancing algorithms, methods of line balancing, numerical problems on largest candidate rule, Kilbridge and Wester method, and Ranked Positional Weights method, Mixed Model line balancing, computerized line balancing methods.

5 Hours

Module-4.

- 7. Computer Numerical Control:** Introduction, components of CNC, CNC programming, manual part programming, G Codes, M Codes, programming of simple components in turning, drilling and milling systems, programming with canned cycles. Cutter radius compensations.

5 Hours

- 8. Robot Technology:** Robot anatomy, joints and links, common robot configurations, robot control systems, accuracy and repeatability, end effectors, sensors in robotics.

Robot programming methods: on-line and off-line methods.

Robot industrial applications: material handling, processing and assembly and inspection.

5 Hours

Module – 5

9. Additive Manufacturing Systems: Basic principles of additive manufacturing, slicing CAD models for AM, advantages and limitations of AM technologies, Additive manufacturing processes: Photo polymerization, material jetting, binder jetting, material extrusion, Powder bed sintering techniques, sheet lamination, direct energy deposition techniques, applications of AM. Recent trends in manufacturing, Hybrid manufacturing. **5 Hours**

10. Future of Automated Factory: Industry 4.0, functions, applications and benefits. Components of Industry 4.0, Internet of Things (IOT), IOT applications in manufacturing, Big-Data and Cloud Computing for IOT, IOT for smart manufacturing, influence of IOT on predictive maintenance, industrial automation, supply chain optimization, supply-chain & logistics, cyber-physical manufacturing systems. **5 Hours**

Course Outcomes:

After studying this course, students will be able to:

CO1	Able to define Automation, CIM, CAD, CAM and explain the differences between these concepts. Solve simple problems of transformations of entities on computer screen.
CO2	Explain the basics of automated manufacturing industries through mathematical models and analyze different types of automated flow lines.
CO3	Analyze the automated flow lines to reduce down time and enhance productivity.
CO4	Explain the use of different computer applications in manufacturing, and able to prepare part programs for simple jobs on CNC machine tools and robot programming.
CO5	Visualize and appreciate the modern trends in Manufacturing like additive manufacturing, Industry 4.0 and applications of Internet of Things leading to Smart Manufacturing.

Text Books:

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

Reference Books:

1. “CAD/CAM” by Ibrahim Zeid, Tata McGraw Hill.
2. “Principles of Computer Integrated Manufacturing”, S.Kant Vajpayee, 1999, Prentice Hall of India, New Delhi.

3. "Work Systems And The Methods, Measurement And Management of Work", Groover M. P., Pearson/Prentice Hall, Upper Saddle River, NJ, 2007.
4. "Computer Automation in Manufacturing", Boucher, T. O., Chapman & Hall, London, UK, 1996.
5. "Introduction to Robotics: Mechanics And Control", Craig, J. J., 2nd Ed., Addison-Wesley Publishing Company, Reading, MA, 1989.
6. Internet of Things (IoT): Digitize or Die: Transform your organization. Embrace the digital evolution. Rise above the competition, by Nicolas Windpassinger, Amazon.
7. "Internet of Things: A Hands-on Approach", by Arshdeep Bahga and Vijay Madisetti (Universities Press)
8. Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, 2nd Ed. (2015), Ian Gibson, David W. Rosen, Brent Stucker
9. "**Understanding Additive Manufacturing**", Andreas Gebhardt, Hanser Publishers, 2011
10. Industry 4.0: The Industrial Internet of Things, Apress, 2017, by Alasdair Gilchrist

Heat Transfer

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Heat Transfer	15ME63	04	3-2-0	80	20	3Hrs

Pre-requisites: Basic and Applied Thermodynamics

Course learning objectives:

- Study the modes of heat transfer.
- Learn how to formulate and solve 1-D steady and unsteady heat conduction problems.
- Apply empirical correlations for fully-developed laminar, turbulent internal flows and external boundary layer convective flow problems.
- Study the basic principles of heat exchanger analysis and thermal design.
- Understand the principles of boiling and condensation including radiation heat transfer related engineering problems.

Module – I

Introductory concepts and definitions: Modes of heat transfer: Basic laws governing conduction, convection, and radiation heat transfer; Thermal conductivity; convective heat transfer coefficient; radiation heat transfer combined heat transfer mechanism, Types of boundary conditions. General Heat Conduction Equation: Derivation of the equation in (i) Cartesian, (ii) Polar and (iii) Spherical Co-ordinate Systems.

Steady-state one-dimensional heat conduction problems in Cartesian System: Steady-state one-dimensional heat conduction problems (i) with and without heat generation and (ii) with and without varying thermal conductivity - in Cartesian system with various possible boundary conditions, Thermal Resistances in Series and in Parallel.

8 Hours

Module – II

Critical Thickness of Insulation: Concept, Derivation, Extended Surfaces or Fins: Classification, Straight Rectangular and Circular Fins, Temperature Distribution and Heat Transfer Calculations, Fin Efficiency and Effectiveness, Applications

Transient [Unsteady-state] heat conduction: Definition, Different cases - Negligible internal thermal resistance, negligible surface resistance, comparable internal thermal and surface resistance, Lumped body, Infinite Body and Semi-infinite Body, Numerical Problems, Heisler and Grober charts.

9 Hours

Module – III

Numerical Analysis of Heat Conduction: Introduction, one-dimensional steady conduction, one dimensional unsteady conduction, two-dimensional steady and unsteady conduction, the difference equation, boundary conditions, solution methods, cylindrical coordinates and irregular boundaries.

Thermal Radiation: Fundamental principles - Gray, White, Opaque, Transparent and Black bodies, Spectral emissive power, Wien's, Rayleigh-Jeans' and Planck's laws, Hemispherical Emissive Power, Stefan-Boltzmann law for the total emissive power of a black body, Emissivity and Kirchhoff's Laws, View factor, Net radiation exchange in a two-body enclosure, Typical examples for these enclosures, Radiation Shield.

9 Hours

Module – IV

Forced Convection: Boundary Layer Theory, Velocity and Thermal Boundary Layers, Prandtl number, Governing Equations – Continuity, Navier-Stokes and Energy equations, Boundary layer assumptions, Integral and Analytical solutions to above equations, Turbulent flow, Various empirical solutions, Forced convection flow over cylinders and spheres, Internal flows –laminar and turbulent flow solutions, Forced Convection Cooling of Electronic Devices.

Free convection: Laminar and Turbulent flows, Vertical Plates, Vertical Tubes and Horizontal Tubes, Empirical solutions.

8 Hours

Module – V

Heat Exchangers: Definition, Classification, applications, LMTD method, Effectiveness - NTU method, Analytical Methods, Fouling Factors, Chart Solution Procedures for solving Heat Exchanger problems: Correction Factor Charts and Effectiveness-NTU Charts, compact heat exchangers.

Heat Transfer with Phase Change: Introduction to boiling, pool boiling, Bubble Growth Mechanisms, Nucleate Pool Boiling, Critical Heat Flux in Nucleate Pool Boiling, Pool Film Boiling, Critical Heat Flux, Heat Transfer beyond the Critical Point, filmwise and dropwise Condensation, heat pipes, entrainment, wicking and boiling limitations.

9 Hours

Course Outcomes

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

- Understand the basic modes of heat transfer.
- Compute temperature distribution in steady-state and unsteady-state heat conduction
- Understand and interpret heat transfer through extended surfaces.
- Interpret and compute forced and free convective heat transfer.
- Explain the principles of radiation heat transfer and understand the numerical formula for heat conduction problems.
- Design heat exchangers using LMTD and NTU methods.

TEXT BOOKS:

1. Principals of heat transfer, Frank Kreith, Raj M. Manglik, Mark S. Bohn, Seventh Edition, Cengage learning, 2011.
2. Yunus A. Cengel - Heat transfer, a practical approach, Fifth edition, Tata Mc Graw Hill.

REFERENCE BOOKS:

1. Heat and mass transfer, Kurt C. Rolfe, second edition, Cengage learning.
2. Heat Transfer, M. Necati Ozisik, A Basic Approach, McGraw Hill, New York, 2005.
3. Fundamentals of Heat and Mass Transfer, Incropera, F. P. and De Witt, D. P., 5th Edition, John Wiley and Sons, New York, 2006.
4. Heat Transfer, Holman, J. P., 9th Edition, Tata McGraw Hill, New York, 2008.

E-Books/Web references:

1. A Text book of Heat Transfer, John H Lienhard, 4th Edition,
2. NPTEL Heat Transfer course for Mechanical Engineering, <http://nptel.ac.in/courses/112101097/>
3. Heat Transfer, Chris Long & Naser Sayma, Bookboon.com

MOOCs:

1. Fluid flow, Heat and Mass Transfer- <http://ocw.tudelft.nl/courses/applied-earth-sciences/fluid-flow-heat-mass-transfer/course>
2. Heat transfer course- <https://legacy.saylor.org/me204/Intro/>

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.

DESIGN OF MACHINE ELEMENTS II

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Design of Machine Elements II	15ME64	04	3-2-0	80	20	3Hrs

Course Objectives:

CLO1	To understand various elements involved in a mechanical system.
CLO2	To analyze various forces acting on the elements of a mechanical system and design them using appropriate techniques, codes, and standards.
CLO3	To select transmission elements like gears, belts, pulleys, bearings from the manufacturers' catalogue.
CLO4	To design completely a mechanical system integrating machine elements.
CLO5	To produce assembly and working drawings of various mechanical systems involving machine elements like belts, pulleys, gears, springs, bearings, clutches and brakes.

MODULE I

Curved Beams: Stresses in curved beams of standard cross sections used in crane hook, punching presses & clamps, closed rings and links.

Cylinders & Cylinder Heads: Review of Lamé's equations; compound cylinders, stresses due to different types of fit on cylinders; cylinder heads and flats.

08 Hours

MODULE 2

Belts: Materials of construction of flat and V belts, power rating of belts, concept of slip and creep, initial tension, effect of centrifugal tension, maximum power condition.

Selection of flat and V belts-length & cross section from manufacturers' catalogues.

Construction and application of timing belts.

Wire ropes: Construction of wire ropes, stresses in wire ropes, and selection of wire ropes.

(Only theoretical treatment)

Chain drive: Types of power transmission chains, modes of failure for chain, and lubrication of chains. (Only theoretical treatment)

Springs:Types of springs, spring materials, stresses in helical coil springs of circular and non-circular cross sections. Tension and compression springs, concentric springs;springs under fluctuating loads.

Leaf Springs: Stresses in leaf springs,equalized stresses, and nipping of leaf springs.

Introduction to torsion and Belleville springs.

10 Hours

MODULE 3

Gear drives: Classification of gears, materials for gears, standard systems of gear tooth, gear tooth failure modes and lubrication of gears.

Spur Gears: Definitions, stresses in gear tooth: Lewis equation and form factor, design for strength, dynamic load and wear.

Helical Gears: Definitions, transverse and normal module, formative number of teeth, design based on strength, dynamic load and wear.

Bevel Gears: Definitions, formative number of teeth, design based on strength, dynamic load and wear.

12 Hours

MODULE 4

Worm Gears:Definitions, types of worm and worm gears, and materials for worm and worm wheel. Design based on strength, dynamic, wear loads and efficiency of worm gear drives.

Design of Clutches:Types of clutches and their applications, single plate and multi-plate clutches.

(Numerical examples only on single and multi-plate clutches)

Design of Brakes:Types of Brakes, Block and Band brakes,selflocking of brakes, and heat generation in brakes.

10 Hours

MODULE 5

Lubrication and Bearings:Lubricants and their properties, bearing materials and properties;mechanisms of lubrication,hydrodynamic lubrication, pressure development in oil film, bearing modulus, coefficient of friction, minimum oil film thickness, heat generated, and heat dissipated.

Numerical examples on hydrodynamic journal and thrust bearing design.

Anti friction bearings:Types of rolling contact bearings and their applications, static and dynamic load carrying capacities, equivalent bearing load, load life relationship; selection of deep groove ball bearings from the manufacturers' catalogue; selection of bearings subjected to cyclic loads and speeds; probability of survival.

10 Hours

Course Outcomes:

After learning the course the students should be able to:

CO1	Apply engineering design tools to product design.
CO2	Design mechanical systems involving springs, belts and pulleys.
CO3	Design different types of gears and simple gear boxes for different applications.
CO4	Design brakes and clutches.
CO5	Design hydrodynamic bearings for different applications.
CO6	Select Anti friction bearings for different applications using the manufacturers, catalogue.
C07	Develop proficiency to generate production drawings using CAD software.
C08	Become good design engineers through learning the art of working in a team with morality and ethics.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

Assignment:

Course work includes a **Design project**. Design project should enable the students to design a mechanical system (like single stage reduction gear box with spur gears, single stage worm reduction gear box, V-belt and pulley drive system, machine tool spindle with bearing mounting, C-clamp, screw jack, single plate clutch, etc.) A group of students (maximum number in a group should be 4) should submit assembly drawing and part drawings, completely dimensioned, indicating the necessary manufacturing tolerances, surface finish symbols and geometric tolerances wherever necessary. Design project must be completed using appropriate solid modeling software. Computer generated drawings must be submitted. Design calculations must be hand written and should be included in the report.

Design project should be given due credit (5 marks) in internal assessment.

Textbooks:

- [1] Richard G. Budynas, and J. Keith Nisbett, “Shigley's Mechanical Engineering Design”, McGraw-Hill Education, 10th Edition, 2015.
- [2] Juvinall R.C, and Marshek K.M, “Fundamentals of Machine Component Design”, John Wiley & Sons, Third Edition, Wiley student edition, 2007.
- [3] V. B. Bhandari, “*Design of Machine Elements*”, 4th Ed., Tata Mcgraw Hill, 2016.

References:

- [1] Robert L. Norton “Machine Design- an integrated approach”, Pearson Education, 2nd edition.
- [2] Spotts M.F., Shoup T.E “Design and Machine Elements”, Pearson Education, 8th edition, 2006.
- [3] Orthwein W, “Machine Component Design”, Jaico Publishing Co, 2003.

[4] Hall, Holowenko, Laughlin (Schaum's Outline Series), "Machine design" adapted by S.K.Somani, Tata McGrawHill Publishing Company Ltd., Special Indian Edition, 2008.

[5] G. M. Maithra and L.V.Prasad, "Hand book of Mechanical Design", Tata McGraw Hill, 2nd edition,2004.

Design Data Hand Book:

[1] Design Data Hand Book, K.Lingaiah, McGraw Hill, 2nd edition, 2003.

[2] Design Data Hand Book, K.Mahadevan and Balaveera Reddy, CBS publication.

[3] Design Data Hand Book, H.G.Patil, I.K.International Publisher, 2010

[4]PSG Design Data Hand Book, PSG College of technology, Coimbatore.

