Syllabus of All Courses

Course Code: 15EMEF201 **Course Title: Mechanics of Materials**

L-T-P: 3-1-0 Credits: 4 Contact Hrs: 5

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Teaching Hrs: 50 Exam Duration: 3 hrs

Unit – 1

1. Stresses and Strains 10 hrs

Normal and shear stress, Bearing stress, Strain, deformation, Stress-strain diagram, Hooke's law, working stress and factor of safety, Analysis of bars of constant and varying sections, Principle of super position, Saint-Venant's principle, Stresses in composite section, Volumetric strain, Elastic Constants, Statically Indeterminate structures, Thermal stresses.

2. Torsion and Buckling 6 hrs

Torsion of circular shafts, Torsional equation, Power transmitted by solid and hollow circular shafts.

Buckling: Elastic Instability, Critical load, Euler's equation for columns with different end conditions, Rankine's formula.

Unit – 2

3. Shear Force and Bending Moment in Beams 6 hrs

Types of beams, Supports and Loads, Shear force and bending moment diagrams for simply supported, overhanging and cantilever beams subjected to point loads, uniformly distributed load, uniformly varying load and couple.

4. Stresses in Beams 5 hrs

Bending stress, Flexure formula, Section modulus, Bending stresses in beams of different cross sections, Economic Sections. Shear stresses in beams, Shear stress across rectangular, I and T sections.

6. Deflection of Beams 5 hrs

Deflection and slope of a beam, Differential equation of the elastic curve, Equations for deflection, slope and moment, Double integration and Macaulay's method, Deflection and slope for simply supported, overhanging and cantilever beams subjected to point loads, uniformly distributed load and couple.

Unit – 3

7. Compound stresses 4 hrs

State of stress at a point, Transformation of plane stress, Principal planes and Principal stresses, Analytical method for determining principal stresses, maximum shear stress and their planes, Mohr's circle for plane stress.

8. Thin and Thick Cylinders 4 hrs

Thin walled pressure vessels, Cylindrical vessels; hoop stress, longitudinal stress and maximum shear stress, change in dimensions of cylinder (diameter, length and volume). Spherical vessels, Thick cylinders subjected to internal and external pressures (Lame's equation)

Text Book (List of books as mentioned in the approved syllabus)

1. Andrew Pytel and Jaan Kiusalaas, Mechanics of Materials, Third Indian Reprint, CENGAGE Le, 2009
2. Hibbeler R.C, Mechanics of Materials, Eighth Edition, Prentice H, 2011

References

1. Nash, W.A, Strength of Material, Fourth Edition, Schaum Outline Series, 2007
2. James M Gere. Mechanics of materials sixth edition THOMSON India edition.2007

Course Code: 15EMEC201		**Course Title: Manufacturing Processes**
L-T-P: 4-0-0	Credits: 4	Contact Hrs: 4
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 50		Exam Duration: 3 hrs

Unit – 1

1. Introduction to Manufacturing Processes 2 Hrs

Definition of manufacturing, Manufacturing sectors and their significance to the economy of a country, Classification of production processes and systems, Criteria for selection of a process for production

2. Casting and Special Casting Processes 12 Hrs

Casting: Introduction, Green sand moulding, Pattern & core making: Pattern types, allowances and materials, Core & core making methods, Moulding methods and machines, Principles of gating, risers and gating ratio. Special Casting Processes: CO_2 moulding, Shell moulding, Investment casting, Die casting and Centrifugal casting processes. Melting Furnaces and Defects in Castings: Crucible furnaces, Electric arc furnaces, Induction furnaces. Defects in castings, Cleaning and fettling operations, Testing methods

3. Fabrication processes 6 Hrs

Classification of joining processes, Soldering, Brazing, Mechanical fastening, Welding, Preparation of base metal and joint. Arc welding, Gas welding, TIG, MIG, FCAW, Thermit welding, Spot, seam and projection welding, Ultrasonic welding, Electron beam welding and Laser welding

Unit – 2

4. Machine Tool Operations 8 Hrs

Principles of metal cutting, Introduction to Lathes, Drilling and Milling machines; Constructional features, Operations, Machining time calculations.
Grinding, Super finishing, Honing and Lapping methods; Constructional features, Operations and types

5. CNC Machine Tool 6 Hrs

Need for CNC machines, Fundamentals of numerical control, Classification of numerical control, NC controllers, and constructional details of CNC machines. Manual part programming

6. Mechanics of Machining 6 Hrs

Geometry of cutting tools, Cutting tool materials, Mechanism of chip formation, Merchant's circle diagram, Velocity and force relationships, Cutting fluids, Thermal aspects of machining, Types of tool wear & wear mechanisms, Tool life, Machinability & its criteria

Unit – 3

7. Forming processes 5 Hrs

Bulk deformation processes: Forging, Rolling, Extrusion and Drawing. Sheet metal working processes. Selection of equipments

8. Advanced Manufacturing Processes 5 Hrs

Non-traditional Machining Processes: Mechanical, Thermal, Electrochemical and Chemical machining processes.
Micro-machining and Additive manufacturing

Text books

1. Kalpakjian S., and Schmid S.R., Manufacturing Engineering & Technology, 7th edition, Pearson Education, 2014.
2. Mikell P. Groover, Fundamentals of Modern Manufacturing, 5th edition, John Wiley & Sons, 2012.

Reference books

1. Rosenthal, P., Heine L., Principles of Metal Casting, Tata McGraw Hill, 1997.
2. John A. Schey, Introduction to Manufacturing Processes, 3rd edition, Tata McGraw Hill, 1999.
3. Juneja B. L. and Sekhon G. S., Fundamentals of Metal Cutting and Machine Tools, 3rd edition, New Age International Limited, 2008.
4. Mikell P. Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, 4th edition, Prentice Hall, 2014.
5. Pandey P. C. and Shan H. S., Modern Machining Processes, 1st edition, Tata McGraw Hill, 2013.
6. Rao P. N., Manufacturing Technology: Volume-1, 3rd edition, Tata McGraw Hill, 2008.
7. Rao P. N., Manufacturing Technology: Volume-2, 3rd edition, Tata McGraw Hill, 2013.

Course Code: 15EMEC204		**Course Title: Machines & Mechanisms**
L-T-P: 4-0-0	Credits: 4	Contact Hrs: 4
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 50		Exam Duration: 3 hrs

Unit I

Chapter 1: Kinematics Fundamentals: 10 Hrs

Links, pairs, Mechanisms, machines, structure, and Inversions. Identifying types of links, pairs, Drawing Kinematic Diagram and finding mobility of linkages Numericals on mobility, Inversions of Four bar mechanism, single slider crank mechanism, double slider crank mechanism. Steering gear mechanism and Ackerman gear mechanism Hook's joint analysis with examples, Crank