METAL FORMING

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Metal Forming	15ME653	3	3-0-0	80	20	3Hrs

Course objectives:

The course is intended to provide basic understanding of Metal Forming with following aspects:

- To acquaint with the basic knowledge on fundamentals of metal forming processes
- To study various metal forming processes
- Understanding plastic deformation during forming processes

MODULE -1

Introduction to Metal Forming: Classification of metal forming processes, advantages and limitations, stress-strain relations in elastic and plastic deformation. Concepts of true stress, true strain, triaxial & biaxial stresses. Determination of flow stress, principal stresses, yield criteria and their significance, Tresca & Von-Mises yield criteria, concepts of plane stress & plane strain. Deformation mechanisms, Hot and Cold working processes and its effect on mechanical properties. **10 Hrs**

MODULE -2

Effects of Parameters: Metallurgical aspects of metal forming, slip, twinning mechanics of plastic deformation, Effects of Temperature, strain rate, friction and lubrication, hydrostatic pressure in metal working, Deformation zone geometry, workability of materials, Residual stresses in wrought products.

Forging: Classification of forging processes. Forging machines equipment. Expressions for forging pressures & load in open die forging and closed die forging by slab analysis, concepts of friction hill and factors affecting it. Die-design parameters. Material flow lines in forging, forging defects, residual stresses in forging. Simple problems. **10 Hrs**

MODULE -3

Rolling: Classification of rolling processes. Types of rolling mills, expression for rolling load. Roll separating force. Frictional losses in bearing, power required in rolling, effects of front & back tensions, friction, friction hill. Maximum possible reduction. Defects in rolled products. Rolling variables. Simple problems.

Drawing: Drawing equipment & dies, expression for drawing load by slab analysis, power requirement. Redundant work and its estimation, optimal cone angle & dead zone formation, drawing variables, Tube drawing, classification of tube drawing. Simple problems. **10 Hrs**

MODULE -4

Extrusion:Types of extrusion processes, extrusion equipment & dies, deformation, lubrication & defects in extrusion. Extrusion dies, extrusion of seamless tubes. Extrusion variables. Simple problems.

Sheet Metal Forming: Forming methods, dies & punches, progressive die, compound die, combination die. Rubber forming. Open back inclinable press (OBI press), piercing, blanking, bending, deep drawing, LDR in drawing, Forming limit criterion, defects of drawn products, stretch forming. Roll bending & contouring. Simple problems. **10 Hrs**

MODULE -5

High Energy Rate Forming Methods & Powder Metallurgy: High Energy Rate Forming Methods: Principles, advantages and applications, explosive forming, electro hydraulic forming, Electromagnetic forming.

Powder Metallurgy: Basic steps in Powder metallurgy brief description of methods of production of metal powders, conditioning and blending powders, compaction and sintering application of powder metallurgy components, advantages and limitations. **10 Hrs**

Course outcomes:

On completion of this subject, students will be:

5. Able to understand the concept of different metal forming process.
6. Able to approach metal forming processes both analytically and numerically
7. Able to design metal forming processes
8. Able to develop approaches and solutions to analyze metal forming processes and the associated problems and flaws.

TEXT BOOKS:

1. Mechanical metallurgy (SI Units), G.E.Dieter, McGraw hill Pub-2001.
2. Production Technology (Manufacturing process, technology and Automation), R.K Jain, Khanna Publishers-2004.
3. Manufacturing Science, Amithab Gosh & A.K.Malik, East-West press 2001.
4. Production Technology Vol-II by O. P. Khanna & Lal, Dhanpat Rai Publications-2012.
5. A Course in Workshop Technology Vol: 1, Manufacturing Process, B.S Raghuwanshi, Published by Dhanpat Rai & Co (P) Ltd.-2014.

REFERENCE BOOKS:

1. Materials & Process in Manufacturing – E.Paul, Degramo, J.T.Black, Ranold, A.K.Prentice-hall of India 2002
2. Elements of Workshop Technology Vol:1, S.K.Hajra Choudhury, Media Promoters & Publishers Pvt Ltd.-2008.
3. Fundamentals of Manufacturing Processes by Lal G K , Narosa
4. Textbook of Production Engineering by P. C. Sharma, S Chand & Company Ltd.

E- Learning

- VTU, E- learning

Scheme of Examination:

Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.

TOTAL QUALITY MANAGEMENT

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Total Quality Management	15ME664	03	3-0-0	80	20	3Hrs

COURSE LEARNING OBJECTIVES:

This course enables students to

1. Understand various approaches to TQM
2. Understand the characteristics of quality leader and his role.
3. Develop feedback and suggestion systems for quality management.
4. Enhance the knowledge in Tools and Techniques of quality management

Module - 1

Principles and Practice: Definition, basic approach, gurus of TQM, TQM Framework, awareness, defining quality, historical review, obstacles, benefits of TQM.

Quality Management Systems: Introduction, benefits of ISO registration, ISO 9000 series of standards, ISO 9001 requirements.

08 Hours

Module - 2

Leadership: Definition, characteristics of quality leaders, leadership concept, characteristics of effective people, ethics, the Deming philosophy, role of TQM leaders, implementation, core values, concepts and framework, strategic planning communication, decision making,

08 Hours

Module - 3

Customer Satisfaction and Customer Involvement:

Customer Satisfaction: customer and customer perception of quality, feedback, using customer complaints, service quality, translating needs into requirements, customer retention, case studies.

Employee Involvement – Motivation, employee surveys, empowerment, teams, suggestion system, recognition and reward, gain sharing, performance appraisal, unions and employee involvement, case studies.

08 Hours

Module - 4

Continuous Process Improvement: process, the Juran trilogy, improvement strategies, types of problems, the PDCA Cycle, problem-solving methods, Kaizen, reengineering, six sigma, case studies.

Statistical Process Control : Pareto diagram, process flow diagram, cause and effect diagram, check sheets, histograms, statistical fundamentals, Control charts, state of control, out of control process, control charts for variables, control charts for attributes, scatter diagrams, case studies

Module - 5

Tools and Techniques: Benchmarking, information technology, quality management systems, environmental management system, and quality function deployment, quality by design, failure mode and effect analysis, product liability, total productive maintenance.

08 Hours

COURSE OUTCOMES:

Student will be able to

1. Explain the various approaches of TQM
2. Infer the customer perception of quality
3. Analyze customer needs and perceptions to design feedback systems.
4. Apply statistical tools for continuous improvement of systems
5. Apply the tools and technique for effective implementation of TQM.

TEXT BOOKS:

1. Total Quality Management: Dale H. Besterfield, Publisher -Pearson Education India, ISBN: 8129702606, Edition 03.
2. Total Quality Management for Engineers: M. Zairi, ISBN:1855730243, Publisher: Wood head Publishing

REFERENCE BOOKS:

1. Managing for Quality and Performance Excellence by James R.Evans and William M Lindsay, 9th edition, Publisher Cengage Learning.
- 2 A New American TQM, four revolutions in management, Shoji Shiba, Alan Graham, David Walden, Productivity press, Oregon, 1990
3. Organizational Excellence through TQM, H. Lal, New age Publications, 2008

Reference Books:

1. Engineering Optimization Methods and Applications, A Ravindran, K, M.Ragsdell, Wiley India Private Limited, 2nd Edition, 2006.
2. : Introduction to Operations Research- Concepts and Cases, F.S. Hillier. G.J. Lieberman, 9th Edition, Tata McGraw Hill. 2010.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.

Heat Transfer Lab

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Heat Transfer Lab	15MEL67	02	1-0-2	80	20	3Hrs

Co-requisite Courses: Heat Transfer

Course Objectives:

- The primary objective of this course is to provide the fundamental knowledge necessary to understand the behavior of thermal systems.
- This course provides a detailed experimental analysis, including the application and heat transfer through solids, fluids, and vacuum. Convection, conduction, and radiation heat transfer in one and two dimensional steady and unsteady systems are examined.

PART – A

1. Determination of Thermal Conductivity of a Metal Rod.
2. Determination of Overall Heat Transfer Coefficient of a Composite wall.
3. Determination of Effectiveness on a Metallic fin.
4. Determination of Heat Transfer Coefficient in a free Convection on a
5. Determination of Heat Transfer Coefficient in a Forced Convection Flow through a Pipe.
6. Determination of Emissivity of a Surface.
7. Analysis of steady and transient heat conduction, temperature distribution of plane wall and cylinder using Numerical approach (ANSYS/CFD package).

PART – B

1. Determination of Steffan Boltzmann Constant.
2. Determination of LMDT and Effectiveness in a Parallel Flow and Counter Flow Heat Exchangers.
3. Experiments on Boiling of Liquid and Condensation of Vapour.
4. Performance Test on a Vapour Compression Refrigeration.
5. Performance Test on a Vapour Compression Air – Conditioner.
6. Experiment on Transient Conduction Heat Transfer.
7. Determination of temperature distribution along a rectangular and circular fin subjected to heat loss through convection using Numerical approach (ANSYS/CFD package)

Course Outcomes: At the end of this course students are able to,

- Perform experiments to determine the thermal conductivity of a metal rod

- Conduct experiments to determine convective heat transfer coefficient for free and forced convection and correlate with theoretical values.
- Estimate the effective thermal resistance in composite slabs and efficiency in pin-fin
- Determine surface emissivity of a test plate
- Estimate performance of a refrigerator and effectiveness of fin
- Calculate temperature distribution of steady and transient heat conduction through plane wall, cylinder and fin using numerical approach.

Reading:

1. M. Necati Ozisik, Heat Transfer – A Basic Approach, McGraw Hill, New York, 2005.
2. Incropera, F. P. and De Witt, D. P., Fundamentals of Heat and Mass Transfer, 5th Edition, John Wiley and Sons, New York, 2006.
3. Holman, J. P., Heat Transfer, 9th Edition, Tata McGraw Hill, New York, 2008.

Scheme of Examination:

ONE question from part -A: 25 Marks

ONE question from part -B: 40 Marks

Viva –Voice : 15 Marks

Total: 80 Marks

Modeling and Analysis Lab (FEA)

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Modeling and Analysis Lab	15MEL68	02	1-0-2	80	20	3Hrs

CREDITS – 02

Prerequisites: Knowledge of any Modeling software, knowledge of coordinate systems and Geometric transformations etc.

Course objectives:

The course is intended to provide basic understanding of Modeling and Analysis techniques students with following aspects:

- To acquire basic understanding of Modeling and Analysis software
- To understand the different kinds of analysis and apply the basic principles to find out the stress and other related parameters of bars, beams loaded with loading conditions.
- To learn to apply the basic principles to carry out dynamic analysis to know the natural frequency of different kind of beams.

PART – A

Study of a FEA package and modeling and stress analysis of:

1. Bars of constant cross section area, tapered cross section area and stepped bar
2. Trusses – **(Minimum 2 exercises of different types)**
3. Beams – Simply supported, cantilever, beams with point load , UDL, beams with varying load etc **(Minimum 6 exercises different nature)**
4. Stress analysis of a rectangular plate with a circular hole

PART - B

- 1) Thermal Analysis – 1D & 2D problem with conduction and convection boundary conditions **(Minimum 4 exercises of different types)**
- 2) Dynamic Analysis to find
 - a) Fixed – fixed beam for natural frequency determination

- b) Bar subjected to forcing function
- c) Fixed – fixed beam subjected to forcing function

PART – C (only for demo and oral exam)

- 1) Demonstrate the use of graphics standards (IGES, STEP etc) to import the model from modeler to solver
- 2) Demonstrate one example of contact analysis to learn the procedure to carry out contact analysis.
- 3) Demonstrate at least two different type of example to model and analyze bars or plates made from composite material

Course Outcomes: At the end of the course the students are able to:

- Demonstrate the basic features of an analysis package.
- Use the modern tools to formulate the problem, and able to create geometry, discretize, apply boundary condition to solve problems of bars, truss, beams, plate to find stress with different-loading conditions.
- Demonstrate the deflection of beams subjected to point, uniformly distributed and varying loads further to use the available results to draw shear force and bending moment diagrams.
- Analyze the given problem by applying basic principle to solve and demonstrate 1D and 2D heat transfer with conduction and convection boundary conditions.
- Carry out dynamic analysis and finding natural frequencies for various boundary conditions and also analyze with forcing function.

REFERENCE BOOKS:

1. **A first course in the Finite element method**, Daryl L Logan, Thomason, Third Edition
2. **Fundamentals of FEM**, Hutton – McGraw Hill, 2004
3. **Finite Element Analysis**, George R. Buchanan, Schaum Series

Scheme for Examination:

One Question from Part A - 32 Marks (08 Write up +24)

One Question from Part B - 32 Marks (08 Write up +24)

Viva-Voce - 16 Marks

Total 80 Marks

ENERGY ENGINEERING

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Energy Engineering	15ME71	04	3-2-0	80	20	3Hrs

Course learning objectives is to

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

Module – I

Thermal Energy conversion system: Review of energy scenario in India, General Philosophy and need of Energy, Different Types of Fuels used for steam generation, Equipment for burning coal in lump form, stokers, different types, Oilburners, Advantages and Disadvantages of using pulverized fuel, Equipment for preparation and burning of pulverized coal, unit system and bin system. Pulverized fuel furnaces, cyclone furnace, Coal and ash handling, Generation of steam using forced circulation, high and supercritical pressures. Chimneys: Natural, forced, induced and balanced draft, Calculations and numerical involving height of chimney to produce a given draft. Cooling towers and Ponds. Accessories for the Steam generators such as Superheaters, De-superheater, control of superheaters, Economizers, Air preheaters and re-heaters.

9 Hours

Module – II

Diesel Engine Power System: Applications of Diesel Engines in Power field. Method of starting Diesel engines. Auxiliaries like cooling and lubrication system, filters, centrifuges, Oil heaters, intake and exhaust system, Layout of diesel power plant.

Hydro-Electric Energy: Hydrographs, flow duration and mass curves, unit hydrograph and numerical. Storage and pondage, pumped storage plants, low, medium and high head plants, Penstock, water hammer, surge tanks, gates and valves. General layout of hydel power plants.

7 Hours

Module – III

Solar Energy: Fundamentals; Solar Radiation; Estimation of solar radiation on horizontal and inclined surfaces; Measurement of solar radiation data, Solar Thermal systems: Introduction; Basics of thermodynamics and heat transfer; Flat plate collector; Evacuated Tubular Collector; Solar air collector; Solar concentrator; Solar distillation; Solar cooker; Solar refrigeration and air conditioning; Thermal energy storage systems, Solar Photovoltaic systems: Introduction; Solar cell Fundamentals; Characteristics and classification; Solar cell: Module, panel and Array construction; Photovoltaic thermal systems

8 Hours

Module – IV

Wind Energy: Properties of wind, 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, coefficient of performance of a wind mill rotor (Numerical Examples).

Tidal Power: Tides and waves as energy suppliers and their mechanics; fundamental characteristics of tidal power, harnessing tidal energy, limitations.

8 Hours

Module – V

Biomass Energy: Introduction; Photosynthesis Process; Biofuels; Biomass Resources; Biomass conversion technologies; Urban waste to energy conversion; Biomass gasification.

Green Energy: Introduction: Fuel cells: Overview; Classification of fuel cells; Operating principles; Fuel cell thermodynamics Nuclear, ocean, MHD, thermoelectric and geothermal energy applications; Origin and their types; Working principles, Zero energy Concepts

8 Hours

Course Outcomes

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

- Summarize the basic concepts of thermal energy systems,
- Identify renewable energy sources and their utilization.
- Understand the basic concepts of solar radiation and analyze the working of solar PV and thermal systems.
- Understand principles of energy conversion from alternate sources including wind, geothermal, ocean, biomass, biogas.
- Understand the concepts and applications of fuel cells, thermoelectric convertor and MHD generator.
- Identify methods of energy storage for specific applications

TEXT BOOKS:

1. B H Khan, Non conventional energy resources, 3rd Edition, McGraw Hill Education
2. Principles of Energy conversion, A. W. Culp Jr., McGraw Hill. 1996

REFERENCE BOOKS:

1. S.P. Sukhatme, Solar Energy: principles of Thermal Collection and Storage, Tata McGraw-Hill (1984).
2. C. S. Solanki, "Solar Photovoltaic's: Fundamental Applications and Technologies, Prentice Hall of India, 2009.
3. L.L. Freris, Wind Energy Conversion Systems, Prentice Hall, 1990.

Scheme of Examination: Two questions to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.

FLUID POWER SYSTEMS

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Fluid Power Systems	15ME72	04	3-2-0	80	20	3Hrs

Course objectives:

CLO1	To provide an insight into the capabilities of hydraulic and pneumatic fluid power.
CLO2	To understand concepts and relationships surrounding force, pressure, energy and power in fluid power systems.
CLO3	To examine concepts centering on sources of hydraulic power, rotary and linear actuators, distribution systems, hydraulic flow in pipes, and control components in fluid power systems.
CLO4	Exposure to build and interpret hydraulic and pneumatic circuits related to industrial applications.
CLO5	To familiarize with logic controls and trouble shooting

Module 1: Introduction to fluid power systems

Fluid power system: components, advantages and applications. Transmission of power at static and dynamic states. Pascal's law and its applications. Fluids for hydraulic system: types, properties, and selection. Additives, effect of temperature and pressure on hydraulic fluid. Seals, sealing materials, compatibility of seal with fluids. Types of pipes, hoses, and quick acting couplings. Pressure drop in hoses/pipes. Fluid conditioning through filters, strainers; sources of contamination and contamination control; heat exchangers.

10 hours

Module 2: Pumps and actuators

Pumps: Classification of pumps, Pumping theory of positive displacement pumps, construction and working of Gear pumps, Vane pumps, Piston pumps, fixed and variable displacement pumps, Pump performance characteristics, pump selection factors, problems on pumps.

Accumulators: Types, selection/ design procedure, applications of accumulators. Types of Intensifiers, Pressure switches /sensor, Temperature switches/sensor, Level sensor.

Actuators: Classification cylinder and hydraulic motors, Hydraulic cylinders, single and double acting cylinder, mounting arrangements, cushioning, special types of cylinders, problems on cylinders.

Construction and working of rotary actuators such as gear, vane, piston motors, and Hydraulic Motor. Theoretical torque, power, flowrate, and hydraulic motor performance; numerical problems. Symbolic representation of hydraulic actuators (cylinders and motors).

10 hours

Module 3: Components and hydraulic circuit design

Components: Classification of control valves, Directional Control Valves-symbolic representation, constructional features of poppet, sliding spool, rotary type valves solenoid and pilot operated DCV, shuttle valve, and check valves.

Pressure control valves - types, direct operated types and pilot operated types.

Flow Control Valves -compensated and non-compensated FCV, needle valve, temperature compensated, pressure compensated, pressure and temperature compensated FCV, symbolic representation.

Hydraulic Circuit Design: Control of single and Double -acting hydraulic cylinder, regenerative circuit, pump unloading circuit, double pump hydraulic system, counter balance valve application, hydraulic cylinder sequencing circuits, cylinder synchronizing circuit using different methods, hydraulic circuit for force multiplication; speed control of hydraulic cylinder- metering in, metering out and bleed off circuits. Pilot pressure operated circuits. Hydraulic circuit examples with accumulator.

10 hours

Module4: Pneumatic power systems

Introduction to Pneumatic systems: Pneumatic power system, advantages, limitations, applications, Choice of working medium. Characteristics of compressed air and air compressors. Structure of pneumatic control System, fluid conditioners-dryers and FRL unit.

Pneumatic Actuators: Linear cylinder –types of cylinders, working, end position cushioning, seals, mounting arrangements, and applications. Rotary cylinders- types, construction and application, symbols.

Pneumatic Control Valves: DCV such as poppet, spool, suspended seat type slide valve, pressure control valves, flow control valves, types and construction, use of memory valve, Quick exhaust valve, time delay valve, shuttle valve, twin pressure valve, symbols.

10 hours

Module5: Pneumatic control circuits

Simple Pneumatic Control: Direct and indirect actuation pneumatic cylinders, speed control of cylinders - supply air throttling and exhaust air throttling.

Signal Processing Elements: Use of Logic gates - OR and AND gates in pneumatic applications.

Practical examples involving the use of logic gates.

Multi- Cylinder Application: Coordinated and sequential motion control, motion and control diagrams. Signal elimination methods, Cascading method-principle, Practical application examples (up to two cylinders) using cascading method (using reversing valves).

Electro- Pneumatic Control: Principles - signal input and output, pilot assisted solenoid control of directional control valves, use of relay and contactors. Control circuitry for simple signal cylinder application.

10 hours

COURSE OUTCOMES:

After studying this course, students will be able to:

CO1	Identify and analyse the functional requirements of a fluid power transmission system for a
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	given application.
CO2	Visualize how a hydraulic/pneumatic circuit will work to accomplish the function.
CO3	Design an appropriate hydraulic or pneumatic circuit or combination circuit like electro-hydraulics, electro-pneumatics for a given application.
CO4	Select and size the different components of the circuit.
CO5	Develop a comprehensive circuit diagram by integrating the components selected for the given application.

TEXT BOOKS:

1. Anthony Esposito, "Fluid Power with applications", Pearson edition, 2000 .
2. Majumdar S.R., "Oil Hydraulics", Tata McGraw Hill, 2002 .
3. Majumdar S.R., "Pneumatic systems - Principles and Maintenance", Tata McGraw-Hill, New Delhi, 2005

REFERENCE BOOKS:

1. John Pippenger, Tyler Hicks, "Industrial Hydraulics", McGraw Hill International Edition, 1980.
2. Andrew Par, Hydraulics and pneumatics, Jaico Publishing House, 2005.
3. FESTO, Fundamentals of Pneumatics, Vol I, II and III.
4. Herbert E. Merritt, "Hydraulic Control Systems", John Wiley and Sons, Inc.
5. Thomson, Introduction to Fluid power, Prentice Hall, 2004
6. John Watton, "Fundamentals of fluid power control", Cambridge University press, 2012.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

Learning Assignment:

The faculty will allocate one or more of the following experiments from group A and B to group of students (containing not more than four students in a group):

Group A: Experiments on hydraulic trainer:

- a. Speed control circuit using metering in and metering out technique
- b. Regenerative and sequencing circuits.
- c. Extend-Retract and Stop system of a linear actuator
- d. Rapid Traverse and Feed circuit.

Group B: Experiments on pneumatic trainer:

- a. Automatic reciprocating circuit
- b. Speed control circuit
- c. Pneumatic circuit involving shuttle valve/ quick exhaust valve
- d. Electro pneumatic valves and circuit

Students should build up the above circuits on computer using software and simulate the flow of fluid during the operation. Afterwards, they themselves can physically connect the circuit on the hydraulic/pneumatic trainer and run the circuit. Record of experiments shall be submitted in the form of journal. Due credit must be given for this assignment (5 Marks).

List of Open Source Software/Learning website:

1. Simulink
2. SimHydraulics

CONTROL ENGINEERING

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Control Engineering	15ME73	04	3-2-0	80	20	3Hrs

Course Objectives	<ol style="list-style-type: none"> 1. Modeling of mechanical, hydraulic, pneumatic and electrical systems. 2. Representation of system elements by blocks and its reduction 3. Transient and steady state response analysis of a system. 4. Frequency response analysis using polar plot. 5. Frequency response analysis using bode plot. 6. Analysis of system using root locus plots. 7. Different system compensators and variable characteristics of linear systems.
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MODULE I

Introduction: Concept of automatic controls, Open loop and closed loop systems, Concepts of feedback, requirements of an ideal control system, Types of controllers-Proportional, Integral, Differential, Proportional & Integral, Proportional Differential and Proportional Integral Differential controllers.

(7 Hours)

MODULE 2

Modeling of Physical Systems :Mathematical Models of Mechanical, Electrical, Thermal, Hydraulic and Pneumatic Systems.

(3 hours)

Analogous Systems: Direct and inverse analogs for mechanical, thermal and fluid systems.

(4 hours)

Block diagram Algebra: General representation of a feedback control system, transfer functions, rules of block diagram algebra, reduction of block dia. to obtain closed loop transfer function.

Signal flow graphs : Mason's gain formula

(6 Hours)

MODULE 3

Steady state operation: Steady state analysis for general block dia. for a control system, steady state characteristics, equilibrium in a system. (3 hours)

Transient Response: Transient response and steady state analysis of unit, step input, general operational representation for a differential equation of control system, distinct, repeated and complex conjugate zeros, general form of transient response, Routh's stability criterion for a control system. (4 hours)

Root Locus Plots : Root locus method: Significance of Root locus, angle and magnitude conditions, breakaway points, angles of departure and arrival, construction of Root locus using general rules and steps, Lead and Lag compensation (6 Hours)

MODULE 4

Frequency Domain Analysis: Relationship between time and frequency response, Polar plot, Bode's Plot, Nyquist plot and Nyquist stability criterion, Relative Stability, Phase and Gain Margins (14 Hours)

MODULE 5

System Compensation and State Variable Characteristics of Linear Systems :Series and feedback compensation, Introduction to state concepts, state equation of linear continuous data system. Matrix representation of state equations, controllability and observability, Kalman and Gilberts test . (7 Hours)

Course Outcomes
CO1: Recognize control system and its types , control actions
CO2: Determine the system governing equations for physical models(Electrical, Thermal, Mechanical, Electro Mechanical)
CO3: Calculate the gain of the system using block diagram and signal flow graph
CO4: Illustrate the response of 1st and 2nd order systems
CO5: Determine the stability of transfer functions in complex domain and frequency domain
CO6: Employ state equations to study the controllability and observability

SMART MATERIALS and MEMS

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Smart Materials and MEMS	15ME745	03	3-0-0	80	20	3Hrs

Course Objective:

This course provides a detailed overview to smart materials, piezoelectric materials structures and its characteristics. The study of Smart structures and modelling helps in Vibration control using smart materials in various applications. Helps to understand the principles and concepts of using MEMS, ER & MR Fluids for various applications.

MODULE 1

Unit1: Introduction: Closed loop and Open loop Smart Structures. Applications of Smart structures, Piezoelectric properties. Inchworm Linear motor, Shape memory alloys, Shape memory effect-Application, Processing and characteristics.

– 5hrs

Unit 2: Shape Memory Alloys: Introduction, Phenomenology, Influence of stress on characteristic temperatures, Modelling of shape memory effect. Vibration control through shape memory alloys. Design considerations, multiplexing embedded NiTiNOL actuators.

– 5hrs

MODULE -2

Unit-3 Electro rheological and Magneto rheological Fluids:Mechanisms and Properties, Characteristics,Fluid composition and behaviour, Discovery and Early developments, Summary of material properties. Applications of ER and MR fluids (Clutches, Dampers, others).

– 5hrs

Unit-4FibreOptics: Introduction, Physical Phenomenon, Characteristics, Fibre optic strain sensors, Twisted and Braided Fibre Optic sensors, Optical fibres as load bearing elements, Crack detection applications, Integration of Fibre optic sensors and shape memory elements. – 5hrs

MODULE-3

Unit 5: Vibration Absorbers: Introduction, Parallel Damped Vibration Absorber, Analysis, Gyroscopic Vibration absorbers, analysis & experimental set up and observations, Active Vibration absorbers. Control of Structures: Introduction, Structures as control plants, Modelling structures for control, Control strategies and Limitations.

– 6hrs

Unit 6: Biomimetics: Characteristics of Natural structures. Fibre reinforced: organic matrix natural composites, Natural creamers, Mollusks. Biomimetic sensing, Challenges and oppurtunities.

– 5hrs

MODULE -4

Unit7: MEMS:History of MEMS, Intrinsic Characteristics, Devices: Sensors and Actuators. Microfabrication: Photolithography, Thermal oxidation, Thin film deposition, etching types, Doping, Dicing, Bonding. Microelectronics fabrication process flow, Silicon based, Process selection and design.

– 5hrs

Unit 8: Piezoelectric Sensing and Actuation: Introduction, Cantilever Piezoelectric actuator model, Properties of Piezoelectric materials, Applications. Magnetic Actuation: Concepts and Principles, Magnetization and Nomenclatures, Fabrication and case studies, Comparison of major sensing and actuation methods.

– 5hrs

MODULE-5

Unit 9: Polymer MEMS&Microfluidics:Introduction, Polymers in MEMS(Polyimide, SU-8,LCP,PDMS,PMMA,Parylene, Others) Applications(Acceleration, Pressure, Flow, Tactile sensors). Motivation for micro fluidics, Biological Concepts, Design and Fabrication of Selective components. Channels and Valves.

– 6hrs

Unit 10: Case Studies: MEMS Magnetic actuators, BP sensors, Microphone, Acceleration sensors, Gyro, MEMS Product development: Performance, Accuracy, Repeatability, Reliability, Managing cost, Market uncertainties, Investment and competition

. – 5hrs

TEXT BOOKS:

- 1.“Smart Structures –Analysis and Design”, A.V.Srinivasan, Cambridge University Press, New York, 2001, (ISBN:0521650267).
2. “Smart Materials and Structures”, M.V.Gandhi and B.S.Thompson Chapman & Hall, London, 1992 (ISBN:0412370107)
3. “Foundation of MEMS, by Chang Liu. Pearson Education. (ISBN:9788131764756)

COURSE OUTCOMES:

1. Describe the methods of controlling vibration using smart systems and fabrication methods of MEMS.
2. Explain the principle concepts of Smart materials, structures, Fibre optics, ER & MR Fluids, Biomimetics and MEMS with principles of working.
3. Analyze the properties of smart structures, MEMS, with the applications and select suitable procedure for fabrication.
4. Summarize the methods and uses of Micro fabrications, Biomimetics, types of polymers used in MEMS, Fibre optics, piezoelectric sensing and actuation.

MECHATRONICS

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Mechatronics	15ME753	03	3-0-0	80	20	3 Hrs

Course objectives:

1. Understand the evolution and development of Mechatronics as a discipline.
2. Substantiate the need for interdisciplinary study in technology education.
3. Understand the applications of microprocessors in various systems and to know the functions of each element
4. Demonstrate the integration philosophy in view of Mechatronics technology

MODULE -1

Introduction: Definition, Multidisciplinary Scenario, Evolution of Mechatronics, Design of Mechatronics system, Objectives, advantages and disadvantages of Mechatronics.

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, proximity switches and Hall Effect sensors. 10 Hours

MODULE -2

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. 10 Hours

MODULE -3

Programmable logic controller: Introduction to PLC's, basic structure, Principle of operation, Programming and concept of ladder diagram, concept of latching & selection of a PLC.

Integration: Introduction & background, Advanced actuators, Pneumatic actuators, Industrial Robot, different parts of a Robot-Controller, Drive, Arm, End Effectors, Sensor & Functional requirements of robot. 10 Hours

MODULE -4

Mechanical actuation systems: Mechanical systems, types of motion, Cams, Gear trains, Ratchet & Pawl, belt and chain drives, mechanical aspects of motor selection.

Electrical actuation systems: Electrical systems, Mechanical switches, Solenoids, Relays, DC/AC Motors, Principle of Stepper Motors & servomotors. 10 Hours

MODULE -5

Pneumatic and hydraulic actuation systems: Actuating systems, Pneumatic and hydraulic systems, Classifications of Valves, Pressure relief valves, Pressure regulating/reducing valves, Cylinders and rotary actuators.

DCV & FCV: Principle & construction details, types of sliding spool valve,

solenoid operated, Symbols of hydraulic elements, components of hydraulic system, functions of various units of hydraulic system. Design of simple hydraulic circuits for various applications.

10 Hours

Course outcomes:

On completion of this subject, students will be able to:

1. Illustrate various components of Mechatronics systems.
2. Assess various control systems used in automation.
3. Develop mechanical, hydraulic, pneumatic and electrical control systems.

TEXT BOOKS:

1. NitaigourPremchandMahalik , Mechatronics-Principles, Concepts and Applications, Tata McGraw Hill, 1stEdition, 2003 ISBN.No. 0071239243, 9780071239240.
2. W.Bolton-Pearson Education, Mechatronics – Electronic Control Systems in Mechanical and Electrical Engineering, 1stEdition, 2005 ISBN No. 81-7758-284-4.

REFERENCE BOOKS:

1. Mechatronics by HMT Ltd. – Tata McGrawHill, 1st Edition, 2000. ISBN:9780074636435.
2. Anthony Esposito, Fluid Power , Pearson Education, 6th Edition, 2011, ISBN No.9789332518544.

E- Learning

- VTU, E- learning

Scheme of Examination:

Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.

DESIGN LABORATORY

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Design Laboratory	15MEL76	02	1-0-2	80	20	3Hrs

Prerequisites: Knowledge of Dynamics and Machines and Design of Machine Elements

COURSE OBJECTIVES:

Students are expected-

1. To understand the natural frequency, logarithmic decrement, damping ratio and damping.
2. To understand the balancing of rotating masses.
3. To understand the concept of the critical speed of a rotating shaft.
4. To understand the concept of stress concentration using Photo elasticity.
5. To understand the equilibrium speed, sensitiveness, power and effort of Governor.

PART –A

1. Determination of natural frequency, logarithmic decrement, damping ratio and damping Co-efficient in a single degree of freedom vibrating systems (longitudinal and torsional)
2. Determination of critical speed of rotating shaft.
3. Balancing of rotating masses.
4. Determination of fringe constant of Photo-elastic material using Circular disk subjected diametric compression, Pure bending specimen (four point bending)
5. Determination of stress concentration using Photo elasticity for simple components like Plate with hole under tension or bending, circular disk with circular hole under compression, 2-d crane hook.

PART –B

1. Determination of equilibrium speed, sensitiveness, power and effort of Porter/ Proel / Hartnell Governor. (at least one)
2. Determination of pressure distribution in Journal bearing
3. Determination of principle stresses and strain in a member subjected to combined loading using strain rosettes.
4. Determination of stresses in curved beam using strain gauge.
5. Experiments on Gyroscope (Demonstration only)

COURSE OUTCOMES

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

1. To understand the working principles of machine elements such as Governors, Gyroscopes etc.,
2. To identify forces and couples in rotating mechanical system components.
3. To identify vibrations in machine elements and design appropriate damping methods and to determine the critical speed of a rotating shaft.
4. To measure strain in various machine elements using strain gauges.
5. To determine the minimum film thickness, load carrying capacity, frictional torque and pressure distribution of journal bearing.
6. To determine strain induced in a structural member using the principle of photo-elasticity.

Scheme of Examination:

One question from Part A:	32 Marks
One question from part B:	32 Marks
Viva- Voce:	16 Marks
Total:	80 Marks

Reference Books:

- [1] “Shigley’s Mechanical Engineering Design”, Richards G. Budynas and J. Keith Nisbett, McGraw-Hill Education, 10th Edition, 2015.
- [2] “Design of Machine Elements”, V.B. Bhandari, TM H publishing company Ltd. New Delhi, 2nd Edition 2007.
- [3] “Theory of Machines”, Sadhu Singh, Pearson Education, 2nd Edition, 2007.
- [4] “Mechanical Vibrations”, G.K. Grover, Nem Chand and Bros, 6th Edition, 1996.

COMPTER INTEGRATED MANUFACTURING LAB

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Computer Integrated Manufacturing LAB	15MEL77	02	1-0-2	80	20	3Hrs

Course Objectives:

CLO1	To expose the students to the techniques of CNC programming and cutting tool path generation through CNC simulation software by using G-Codes and M-codes.
CLO2	To educate the students on the usage of CAM packages.
CLO3	To make the students understand the importance of automation in industries through exposure to FMS, Robotics, and Hydraulics and Pneumatics.

Part-A

Manual CNC part programming for 2 turning and 2 milling parts. Selection and assignment of tools, correction of syntax and logical errors, and verification of tool path.

CNC part programming using CAM packages. Simulation of Turning, Drilling, Milling operations.

3 typical simulations to be carried out using simulation packages like: **CademCAMLab-Pro, Master- CAM.**

Program generation using software. Optimize spindle power, torque utilization, and cycle time. Generation and printing of shop documents like process and cycle time sheets, tool list, and tool layouts. Cut the part in single block and auto mode and measure the virtual part on screen. Post processing of CNC programs for standard CNC control systems like FANUC, SINUMERIC and MISTUBISHI.

Part B

(Only for Demo/Viva voce)

FMS (Flexible Manufacturing System): Programming of Automatic storage and Retrieval system (ASRS) and linear shuttle conveyor Interfacing CNC lathe, milling with loading unloading arm and ASRS to be carried out on simple components.

(Only for Demo/Viva voce)

Robot programming: Using Teach Pendent & Offline programming to perform pick and place, stacking of objects (2 programs).

Pneumatics and Hydraulics, Electro-Pneumatics: 3 typical experiments on Basics of these topics to be conducted.

Course Outcomes:

After studying this course, students will be able to:

CLO1	Generate CNC Lathe part program for Turning, Facing, Chamfering, Grooving, Step turning, Taper turning, Circular interpolation etc.
CLO2	Generate CNC Mill Part programming for Point to point motions, Line motions, Circular interpolation, Contour motion, Pocket milling- circular, rectangular, Mirror commands etc.
CLO3	Use Canned Cycles for Drilling, Peck drilling, Boring, Tapping, Turning, Facing, Taper turning Thread cutting etc.
CLO4	Simulate Tool Path for different Machining operations of small components using CNC Lathe & CNC Milling Machine.
CLO5	Use high end CAM packages for machining complex parts; use state of art cutting tools and related cutting parameters; optimize cycle time.
CLO6	Understand & write programs for Robotcontrol; understand the operating principles of hydraulics, pneumatics and electropneumatic systems. Apply this knowledge to automate & improve efficiency of manufacturing.

Scheme for Examination:

Two Questions from Part A - 60 Marks (30 +30)

Viva-Voce - 20 Marks

Total: 80 Marks

OPERATIONS RESEARCH

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Operations Research	15ME81	4	3-2-0	80	20	3 Hrs

Course objectives:

1. To enable the students to understand the scientific methods of providing various departments of an organization with a quantitative basis of decision making.
2. To enable the students to understand the importance of various tools and techniques in finding optimal solutions to problems involving limited resources in the form of Men, Materials and machinery.

MODULE -1

Introduction: Evolution of OR, Definitions of OR, Scope of OR, Applications of OR, Phases in OR study. Characteristics and limitations of OR, models used in OR,

Linear Programming Problem (LPP), Generalized LPP- Formulation of problems as L.P.P. Solutions to LPP by graphical method (Two Variables).

08 Hours

MODULE -2

LPP: Simplex method, Canonical and Standard form of LP problem, slack, surplus and artificial variables, Solutions to LPP by Simplex method, Big-M Method and Two Phase Simplex Method, Degeneracy in LPP. Concept of Duality, writing Dual of given LPP. Solutions to L.P.P by Dual Simplex Method.

12 Hours

MODULE -3

Transportation Problem: Formulation of transportation problem, types, initial basic feasible solution using North-West Corner rule, Vogel's Approximation method. Optimality in Transportation problem by Modified Distribution (MODI) method. Unbalanced T.P. Maximization T.P. Degeneracy in transportation problems, application of transportation problem.

Assignment Problem: Formulation, Solutions to assignment problems by Hungarian method, Special cases in assignment problems, unbalanced, Maximization assignment problems.

Travelling Salesman Problem (TSP). Difference between assignment and T.S.P, Finding best route by Little's method. Numerical Problems.

12 Hours

MODULE -4

Network analysis: Introduction, Construction of networks, Fulkerson's rule for numbering the nodes, AON and AOA diagrams; Critical path method to find the expected completion time of a project, determination of floats in networks, PERT networks, determining the probability of completing a project, predicting the completion time of project; Cost analysis in networks. Crashing of networks- Problems.

Queuing Theory: Queuing systems and their characteristics, Pure-birth and Pure-death models (only equations), Kendall & Lee's notation of Queuing, empirical queuing models – Numerical on M/M/1 and M/M/C Queuing models. 10 Hours

MODULE -5

Game Theory: Definition, Pure Strategy problems, Saddle point, Max-Min and Min-Max criteria, Principle of Dominance, Solution of games with Saddle point. Mixed Strategy problems. Solution of 2X2 games by Arithmetic method, Solution of 2Xn and mX2 games by graphical method. Formulation of games.

Sequencing: Basic assumptions, Johnson's algorithm, sequencing 'n' jobs on single machine using priority rules, sequencing using Johnson's rule-'n' jobs on 2 machines, 'n' jobs on 3 machines, 'n' jobs on 'm' machines. Sequencing of 2 jobs on 'm' machines using graphical method. 08 Hours

Course outcomes:

On completion of this subject, students will be able to:

1. Understand the meaning, definitions, scope, need, phases and techniques of operations research.
2. Formulate as L.P.P and derive optimal solutions to linear programming problems by graphical method, Simplex method, Big-M method and Dual Simplex method.
3. Formulate as Transportation and Assignment problems and derive optimum solutions for transportation, Assignment and travelling salesman problems.
4. Solve problems on game theory for pure and mixed strategy under competitive environment.
5. Solve waiting line problems for M/M/1 and M/M/K queuing models.
6. Construct network diagrams and determine critical path, floats for deterministic and PERT networks including crashing of Networks.
7. Determine minimum processing times for sequencing of n jobs-2 machines, n jobs-3 machines, n jobs-m machines and 2 jobs-n machines using Johnson's algorithm.

1. Operations Research, P K Gupta and D S Hira, S. Chand and Company LTD.

Publications, New Delhi – 2007

2. Operations Research, An Introduction, Seventh Edition, Hamdy A. Taha, PHI Private Limited, 2006.

REFERENCE BOOKS:

1. Operations Research, Theory and Applications, Sixth Edition, J K Sharma, Trinity Press, Laxmi Publications Pvt.Ltd. 2016.
2. Operations Research, Paneerselvan, PHI
3. Operations Research, A M Natarajan, P Balasubramani, Pearson Education, 2005
4. Introduction to Operations Research, Hillier and Lieberman, 8th Ed., McGraw Hill

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.

ADDITIVE MANUFACTURING

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Additive Manufacturing	15ME82	4	4-0-0	80	20	3 Hrs

Course Objectives:

Students will be able to

1. Understand the additive manufacturing process, polymerization and powder metallurgy process
2. Understand characterisation techniques in additive manufacturing.
3. Acquire knowledge on CNC and Automation.

Module 1

Introduction to Additive Manufacturing: Introduction to AM, AM evolution, Distinction between AM & CNC machining, Advantages of AM, **AM process chain:** Conceptualization, CAD, conversion to STL, Transfer to AM, STL file manipulation, Machine setup, build, removal and clean up, post processing.

Classification of AM processes: Liquid polymer system, Discrete particle system, Molten material systems and Solid sheet system.

Post processing of AM parts: Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non-thermal and thermal techniques.

Guidelines for process selection: Introduction, selection methods for a part, challenges of selection

AM Applications: Functional models, Pattern for investment and vacuum casting, Medical models, art models, Engineering analysis models, Rapid tooling, new materials development, Bi-metallic parts, Re-manufacturing. Application examples for Aerospace, defence, automobile, Bio-medical and general engineering industries

10 Hours

Module 2

System Drives and devices: Hydraulic and pneumatic motors and their features, Electrical motors AC/DC and their features

Actuators: Electrical Actuators; Solenoids, Relays, Diodes, Thyristors, Triacs, Hydraulic and Pneumatic actuators, Design of Hydraulic and Pneumatic circuits, Piezoelectric actuators, Shape memory alloys.

8 Hours

Module 3

POLYMERS & POWDER METALLURGY

Basic Concepts: Introduction to Polymers used for additive manufacturing: polyamide, PF resin, polyesters etc. Classification of polymers, Concept of functionality,

12 Hours

	<p>Polydispersity and Molecular weight [MW], Molecular Weight Distribution [MWD] Polymer Processing: Methods of spinning for additive manufacturing: Wet spinning, Dry spinning. Biopolymers, Compatibility issues with polymers. Moulding and casting of polymers, Polymer processing techniques General Concepts: Introduction and History of Powder Metallurgy (PM), Present and Future Trends of PM Powder Production Techniques: Different Mechanical and Chemical methods, Atomisation of Powder, other emerging processes.Characterization Techniques: Particle Size & Shape Distribution, Electron Microscopy of Powder, Interparticle Friction, Compression ability, Powder Structure, Chemical Characterization Microstructure Control in Powder: Importance of Microstructure Study, Microstructures of Powder by Different techniques Powder Shaping: Particle Packing Modifications, Lubricants & Binders, Powder Compaction & Process Variables, Pressure & Density Distribution during Compaction, Isotactic Pressing, Injection Moulding, Powder Extrusion, Slip Casting, Tape Casting. Sintering: Theory of Sintering, Sintering of Single & Mixed Phase Powder, Liquid Phase Sintering Modern Sintering Techniques, Physical & Mechanical Properties Evaluation, Structure-Property Correlation Study, Modern Sintering techniques, Defects Analysis of Sintered Components Application of Powder Metallurgy: Filters, Tungsten Filaments, Self-Lubricating Bearings, Porous Materials, Biomaterials etc.</p>	
Module 4		
	<p>NANO MATERIALS & CHARACTERIZATION TECHNIQUES: Introduction: Importance of Nano-technology, Emergence of Nanotechnology, Bottom-up and Top-down approaches, challenges in Nanotechnology Nano-materials Synthesis and Processing: Methods for creating Nanostructures; Processes for producing ultrafine powders- Mechanical grinding; Wet Chemical Synthesis of Nano-materials- sol-gel process; Gas Phase synthesis of Nano-materials- Furnace, Flame assisted ultrasonic spray pyrolysis; Gas Condensation Processing (GPC), Chemical Vapour Condensation(CVC). Optical Microscopy - principles, Imaging Modes, Applications, Limitations. Scanning Electron Microscopy (SEM) - principles, Imaging Modes, Applications, Limitations. Transmission Electron Microscopy (TEM) - principles, Imaging Modes, Applications, Limitations.X- Ray Diffraction (XRD) - principles, Imaging Modes, Applications, Limitations.Scanning Probe Microscopy (SPM) - principles, Imaging Modes, Applications, Limitations.Atomic Force Microscopy (AFM) - basic principles, instrumentation, operational modes, Applications, Limitations. Electron Probe Micro Analyzer (EPMA) - Introduction, Sample preparation, Working procedure, Applications, Limitations.</p>	10 Hours
Module 5		
	<p>MANUFACTURING CONTROL AND AUTOMATION CNC technology - An overview: Introduction to NC/CNC/DNC machine tools,</p>	10 Hours

	<p>Classification of NC /CNC machine tools, Advantage, disadvantages of NC /CNC machine tools, Application of NC/CNC Part programming: CNC programming and introduction, Manual part programming: Basic (Drilling, milling, turning etc.), Special part programming, Advanced part programming, Computer aided part programming (APT)</p> <p>Introduction: Automation in production system principles and strategies of automation, basic Elements of an automated system. Advanced Automation functions. Levels of Automations, introduction to automation productivity</p> <p>Control Technologies in Automation: Industrial control system. Process industry vs discrete manufacturing industries. Continuous vs discrete control. Continuous process and its forms. Other control system components.</p>	
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Course Outcomes

1. Understand the different process of Additive Manufacturing. using Polymer, Powder and Nano materials manufacturing.
2. Analyse the different characterization techniques.
3. Describe the various NC, CNC machine programing and Automation techniques.

TEXT BOOKS:

1. Chua Chee Kai, Leong Kah Fai, "Rapid Prototyping: Principles & Applications", World Scientific, 2003.
2. G Odian Principles of Polymerization, Wiley Inerscience John Wiley and Sons, 4th edition, 2005
3. Mark James Jackson, Microfabrication and Nanomanufacturing, CRC Press, 2005.
4. Powder Metallurgy Technology, Cambridge International Science Publishing, 2002.
5. P. C. Angelo and R. Subramanian: Powder Metallurgy- Science, Technology and Applications, PHI, New Delhi, 2008.
6. Mikell P Groover, Automation, Production Systems and Computer Integrated Manufacturing, 3rd Edition, Prentice Hall Inc., New Delhi, 2007.

REFERENCE BOOKS:

1. Wohler's Report 2000 - Terry Wohlers - Wohler's Association -2000
2. Computer Aided Manufacturing - P.N. Rao, N.K. Tewari and T.K. Kundra Tata McGraw Hill 1999
3. Ray F. Egerton , Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM , Springer, 2005.
4. P. C. Angelo and R. Subramanian: Powder Metallurgy- Science, Technology and Applications, PHI, New Delhi, 2008.

3. "Engineering Plasticity", W. Johnson and P. B. Mellor, Van Nostrand Co. Ltd 2000
4. Advanced Mechanics of solids, L. S. Srinath, Tata Mc. Graw Hill, 2009.

Green Manufacturing

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Green Manufacturing	15ME834	3	3-0-0	80	20	3 Hrs

COURSE OBJECTIVES

Students will be able to

1. Acquire a broad understanding of sustainable manufacturing, green product and process
2. Understand the analytical tools, techniques in green manufacturing
3. Understand the structures of sustainable manufacturing, environmental and management practice.

Module- 1

Introduction to Green Manufacturing

Why Green Manufacturing, Motivations and Barriers to Green Manufacturing, Environmental Impact of Manufacturing, Strategies for Green Manufacturing.

The Social, Business, and Policy Environment for Green Manufacturing

Introduction, The Social Environment—Present Atmosphere and Challenges for Green Manufacturing, The Business Environment: Present Atmosphere and Challenges, The Policy Environment—Present Atmosphere and Challenges for Green Manufacturing. **08Hrs**

Module- 2

Metrics for Green Manufacturing

Introduction, Overview of Currently Used Metrics, Overview of LCA Methodologies, Metrics Development Methodologies, Outlook and Research Needs.

Green Supply Chain

Motivation and Introduction, Definition, Issues in Green Supply Chains (GSC), Techniques/Methods of Green Supply Chain, Future of Green Supply Chain.

Principles of Green Manufacturing

Introduction, Background, and Technology Wedges, Principles, Mapping Five Principles to Other Methods and Solutions.

08Hrs

Module -3

Closed-Loop Production Systems

Life Cycle of Production Systems, Economic and Ecological Benefits of Closed-Loop Systems, Machine Tools and Energy Consumption, LCA of Machine Tools, Process Parameter Optimization, Dry Machining and Minimum Quantity Lubrication, Remanufacturing, Reuse, Approaches for Sustainable Factory Design.

Semiconductor Manufacturing

Overview of Semiconductor Fabrication, Micro fabrication Processes, Facility Systems, Green Manufacturing in the Semiconductor Industry: Concepts and Challenges, Use-Phase Issues with Semiconductors, Example of Analysis of Semiconductor Manufacturing. **08Hrs**

Module- 4

Environmental Implications of Nano-manufacturing

Introduction, Nano-manufacturing Technologies, Conventional Environmental Impact of Nano-manufacturing, Unconventional Environmental Impacts of Nano-manufacturing, Life Cycle Assessment (LCA) of Nanotechnologies.

Green Manufacturing Through Clean Energy Supply

Introduction, Clean Energy Technologies, Application Potential of Clean Energy Supplying Green Manufacturing **08Hrs**

Module- 5

Packaging and the Supply Chain: A Look at Transportation

Introduction, Background, Recommended Method to Determine Opportunities for Improved Pallet Utilization, Discussion.

Enabling Technologies for Assuring Green Manufacturing

Motivation, Process Monitoring System, Applying Sensor Flows in Decision Making: Automated Monitoring, Case Study.

Concluding Remarks and Observations about the Future

Introduction, Evolution of Manufacturing, Leveraging Manufacturing, Energy of Labor. **08Hrs**

COURSE OUTCOMES

1. Understand the basic design concepts, methods, tools, the key technologies and the operation of sustainable green manufacturing.
2. Apply the principles, techniques and methods to customize the learned generic concepts to meet the needs of a particular industry/enterprise.
3. Identify the strategies for the purpose of satisfying a set of given sustainable green manufacturing requirements.

Reference Books:

- 1.. Saaksvuori Antti / ImmonenAnselmie, product Life Cycle Management Springer,Dreamtech,3-540-25731-4
2. Product Lifecycle Management, Michael Grieves, Tata McGraw Hill

Internship/ Professional Practice

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Internship/ Professional Practice	15ME84	2	Industry Oriented	50	50	3 Hrs

Project Work, Phase II

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Project Work, Phase II	15MEP85	6	0-6-0	100	100	3 Hrs

Seminar

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Seminar	15MES86	1	0-4-0	100	-	-

I SEMESTER
ADVANCED THEORY OF VIBRATIONS
 (Common to MDE, MEA, MMD, CAE)

Course Code	18MDE12	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50(10 Hours per Module)	Exam Hours	03

Course Learning Objectives:

CL01	To understand the theoretical principles of vibration, and vibration analysis techniques for the practical solution of vibration problems.
CL02	To understand the importance of vibrations in design of machine parts subject to vibrations.
CL03	To understand the concepts of Transient and Non-linear vibrations.
CL04	To understand concepts of vibration measurements and its applications.
CL05	To understand the principles of Transient and Non linear vibrations.

Course Content:

Module

1: Review of Mechanical Vibrations: Basic concepts; free vibration of single degree of freedom systems with and without damping, forced vibration of single DOF-systems, Natural frequency. Vibration Control: Introduction, Vibration isolation theory, Vibration isolation and motion isolation for harmonic excitation, practical aspects of vibration analysis, vibration isolation, Dynamic vibration absorbers, and Vibration dampers **12 Hours**

Module

2:

Vibration Measurement and applications: Introduction, Transducers, Vibration pickups, Frequency measuring instruments, Vibration exciters, Signal analysis. Modal analysis & Condition Monitoring: Dynamic Testing of machines and Structures, Experimental Modal analysis, Machine Condition monitoring and diagnosis. **10 Hours**

Module

3: Transient Vibration of single Degree-

of freedom systems: Impulse excitation, arbitrary excitation, Laplace transform formulation, Pulse excitation and rise time, Shock response spectrum, Shock isolation.

Random Vibrations: Random phenomena, Time averaging and expected value, Frequency response function, Probability distribution, Correlation, Power spectrum and power spectral density, Fourier transforms and response. **10 Hours**

Module

4: Non Linear Vibrations: Introduction, Sources of nonlinearity, Qualitative analysis of nonlinear systems. Phase plane, Conservative systems, Stability of equilibrium, Method of isoclines, Perturbation method, Method of iteration, Self-excited oscillations. **10 Hours**

10 Hours

Module 5: Continuous Systems: Vibration of string, longitudinal vibration of rods, Torsional vibration of rods, Euler equation for beams.

08 Hours

Course Outcomes:

Upon completion of this course, students will be able to:

C01	Apply Newtons equation of motion and energy methods to model basic vibrating mechanical system, model undamped and damped mechanical systems and structures for free and harmonically forced vibrations.
C02	Model single-and multi-degree of freedom for free and forced vibrations and determine response to vibration, natural frequencies and modes of vibration.
C03	Apply the fundamentals of vibration to its measurement and analysis.
C04	Solve realistic vibration problems in mechanical engineering design that involves application of most of the course syllabus.

Text Books

1. S. S. Rao, “ Mechanical Vibrations” , Pearson Education, 4th edition.
2. S. Graham Kelly, “ Fundamentals of Mechanical Vibration” -McGraw-Hill, 2000
3. Theory of Vibration with Application, -William T. Thomson, Marie Dillon Dahleh, Chandramouli Padmanabhan, 5th edition Pearson Education.

Reference Books

1. S. Graham Kelly, “ Mechanical Vibrations” , Schaum’ s Outlines, Tata McGraw Hill, 2007.
2. C Sujatha, “ Vibrations and Acoustics – Measurements and signal analysis” , Tata McGraw Hill, 2010.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

DYNAMICS AND MECHANISM DESIGN
(Common to MDE, MEA, MMD)

Course Code	18MDE14	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50(10 Hours per Module)	Exam Hours	03

Course Learning Objectives:

CL01	To provide a theoretical and practical foundation for analysis and design of articulated mechanical systems for desired applications.
CL02	Develop skills to analyze the displacement, velocity, and acceleration of mechanisms.
CL03	Improve understanding of the synthesis of mechanisms for given tasks
CL04	To include dynamics considerations in the design of mechanisms for engineering applications.

Course Content:

Module

1: Geometry of Motion: Introduction, analysis and synthesis, Mechanism terminology, planar, Spherical and spatial mechanisms, mobility, Grashoff's law, Equivalent mechanisms, unique mechanisms.

Kinematic analysis of planar mechanisms: Auxiliary point method using rotated velocity vector, Hall - Ault auxiliary point method, Goodman's indirect method. Numerical examples.

08 Hours

Module

2: Generalized Principles of Dynamics: Fundamental laws of motion, generalized coordinates, configuration space, constraints, virtual work, principle of virtual work, energy and momentum, work and kinetic energy, and stability, kinetic energy of a system, angular momentum, generalized momentum.

Lagrange's Equation: Lagrange's equation from D'Alembert's principles, examples, Hamilton equations, Hamilton's principle, Lagrange's equation from Hamilton's principle, Derivation of Hamilton equations, numerical examples.

12 Hours

Module 3: Synthesis of Linkages: Type, number, and dimensional synthesis, function generation, path generation and body guidance, precision positions, structural error, Chebychev spacing. Two position synthesis of slider crank mechanisms, crank-rocker mechanisms with optimum transmission angle.

Motion Generation: Poles and relative poles, Location of poles and relative poles, polode, curvature, Inflection circle, numerical examples.

10 Hours

Module

4: Graphical Methods of Dimensional Synthesis: Two position synthesis of crank and rocker mechanisms, three position synthesis, four position synthesis (point precision reduction), Overlay method, Coupler curves synthesis, Cognate linkages.

Analytical Methods of

Dimensional Synthesis: Freudenstein's equation for four bar mechanism and slider crank mechanism, exa

mples, Bloch's method of synthesis, analytical synthesis using complex algebra.

12 Hours

Module 5:

System Dynamics: Gyroscopic action in machines, Euler's equation of motion, Phase Plane representation, Phase plane Analysis, Response of Linear System to transient disturbances.

Spatial Mechanisms: Introduction, Position analysis problem, Velocity and acceleration analysis, Eulerian angles, numerical examples.

08 Hours

Course Outcomes:

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

C01	Apply the tools of analytical dynamics with the main goal of developing mathematical models that describe the dynamics of systems of rigid bodies.
C02	Formulate equations of motion for complicated mechanical systems / linkages and methods for solving these equations.
C03	Understand multi body dynamics in mechanical engineering design.

Text Books:

1. K.J. Waldron & G.L. Kinzel, "Kinematics, Dynamics and Design of Machinery", Wiley India, 2007.
2. Greenwood, "Classical Dynamics", Prentice Hall of India, 1988.

References Books:

1. J E Shigley, "Theory of Machines and Mechanism" - McGraw-Hill, 1995
2. A.G. Ambekar, "Mechanism and Machine Theory", PHI, 2007.
3. Ghosh and Mallick, "Theory of Mechanism and Mechanism", East West press 2007.
4. David H. Myszka, "Machines and Mechanisms", Pearson Education, 2005.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

FRACTURE MECHANICS
(Common to MDE, MEA, MMD)

Course Code	18MDE15	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50(10 Hours per Module)	Exam Hours	03

Course Learning Objectives:

CL01	To understand the design principle of materials and structures using fracture mechanics approaches.
CL02	To introduce the mathematical and physical principles of fracture mechanics and their applications to engineering design.
CL03	To develop the ability in students to compute the stress intensity factor, strain energy release rate and the stress and strain fields around a crack tip for linear and non linear materials.
CL04	To prepare the students for broader applications of fracture mechanics in material testing, evaluation, characterization, and material selection.

Course Content:

Module 1: Fracture mechanics principles: Introduction and historical review, sources of

micro and macro cracks. stress concentration due to elliptical hole, strength ideal materials, Griffith's energy balance approach. Fracture mechanics approach to design. NDT and Various NDT methods used in fracture mechanics, numerical problems. The Airy stress function, complex stress function, solution to crack problems, effect of finite size, special cases, elliptical cracks, numerical problems.

10 Hours

Module 2: Plasticity effects, Irwin plastic zone correction, and Dugdale approach. The shape of the plastic zone for plane stress and plane strain cases, plastic constraint factor. The thickness effect, and numerical problems.

Determination of stress intensity factors and plane strain fracture toughness: Introduction, analysis and numerical methods, experimental methods, estimation of stress intensity factors.

Plane strain fracture toughness test; standard test, and specimen size requirements.

10 Hours

Module 3: The energy release rate, and criteria for crack growth. The crack resistance (R curve), compliance, J integral, tearing modulus and stability.

Elastic Plastic Fracture Mechanics (EPFM): Fracture beyond general yield. The crack-tip opening displacement, the use of CTOD criteria, and experimental determination of CTOD. Parameters affecting the critical CTOD, use of J integral, and limitation of J integral.

10 Hours

Module 4: Dynamics and crack arrest: Crack speed and kinetic energy. Dynamic stress intensity and elastic energy release rate. Crack branching. Principles of crack arrest. Crack arrest in practice. Dynamic fracture toughness.

10 Hours

Module 5: Fatigue crack propagation and applications of fracture mechanics: Crack growth and the stress intensity factor. Factors affecting crack propagation. Variable amplitude service loading, means to provide fail-safety, required information for fracture mechanics approach, mixed mode (combined) loading and design criteria.

10 Hours

Course Outcomes:

At the end of the course students will:

C01	Develop basic fundamental understanding of the effects of crack like defects on the performance of aerospace, civil, and mechanical engineering structures.
C02	Be able to select appropriate materials for engineering structures to insure damage tolerance.
C03	Learn to employ modern numerical methods to determine critical crack sizes and fatigue crack propagation rates in engineering structures.

C04	Understand the relationship between crack tip opening displacement, SIF and ERR and application of such parameters for ductile and brittle materials.
C05	Understanding of experimental techniques to determine the critical values of parameters at crack tip.
C06	Understand and appreciate of the status of academic research in field of fracture mechanics.

Text Books:

1. David Broek, "Elementary Engineering Fracture Mechanics", Springer Netherlands, 2011
2. Anderson, "Fracture Mechanics-Fundamental and Application", T.L CRC press 1998.

Reference Books:

1. Karen Hellan, "Introduction to fracture mechanics", McGraw Hill, 2nd Edition
2. S.A. Meguid, "Engineering fracture mechanics" Elsevier Applied Science, 1989
3. Jayatilaka, "Fracture of Engineering Brittle Materials", Applied Science Publishers, 1979
4. Rolfe and Barsom, "Fracture and Fatigue Control in Structures", Prentice Hall, 1977
5. Knott, "Fundamentals of fracture mechanisms", Butterworths, 1973

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

DESIGN LABORATORY-I
(Common to MDE, MEA, MMD)

Course Code	18MDEL16	CIE Marks	40
Number of Practical Hours/Week	04	SEE Marks	60
Total Number of Hours	50	Exam Hours	03

Note:

1. These are independent laboratory exercises.
2. Student must submit a comprehensive report on the problems solved and give a presentation on the same for Internal Evaluation.
3. Any one of the experiments done from the following list has to be set in the examination for conduction and evaluation.

Experiment #1

Experimental and Numerical Analysis of Tensile Test
Part A: Experimental study of Tensile Test
Part B: Numerical Analysis of Tensile Test.

Experiment #2

Experimental and Numerical Analysis of Flexural Test

Part A: Experimental study of Flexural Test

Part B: Numerical Analysis of Flexural Test.

Experiment #3

Numerically Calculation and MATLAB Simulation

Part A: Invariants, Principal stresses and strains with directions

Part A: Maximum shear stresses and strains and planes, Von-Mises stress

Part C: Calculate and Plot Stresses in Thick-Walled Cylinder

Experiment #4

Stress analysis of rectangular plate with circular hole under i. Uniform Tension and ii. shear Part A: Matlab simulation for Calculation and Plot of normalized hoop Stress at hole boundary in Infinite Plate

Part B: Modeling of plate geometry under chosen load conditions and study the effect of plate geometry.

Part C: Numerical Analysis using FEA package.

Experiment #5

Single edge notched beam in four point bending.

Part A: Modeling of single edge notched beam in four point bending.

Part B: Numerical Studies using FEA.

Part C: Correlation Studies.

Experimental #6

Torsion of Prismatic bar with Rectangular cross-section.

Part A: Elastic solutions, MATLAB Simulation

Part B: Finite Element Analysis of any chosen geometry. Part C: Correlation studies.

Experiment #7

Contact Stress Analysis of Circular Disc under diametrical compression

Part A: 3-D Modeling of Circular Discs with valid literature background, supported with experimental results on contact stress.

Part B: Numerical Analysis using any FEA package.

Part C: 2D Photo Elastic Investigation.

Experiment #8

Vibration Characteristics of a Spring Mass Damper System.

Part A: Analytical Solutions.

Part B: MATLAB Simulation. Part C: Correlation Studies.

II Semester
FINITE ELEMENT METHOD
(Common to MDE, MEA, MMD, CAE)

Course Code	18MEA21	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50(10 Hours per Module)	Exam Hours	03

Course Learning Objectives:

CL01	To present the Finite element method (FEM) as a numerical method for engineering analysis of continua and structures.
CL02	To present Finite element formulation using variational and weighted residual approaches.
CL03	To present Finite elements for the analysis of bars & trusses, beams & frames, plane stress & plane strain problems and 3-D solids, for thermal and dynamics problems.
CL04	Learn to model complex geometry problems and technique of solutions.

Course Content:

Module 1: Introduction to finite element method: basic steps in finite element method to solve mechanical engineering problems (solid, fluid and heat transfer). Functional approach and Galerkin approach. Displacement approach: admissible functions. Convergence criteria: conforming and nonconforming elements, C0, C1 and Cn continuity elements. Basic equations, element characteristic equations, assembly procedure, boundary and constraint conditions.

10 Hours.

Module 2: Solid Mechanics: One-dimensional finite element formulations and analysis – bars- uniform, varying and stepped cross section. Basic (Linear) and higher order elements formulations for axial, torsional and temperature loads with problems.

Beams- basic (linear) element formulation-for uniform, varying and stepped cross section-for different loading and boundary conditions, numericals.

Trusses, Plane frames and Space frame – basic (Linear) elements formulations for different boundary conditions -axial, bending, torsional, and temperature loads, numericals.

10 Hours.

Module 3: Two dimensional finite element formulations for solid mechanics problems: triangular membrane (tria 3, tria 6, tria 10) element, fournoded quadrilateral membrane (quad 4, quad 8) element formulations for in-plane loading with simple problems.

Triangular and quadrilateral axi-symmetric basic and higher order elements formulation for axi-symmetric loading with simple numericals.

Three dimensional finite element formulations for solid mechanics problems: finite element formulation of tetrahedral element (tet 4, tet 10), hexahedral element (hexa 8, hexa 20), for different loading conditions. Serendipity and Lagrange family elements.

10 Hours.

Module 4: Finite element formulations for structural mechanics problems: Basics of plates and shell theories: classical thin plate theory, shear deformation theory and thick plate theory. Finite element formulations for triangular and quadrilateral plate elements. Finite element formulation of flat, curved, cylindrical and conical shell elements.

10 Hours.

Module 5: Dynamic analysis: finite element formulation for point/lumped mass and distributed masses system, finite element formulation of one dimensional dynamic analysis: bar, truss, frame and beam element. Finite element formulation of two dimensional dynamic analysis: triangular membrane and axi-symmetric element, quadrilateral membrane and axi-symmetric element. Evaluation of eigen values and eigen vectors applicable to bars, shaft, beams, plane and space frame.

10 Hours.

Course Outcomes:

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

C01	Understand the concepts of Variational methods and Weighted residual methods.
C02	Identify the application and characteristics of FEA elements such as bars, beams, plane and isoparametric elements, and 3D element.
C03	Develop element characteristic equations and generate global stiffness equations.
C04	Apply suitable boundary conditions to a global structural equation, and reduce it to a solvable form.
C05	Identify how the finite element method expands beyond the structural domain, for problems involving dynamics and heat transfer.

Text Books:

1. T. R. Chandrupatla and A. D. Belegundu, Introduction to Finite Elements in Engineering, Prentice Hall, 3rd Ed, 2002.
2. Lakshminarayana H. V., Finite Elements Analysis– Procedures in Engineering, Universities Press, 2004.

Reference Books:

1. Rao S. S, Finite Elements Method in Engineering- 4th Edition, Elsevier, 2006
2. P.Seshu, Textbook of Finite Element Analysis, PHI, 2004.
3. J.N.Reddy, Introduction to Finite Element Method, mcgraw -Hill, 2006.
4. Bathe K. J, Finite Element Procedures, Prentice-Hall, 2006..
5. Cook R. D., Finite Element Modeling for Stress Analysis, Wiley,1995.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

ADVANCED MACHINE DESIGN

(Common to MDE, MEA, MMD, CAE)

Course Code	18MDE22	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50(10 Hours per Module)	Exam Hours	03

Course Learning Objectives:

CL01	To identify failure modes and evolve design by analysis methodology.
CL02	To understand the theories of failure relating to different ductile and brittle materials.
CL03	To understand the concept of fatigue testing of materials including criteria for fatigue design and different fatigue life models.
CL04	To understand the concepts of the stress life behavior, strain life behavior and factors influencing stress life behavior and strain life behavior.
CL05	To understand the concept of crack nucleation, crack growth and fracture of materials using fundamentals of linear elastic fracture mechanics.
CL06	To gain the knowledge of various cumulative damage theories and different cycle counting methods relating to fatigue from variable amplitude loading.
CL07	To understand the different surface failure mechanisms with stress distribution of various contact surfaces.
CL08	To learn fundamental approaches to failure prevention for static and repeated loading.

Course Content:**Module****1:**

Introduction: Role of failure prevention analysis in mechanical design, Modes of mechanical failure, Review of failure theories for ductile and brittle materials including Mohr's theory and modified Mohr's theory. Numerical examples.

Fatigue of Materials: Introductory

concepts, High cycle and low cycle fatigue, Fatigue design models, Fatigue design methods, Fatigue design criteria, Fatigue testing, Test methods and standard test specimens, Fatigue fracture surfaces and macroscopic features, Fatigue mechanisms and microscopic features.

10 Hours

Module 2: Stress-Life (S-N) Approach: S-N curves, Statistical nature of fatigue test data, General S-N behavior, Mean stress effects, Different factors influencing S-N behaviour, S-N curve representation and approximations, Constant life diagrams, Fatigue life estimation using S-N approach.

Strain-Life (ϵ -N) approach: Monotonic

stress-strain behavior

, Strain controlled test methods, Cyclic stress-strain behavior, Strain based approach to life estimation, Determination of strain life fatigue properties, Mean stress effects, Effect of surface finish, Life estimation by ϵ -N approach.

10 Hours

Module

3: LEFM Approach: LEFM concepts, Crack tip plastic zone, Fracture toughness, Fatigue crack growth, Mean stress effects, Crack growth life estimation.

Notches and their effects: Concentrations and gradients in stress and strain, S-N approach for notched membranes, mean stress effects and Haigh diagrams, Numerical examples.

10 Hours

Module

4:

Fatigue from Variable Amplitude Loading: Spectrum loads and cumulative damage, Damage quantification and the concepts of damage

fraction and accumulation, Cumulative damage theories, Load interaction and sequence effects, Cycle counting methods, Life estimation life approach. Numerical examples using stress

examples.

Notch strain analysis: Strain– life approach, Neuber’s rule, Glinka’s rule, applications of fracture mechanics to crack growth at notches. Numerical examples. **10 Hours**

Module

5: Surface Failure: Introduction, Surface geometry, Mating surface, Friction, Adhesive wear, Abrasive wear, Corrosion wear.

Surface fatigue: spherical contact, Cylindrical contact, General contact, Dynamic contact stresses, Surface fatigue strength, Surface fatigue failure modes, Design to avoid Surface failures. **10 Hours**

Course Outcomes:

Upon completion of this course, students will be able to:

C01	Apply state of the art design methodology namely design by analysis and damage tolerant design to mechanical components.
C02	Distinguish different design criteria and their procedure to carry out the design of mechanical components.
C03	Design machine components which are subjected to fluctuating loads.
C04	Design machine components using techniques like stress life approach, Strain life approach and Fracture mechanics approach.
C05	Define the various statistical aspects of fatigue using different probability distribution plots.
C06	Explain the contact stresses and implementation of Hertz contact phenomenon to the real field problem.
C07	Explain surface failure mechanisms.

Text Books:

1. Ralph I. Stephens, Ali Fatemi, Robert, Henryo. Fuchs, “Metal Fatigue in engineering”, John Wiley New York, Second edition. 2001.
2. Failure of Materials in Mechanical Design, Jack.A. Collins, John Wiley, New York 1992.

Company, 2000.

Reference Books:

1. Dudley D.Fulier " Theory and practice of Lubrication for Engineers", New York Company.1998
2. Moore "Principles and applications of Tribology", Pergamon press, 1975.
3. Oscar Pinkus, BenoSternlicht, "Theory of hydrodynamic lubrication", McGraw-Hill, 1961.
4. G W Stachowiak, A W Batchelor , "Engineering Tribology", Elsevier publication 1993.
5. Hydrostatic and hybrid bearings, Butterworth 1983.
6. F. M. Stansfield, Hydrostatic bearings for machine tools and similar applications, Machinery Publishing, 1970.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

**PROFESSIONAL ELECTIVE 1
MATERIAL HANDLING EQUIPMENT DESIGN
(Common to MDE, MEA, MMD)**

Course Code	18MDE241	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50(10 Hours per Module)	Exam Hours	03

Course Learning Objectives:

This subject provides students with:

A basic understanding of material handling facilities and the fundamental principles of material handling;

A quantitative techniques for designing material handling systems and an understanding of their limitations;

An understanding of safety issues and regulations in material handling.

Module 1: Introduction: Elements of Material Handling System, Importance, Terminology, Objectives and benefits of better Material Handling; Principles and features of Material Handling System; Interrelationships between material handling and plant layout, physical facilities and other organizational functions; Classification of Material Handling Equipment.

Selection of Material Handling Equipment: Factors affecting for selection; Material Handling Equation; Choices of Material Handling Equipment; General analysis Procedures; Basic Analytical techniques; The unit load concept; Selection of suitable types of systems for applications ; Activity cost data and economic analysis for design of components of Material Handling Systems; functions and parameters affecting service; packing and storage of materials. **10 Hours**

Module 2: Conveyor Design: Introduction to apron conveyors, Pneumatic conveyors, Belt Conveyors, Screw conveyors and vibratory conveyors and their applications, Design of Belt conveyor-Belt selection procedure and calculation of drop energy, Idler design.

10 Hours

Module 3: Design of hoisting elements: Welded and roller chains -Hemp and wire ropes - Design of ropes, pulleys, pulley systems, sprockets and drums, Load handling attachments. Design of forged hooks and eye hooks – crane grabs-lifting magnets - Grabbing attachments -Design of arresting gear -Brakes: shoe, band and cone types

10 Hours

Module 4: Design of cranes: Hand-propelled and electrically driven E.O.T overhead Traveling cranes; Traveling mechanisms of cantilever and monorail cranes; design considerations for structures of rotary cranes with fixed radius ; fixed post and overhead traveling cranes; Stability of stationary rotary and traveling rotary cranes.

10 Hours

Module 5: Design of Bucket Elevators: Introduction, Types of Bucket Elevator, Design of Bucket Elevator - loading and bucket arrangements, Cage elevators , shaft way, guides, counter weights.

Packaging and storage of bulk materials:Steps for design of packages, protective packaging, testing the physical characteristics of packaging, container testing, types of storage and industrial containers, Automatic guided vehicles, Automatic storage and retrieval system. **10 Hours**

Course Outcomes:

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

C01	Select appropriate equipment for material handling and understand the basic roles of the different equipment.
C02	Apply appropriate techniques for improving existing material handling systems; recognize the importance of safety and applications of optimization techniques to material handling.

Reference Books:

1. Conveyor Equipment Manufacturer' s Association, “ Belt conveyors for bulk materials” 6th edition,The New CEMA Book
2. Rudenko N., “ Materials handling equipment ” , Elnvee Publishers, 1970
3. Ishwar G Mulani and Mrs.Madhu I Mulani, “ Engineering Science and application design for belt conveyor” , Madhu I. Mulani, 2002.
4. Spivakovsy A.O. and Dyachkov V.K., “ Conveying Machines, Volumes I and II” , MIR Publishers, 1985.
5. Alexandrov, M., “ Materials Handling Equipments ” , MIR Publishers, 1981.
6. Boltzharol, A., “ Materials Handling Handbook” , The Ronald press company 1958.
7. Kulwiac R. A., ‘Material Handling Hand Book’ , 2nd edition, JohnWilly Publication, NewYork.
8. James M. Apple, ‘ Material Handling System Design’ , John-Willlwy and Sons Publication, NewYork.

Scheme of Examination:

PROFESSIONAL ELECTIVE 2

DESIGN OPTIMIZATION

(Common to MDE, MEA, MMD, CAE)

Course Code	18CAE251	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50(10 Hours per Module)	Exam Hours	03

Course Learning Objectives:

CL01	To understand the fundamentals of optimisation methods and their applications to manufacturing process and product design.
CL02	To learn optimisation models including design objectives, constraints and variables.
CL03	To learn appropriate optimisation techniques and programs.
CL04	To understand the limitations of solutions obtained from optimisation, and to use optimal design tools/software.

Course Content:

Module

1:Engineering Design Practice: Evolution of Design Technology, Introduction to Design and the Design Process, Design versus Analysis, Role of Computers in Design Cycle, Impact of CAE on Design, Numerical Modeling with FEA and Correlation with Physical Tests.

Applications of Optimization in Engineering Design: Automotive, Aerospace and General Industry Applications, Optimization of Metallic and Composite Structures, Minimization and Maximization Problems, MDO and MOO. **10 Hours**

Module**2:**

Optimum Design Problem Formulation: Types of Optimization Problems, The Mathematics of Optimization, Design Variables and Design Constraints, Feasible and infeasible Designs, Equality and Inequality Constraints, Discrete and Continuous Optimization, Linear and NonLinear Optimization.

Optimization Theory–

Fundamental Concepts, Global and Local Minimum, Gradient Vector and Hessian Matrix, Concept of Necessary and Sufficient Conditions, Constrained and Unconstrained Problems, Lagrange Multipliers and Kuhn Tucker Conditions.

10 Hours

Module 3: Sensitivity Analysis: Linear and NonLinear Approximations. Gradient Based Optimization Methods– Dual and Direct.

Optimization Disciplines: Conceptual Design Optimization and Design Fine Tuning, Combined Optimization, Optimization of Multiple Static and Dynamic Loads, Transient Simulations, Equivalent Static Load Methods. Internal and External Responses, Design Variables in Each Discipline.

10 Hours**Module**

4: Manufacturability in Optimization Problems: Design For Manufacturing, Manufacturing Methods and Rules, Applying Manufacturing Constraints to Optimization Problems.

Design Interpretation: Unbound Problems, Over Constrained Problems, Problems with No or Multiple Solutions, Active and Inactive Constraints, Constraint Violations and Constraint Screening, Design Move Limits, Local and Global Optimum.

10 Hours

Module 5: Dynamic Programming: Introduction, Multistage decision processes, Principle of optimality, Computational Procedure in dynamic programming, Initial value problem, Examples.

10 Hours**Course Outcomes:**

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

C01	Identify and apply relevant problem solving methodologies.
C02	Design components, systems and/ or processes to meet required specification.
C03	Optimize an existing design with single or multiple objective functions.
C04	Apply decision-making methodologies to evaluate solutions for efficiency, effectiveness and sustainability.

Text Books:

1. S.S.Rao, Engineering Optimization: Theory and Practice, John Wiley, 2009
2. Jasbir Arora, Introduction to Optimum Design, McGraw Hill, 2011.

Reference Books:

1. Optimisation and Probability in System Engg-Ram, Van Nostrand.
2. Optimization methods -K. V. Mital and C. Mohan, New age International Publishers,

2D and 3D examples.Heat and Mass transfer Problems; Multi Phase Flows. **10 Hours**

Course Outcomes:

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

C01	Understand the process of developing a geometrical model of the flow, applying appropriate boundary conditions, specifying solution parameters, and visualising and analysing the results.
C02	Apply CFD analysis to real engineering designs.

Text Books:

1. Computational Methods for Fluid Dynamics, 3rd edition - J.H. Ferziger& M. Peric, Springer, 2002.
2. Numerical Solutions of Partial Differential Equations, Finite Difference methods, 3rd ed., G.D. Smith, Oxford University Press. 1986.

Reference Books:

1. Computational Fluid Dynamics - T. J. Chung, Cambridge Univ. Press, 2002.
2. Partial Differential Equations for Scientists and Engineers - Farlow, John Wiley, 1982.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

**Design Laboratory -Lab2
(Common to MDE, MEA, MMD)**

Course Code	18MDEL26	CIE Marks	40
Number of Practical Hours/Week	04	SEE Marks	60
Total Number of Hours	50	Exam Hours	03

Note:

1. These are independent laboratory exercises.
2. Student must submit a comprehensive report on the problems solved and give a presentation on the same for Internal Evaluation.
3. Any one of the experiments done from the following list has to be set in the examination for conduction and evaluation.

Course Content:

Experiment #1

Structural Analysis

Part A: FE Modeling of a stiffened Panel using a commercial preprocessor.

Part B: Buckling, Bending and Modal analysis of stiffened Panels.

Part C: Parametric Studies.

Experiment #2

Design Optimization

Part A: Shape Optimization of a rotating annular disk.

Part B: Weight Minimization of a Rail Car Suspension Spring.

Part C: Topology Optimization of a Bracket.

Experiment #3

Thermal analysis

Part A: Square Plate with Temperature Prescribed on one edge and Opposite edge insulated.

Part B: A Thick Square Plate with the Top Surface exposed to a Fluid at high temperature, Bottom Surface at room temperature, Lateral Surfaces Insulated.

Experiment #4

Thermal Stress Analysis

Part A: A Thick Walled Cylinder with specified Temperature at inner and outer Surfaces. Part

B: A Thick Walled Cylinder filled with a Fluid at high temperature and Outer Surface exposed to atmosphere.

Experiment#5

CFD Analysis

Part A: CFD Analysis of a Hydro Dynamic Bearing using commercial code.

Part B: Comparison of predicted Pressure and Velocity distributions with Target solutions.

Part C: Experimental Investigations using a Journal Bearing Test Rig.

Part D: Correlation Studies.

Experiment #6

Welded Joints.

Part A : Fabrication and Testing.

Part B : FE Modeling and Failure Analysis .

Part C : Correlation Studies.

Experiment #7

Bolted Joints.

Part A : Fabrication and Testing.

Part B : FE Modeling and Failure Analysis .

Part C : Correlation Studies.

Experiment #8

Adhesive Bonded Joints.

Part A : Fabrication and Testing.

Part B : FE Modeling and Failure Analysis .

Part C : Correlation Studies.

III Semester
DESIGN FOR MANUFACTURE AND ASSEMBLY
 (Common to MDE, MEA, MMD)

Course Code	18MDE31	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50(10 Hours per Module)	Exam Hours	03

Course Learning Objectives:

CL01	To understand various general design rules for manufacturability and criteria for material selection
CL02	To study various machining process and tolerance aspects in machining.
CL03	To know the design considerations for casting, forging and welding process.
CL04	To study the general design guidelines for manual assembly and development of DFA Methodology.

Course Content:

Module 1: Effect of Materials And Manufacturing

Process On Design: Major phases of design. Effect of material properties on design. Effect of manufacturing processes on design. Material selection process-

cost per unit property, Weighted properties and limits on properties methods.

Tolerance Analysis: Process capability, mean, variance, skewness, kurtosis, Process capability metrics, Cp, Cpk, Cost aspects, Feature tolerances relevant to manufacturing and assembly,

tolerance stacks, effects on assembly, methods of eliminating tolerance stacks, Geometrical tolerances, Geometric tolerances, Surface finish, Review of relationship between attainable tolerance grades and different machining process. Cumulative effect of tolerance - Sure fit law and truncated normal law

10 Hours

Module 2: Selective Assembly: Interchangeable part manufacture and selective assembly, Deciding the number of groups - Model-1 : Group tolerance of mating parts equal, Model total and group tolerances of shaft equal. Control of axial play - Introducing secondary machining operations, Laminated shims, examples. Datum Features: Functional datum, Datum for manufacturing, Changing the datum. Examples.

10 Hours

Module

3: Design Considerations: Design of components with casting consideration. Pattern, Mould, and Parting line. Cored holes and Machined holes. Identifying the possible and probable parting line. Casting requiring special sand cores. Designing to obviate sand cores. Welding considerations: requirements and rules, redesign of components for welding; case studies.

Component Design: Component design with machining considerations link design for turning components - milling, Drilling and other related processes including finish-machining operations

12 Hours

Module 4: Forging considerations - Requirements and rules - Redesign of components for forging and Case studies.

True positional theory : Comparison between co-ordinate and convention method of feature location. Tolerance and true position tolerancing, virtual size concept, floating and fixed fasteners. Projected tolerance zone. Assembly with gasket, zero position tolerance. Functional gauges, and Paper layout gauging

10 Hours

Module 5: Approaches to design for assembly - Qualitative evaluation procedures, knowledge based approach, Computer aided DFA methods. Assemblability measures. Boothroyd-Dewhurst DFA method - Redesign of a simple product - Case studies. **08 Hours**

Course Outcomes:

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

C01	Describe the different types of manufacturing systems and compare their suitability for economic production of various components and products.
C02	Identify factors and causing mechanisms of the defects likely to occur with different manufacturing processes in producing mechanical products and the relevant design approaches to rectify them.
C03	Select proper materials and manufacturing processes for designing products/components by applying the relevant principles for ease and economic

production.

Reference Books:

1. Harry Peck, "Designing for Manufacturing", Pitman Publications, 1983.
2. Dieter, "Machine Design" - McGraw-Hill Higher Education, -2008
3. R.K. Jain, "Engineering Metrology", Khanna Publishers, 1986
4. Product design for manufacture and assembly - Geoffrey Boothroyd, Peter Dewhurst, Winston Knight, Mercel Dekker. Inc. CRC Press, Third Edition
5. Material selection and Design, Vol. 20 - ASM Handbook.
6. Alan Redford and Chal, (1994) Design for Assembly - Principles and Procedures. McGraw Hill International.
7. James G. Bralla, (1986) Hand Book of Product Design for Manufacturing. McGraw Hill Co

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

**PROFESSIONAL ELECTIVE 3
EXPERIMENTAL MECHANICS
(Common to MDE, MEA, MMD, CAE)**

Course Code	18CAE321	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50(10 Hours per Module)	Exam Hours	03

Course Learning Objectives:

CL01	To introduce the concepts of dynamic measurements and analysis of experimental data.
CL02	To expose them to the techniques of Data Acquisition, Signal conditioning and processing.
CL03	To introduce students to different aspects of measuring deformation, strains, and stresses for developing a mechanistic understanding of both the material and the structure behavior.
CL04	To familiarize the student with state-of-the-art experimental techniques employing strain gauges, photoelasticity, Moiré interferometry, brittle coating, Moiré fringes and holography.

Course Content:

Module

1: Introduction: Definition of terms, calibration, standards, dimension and units, generalized meas

measurements, system response, distortion, impedance matching, experiment planning.

Analysis of Experimental Data: Cause and types of experimental errors, error analysis. Statistical analysis of experimental data - probability distribution, Gaussian, Normal distribution. Chi-square test, method of least square, correlation coefficient, multivariable regression, standard deviation of mean, graphical analysis and curve fitting, general consideration in data analysis.

10 Hours

Module 2: Data Acquisition and Processing: General data acquisition system, signal conditioning revisited, data transmission, Analog-to-Digital and Digital-to-Analog conversion. Basic components (storage and display) of data acquisition system. Computer program as a substitute for wired logic.

Force, Torque and Strain Measurement: Mass balance measurement, elastic element for force measurement, torque measurement. Strain gages - gages - strain sensitivity of gage metals, gage construction, gage sensitivity and gage factor, performance characteristics, environmental effects, Strain gage circuits, Potentiometer, Wheat Stone's bridges, Constant current circuits. Strain analysis methods - two element and three element, rectangular and delta rosettes, correction for transverse strain effects, stress gage - plane shear gage, stress intensity factor gage.

10 Hours

Module 3: Stress Analysis: Two Dimensional Photoelasticity - nature of light, - wave theory of light, - optical interference - Polariscopes stress optic law effect of stressed model in plane and circular polariscopes, Isoclinics, Isochromatics fringe order determination - Fringe multiplication techniques - Calibration photoelastic model materials. Separation methods - shear difference method, Analytical separation methods, Model to prototype scaling

10 Hours

Module 4: Three Dimensional Photoelasticity: Stress freezing method, General slice, Effective stresses, Stress separation, Shear deference method, Oblique incidence method, secondary principal stresses, scattered light photoelasticity, Polariscopes and stress data analyses.

10

Hours

Module 5: Coating Methods: a) Photoelastic Coating Method - Birefringence coating techniques, Sensitivity Reinforcing and thickness effects - data reduction - Stress separation techniques, Photoelastic strain gauges.

b) Brittle Coatings Method: Brittle coating technique Principles data analysis - coating materials, Coating techniques.

c) Moire Technique - Geometrical approach, Displacement approach - sensitivity of Moire data reduction, In plane and out plane Moire methods, Moire photography, Moire grid production.

Holography: Introduction, Equation for plane waves and spherical waves, Intensity, Coherence, Spherical radiator as an object (record process), Hurter, Driffeld curves, Reconstruction process, Holographic interferometry, Realtime and double exposure methods, Displacement measurement, Isopachics.

10 Hours

Course Outcomes:

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

	Mount strain gages, take measurements and analyze the obtained data.
	Design strain gage-based transducers for measuring specific loads.
	Describe the different methods photo elasticity for strain measurement viz, stress freezing , and Moirés method.
	Undertakeexperimentalinvestigationstoverifypredictionsbyothermethods.
	Apply the principles and techniques of brittle coating analysis.
	Apply the principles and techniques of holographic interferometry.

C01

C02

C03

C04

C05

C06

TextBooks:

- 1 . Holman,“ ExperimentalMethodsforEngineers” 7th Edition,TataMcGraw-Hill Companies,Inc,NewYork,2007.
- 2 . R.S.Sirohi,H.C.RadhaKrishna,“ Mechanicalmeasurements” NewAgeInternational Pvt.Ltd.,NewDelhi,2004
3. ExperimentalStressAnalysis- Srinath,Lingaiah,Raghavan,Gargesa,Ramachandraand Pant,TataMcGrawHill,1984.
4. Instrumentation,MeasurementAndAnalysis-Nakra&Chaudhry,BCNakraKKChaudhry, TataMcGraw-HillCompanies,Inc,NewYork, SeventhEdition,2006.

ReferenceBooks:

1. MeasurementSystemsApplicationandDesign- DoebelinE.A.,4th(S.I.)Edition,McGrawHill,NewYork.1989
2. DesignandAnalysisofExperiments- MontgomeryD.C.,JohnWiley&Sons,1997.
3. ExperimentalStressAnalysis-DallyandRiley,McGrawHill,1991.
4. ExperimentalStressAnalysis-SadhuSingh,Khannapublisher,1990.
5. PhotoelasticityVollandVolIII- M.M.Frocht,.JohnWileyandsons,1969.
6. StrainGaugePrimer-PerryandLissner,McGrawHill,1962.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

**PROFESSIONAL ELECTIVE 3
Mechatronics System Design
(Common to MDE, MEA, MMD,CAE)**

Course Code	18MEA322	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50(10 Hours per Module)	Exam Hours	03

Course Learning Objectives:

- CL01** To educate the student regarding integration of mechanical, electronics, electrical and computer systems in the design of CNC machine tools, Robots etc.
- CL02** To provide students with an understanding of the Mechatronic design process, actuators, sensors, transducers, signal conditioning, MEMS and Microsystems and also the advance applications in Mechatronics.
-

Course Content:

Module 1: Introduction: Definition and introduction to Mechatronic Systems. Modeling & Simulation of physical systems. Overview of Mechatronic products and their functioning. Measurement systems, control systems, simple controllers. Study of sensors and transducers, Pneumatic and Hydraulic Systems, Mechanical actuation systems, Electrical actuation systems, Real time interfacing and hardware components for Mechatronics.

10 Hours

Module 2: Electrical Actuation Systems: Electrical systems, mechanical switches, solid state switches, solenoids, DC & AC motors, Stepper motors. System Models: Mathematical models, mechanical system building blocks, electrical system building blocks, thermal system building blocks, electro-mechanical systems, hydro-mechanical systems, pneumatic systems.

10 Hours

Module 3: Signal Conditioning: Signal conditioning, the operational amplifier, protection, filtering, Wheatstone Bridge, Digital signals, Multiplexers, Data Acquisition, Introduction to digital system processing, Pulse-modulation.

MEMS and Micro systems: Introduction, working principle, materials for MEMS and Micro systems, Micro system fabrication process, overview of Micro Manufacturing, Micro system Design, and Micro system packaging.

10 Hours

Module 4: Data Presentation Systems: Basic System Models, System Models, Dynamic Responses of System.

10 Hours

Module 5: Advanced Applications in Mechatronics: Fault Finding, Design arrangements and practical case studies, Design for manufacturing, User- friendly design.

10 Hours**Course Outcomes:****At the end of the course, students will be able to:**

C01	Describe mechatronic systems and overview of control systems & actuators.
C02	Identify and describe the different types of actuators used in mechatronic systems
C03	Differentiate between various sensors, transducers and actuators and their applications.
C04	Identify and describe the different types of speed- and position-feedback devices.
C05	Relate various signal conditioning units, amplifiers, logic gates and their role in programmable logic controllers.
C06	Discuss the importance of feedback in controlling physical systems with the use of examples.
C07	Explain the principle of operation of ac induction motor, dc motor, servomotor,

	and stepper motor.
C08	Identify and describe the types of controllers used in mechatronic systems.

Text Books:

1. W. Bolton, “ Mechatronics” - Addison Wesley Longman Publication, 1999
2. HSU “ MEMS and Microsystems design and manufacture” - Tata McGraw-Hill Education, 2002

Reference Books:

1. Kamm, “ Understanding Electro-Mechanical Engineering an Introduction to Mechatronics” - IEEE Press, 1 edition ,1996
2. Shetty and Kolk “ Mechatronics System Design” - Cengage Learning, 2010
3. Mahalik “ Mechatronics” - Tata McGraw-Hill Education, 2003
4. HMT “ Mechatronics” - Tata McGraw-Hill Education, 1998
5. Michel .B. Histan& David. Alciatore, “ Introduction to Mechatronics & Measurement Systems”– . Mc Grew Hill, 2002
6. “ Fine Mechanics and Precision Instruments” - Pergamon Press, 1971.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

PROFESSIONAL ELECTIVE 3
Robust Design
(Common to MDE, MEA, MMD, CAE)

Course Code	18MEA323	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50(10 Hours per Module)	Exam Hours	03

Course Learning Objectives:

	CL01 To impart a holistic view of the fundamentals of experimental designs, analysis tools and techniques, interpretation and applications.
CL02	To cover the statistical design of experiments for systematically examining functioning of the system.
CL03	To understand Taguchi’ s orthogonal array techniques which are predominantly

	used in optimization of parameters.
CL04	To understand the applications of statistical models in analysing experimental data.

Course Content:

Module 1: Quality by Experimental Design : Quality, western and Taguchi quality philosophy, elements of cost, noise factors causes of variation, quadratic loss function and variation of quadratic loss functions. Robust design : steps in robust design, parameter design and tolerance design, reliability improvement through experiments, illustration through numerical examples.

Experimental design: classical experiments, factorial experiments, terminology, factor levels, interactions, treatment combination, randomization, 2-level experimental design for two factors and three factors, 3-level experiment designs for two factors and three factors, factor effects, factor interactions, fractional factorial design, saturated design, central composite designs, and illustration through numerical examples.

10 Hours

Module 2: Measures of Variability: Measures of variability, concept of confidence level. Statistical distributions : normal, log normal and Weibull distributions. Hypothesis testing, probability plots, choice of sample size illustration through numerical examples. Analysis and interpretation of experimental data: Measures of variability, ranking method, column effect method and plotting method. Analysis of Variance (ANOVA) in factorial experiments: Yate' s algorithm for ANOVA, regression analysis, mathematical models from experimental data, illustration through numerical examples.

10 Hours

Module 3: Taguchi's Orthogonal Arrays : Types orthogonal arrays, selection of standard orthogonal arrays, linear graphs and interaction assignment, dummy level technique, compound factor method, modification of linear graphs, column merging method, branching design, strategies for constructing orthogonal arrays. Signal to Noise ratio (S-N ratios): Evaluation of sensitivity to noise, signal to noise ratios for static problems, smaller – the – better types, nominal – the – better – type, larger – the- better – type. Signal to Noise ratios for dynamic problems, illustrations through numerical examples.

10 Hours

Module 4: Parameter Design and Tolerance Design : Parameter and tolerance design concepts, Taguchi' s inner and outer arrays, Parameter design strategy, Tolerance design strategy, Illustrations through numerical examples.

10 Hours

Module 5: Reliability Improvement Through Robust Design : Role of S-N ratios in reliability improvement ; Case study; Illustrating the reliability improvement of routing process of a printed wiring boards using robust design concepts.

10 Hours

Course Outcome:

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

C01	Apply methods to analyze and identify opportunities to improve design processes for robustness.
C02	Set up full and fraction Factorial experiment design.
C03	Perform ANOVA and Hypothesis Testing.
C04	Apply statistical models in analysing experimental data.
C05	Lead product development activities that include robust design techniques.

Text Books:

1. Madhav S. Phadake , “ Quality Engineering using Robust Design” , Prentice Hall,1989.
2. Douglas Montgomery, “ Design and analysis of experiments” , Willey India Pvt.Ltd., 2007.
3. Phillip J. Ross, Taguchi , “ Techniques for Quality Engineering” ,McGraw Hill Int. Ed., 1996

Reference Books:

1. Thomas B. Barker , “ Quality by Experimental Design” , Marcel Dekker Inc, ASQC Quality Press, 1985
2. C.F. Jeff Wu, Michael Hamada , “ Experiments planning, analysis and parameter design optimization” , John Willey Ed., 2002
3. W.L. Condra, Marcel Dekker , “ Reliability improvement by Experiments” , MarcelDekkerInc, ASQC Quality Press, 1985

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

**PROFESSIONAL ELECTIVE 4
Smart Materials and Structures
(Common to MDE, MEA, MMD,CAE)**

Course Code	18CAE331	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50(10 Hours per Module)	Exam Hours	03

Course Learning Objectives:

CL01	To understand the concepts of functional material, smart material and smart systems.
CL02	To expose the students to design smart structures for advanced engineering applications.

CL03	To introduce the concepts of shape memory alloys, ER and MR fluids, and MEMS.
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Course Content:

Module 1: Smart Structures: Types of smart structures, potential feasibility of smart structures, key elements of smart structures, applications of smart structures. Piezoelectric materials, properties, piezoelectric constitutive relations, depoling and coersive field, field strain relation. Hysteresis, creep and strain rate effects, inchworm linear motor. Beam modeling: Beam modeling with induced strain rate effects, inchworm linear motor beam modeling with induced strain actuation-single actuators, dual actuators, pure extension, pure bending harmonic excitation, Bernoulli-Euler beam model, problems, piezo-electrical applications.

10 Hours

Module 2: Shape memory Alloy: Experimental phenomenology, shape memory effect, phase transformation, Tanaka' s constitutive model, testing of SMA wires, vibration control through SMA, multiplexing. Applications of SMA and problems. ER and MR fluids: Mechanisms and properties, fluid composition and behavior, the Bingham plastic and related models, pre-yield response, post-yield flow applications in clutches, dampers and others.

08 Hours

Module 3:Vibration absorbers: Series and parallel damped vibrations (overview), active vibration absorbers, fiber optics, physical phenomena,characteristics, sensors, fiber optics in crack detection, applications. Control of structures: Modeling, control strategies and limitations, active structures in practice.

10 Hours

Module 4: MEMS: Mechanical Properties of MEMS Materials, Scaling of Mechanical Systems, Fundamentals of Theory, The Intrinsic Characteristics of MEMS, Miniaturization, Microelectronics Integration.

10 Hours

Module 5: Devices: Sensors and Actuators, conductivity of Semiconductors, crystal planes and orientation, Stress and Strain Relations, Flexural Beam Bending Analysis under simple loading conditions, polymers in MEMS, optical MEMS applications.

10 Hours**Course Outcomes:****At the end of this course, students will be able to:**

C01	Understand the behavior and applicability of various smart materials.
C02	Design simple models for smart structures & materials.
C03	Devise experiments to verify the predictions.
C04	Judge the appropriate application of smart materials with respect to the feasibility of their fabrication and implementation, and to the economic aspects.

Text Books:

1. Smart Materials and Structures - M. V. Gandhi and B. So Thompson, Chapman and Hall, London; New York, 1992 (ISBN: 0412370107).
2. Smart Structures and Materials - B. Culshaw, ArtechHouse, Boston, 1996 (ISBN :0890066817).
3. Smart Structures: Analysis and Design - A. V. Srinivasan, Cambridge University Press, Cambridge; New York, 2001 (ISBN: 0521650267).

Reference Books:

1. Electroceramics: Materials, Properties and Applications - A. J. Moulson and J. M. Herbert. John Wiley & Sons, ISBN: 0471497429
 2. Piezoelectric Sensories: Force, Strain, Pressure, Acceleration and Acoustic Emission Sensors. Materials and Amplifiers, Springer, Berlin;New York, 2002 (ISBN: 3540422595).
3. Piezoelectric Actuators and Wtrasonic Motors - K. Uchino, Kluwer Academic Publishers, Boston, 1997 (ISBN: 0792398114).
4. Handbook of Giant Magnetostrictive Materials - G. Engdahl, Academic Press, San Diego, Calif.; London, 2000 (ISBN: 012238640X).
5. Shape Memory Materials - K. Otsuka and C. M. Wayman, Cambridge University Press, Cambridge; New York, 199~ (ISBN:052144487X).

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

**PROFESSIONAL ELECTIVE 4
COMPOSITE MATERIALS TECHNOLOGY
(Common to MDE, MEA, MMD)**

Course Code	18MDE332	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50(10 Hours per Module)	Exam Hours	03

Course Learning Objectives:

CL01	To impart a basic understanding of micro-mechanics of layered composites, analysis and design of composite structures and failure analysis of laminated panels.
CL02	To understand the principles, matrix and reinforcement material options,

	advantages and disadvantages of different manufacturing techniques of composites.
CL03	To comprehend recent developments in composites, including metal, ceramic and polymer matrix composites.
CL04	To know the use of composites in engineering applications.

Course Content:

Module 1: Introduction to Composite Materials: Definition, Classification, Types of matrices material and reinforcements, Characteristics & selection, Fiber composites, laminated composites, Particulate composites, Prepregs, and sandwich construction.

Metal Matrix Composites: Reinforcement materials, Types, Characteristics and selection, Base metals, Selection, Applications. Macro Mechanics of a Lamina: Hooke's law for different types of materials, Number of elastic constants, Derivation of nine independent constants for orthotropic material, Two - dimensional relationship of compliance and stiffness matrix. Hooke's law for two-dimensional angle lamina, engineering constants - Numerical problems. Invariant properties. Stress-Strain relations for lamina of arbitrary orientation, Numerical problems.

10 Hours

Module 2: Micro Mechanical Analysis of a Lamina: Introduction, Evaluation of the four elastic moduli, Rule of mixture, Numerical problems. Experimental Characterization of Lamina- Elastic Moduli and Strengths. Failure Criteria: Failure criteria for an elementary composite layer or Ply, Maximum Stress and Strain Criteria, Approximate strength criteria, Inter-laminar Strength, Tsai-Hill theory, Tsai, Wu tensor theory, Numerical problem, practical recommendations.

10 Hours

Module 3: Macro Mechanical Analysis of Laminate: Introduction, Kirchhoff hypothesis, Classical Lamination Theory, A, B, and D matrices (Detailed derivation), Special cases of laminates, Numerical problems. Shear Deformation Theory, A, B, D and E matrices (Detailed derivation).

10 Hours

Module 4: Analysis of Composite Structures: Optimization of Laminates, composite laminates of uniform strength, application of optimal composite structures, composite pressure vessels, spinning composite disks, composite lattice structures.

Applications: Aircrafts, missiles, Space hardware, automobile, Electrical and Electronics, Marine, Recreational and sports equipment-future potential of composites.

10 Hours

Module 5: Manufacturing and Testing: Layup and curing - open and closed mould processing, Hand lay-up techniques, Bag moulding and filament winding. Pultrusion, Pulforming, Thermoforming, Injection moulding, Cutting, Machining, joining and repair.

NDT tests- Purpose, Types of defects, NDT method - Ultrasonic inspection, Radiography, Acoustic emission and Acoustic ultrasonic method.

10 Hours

Course Outcomes: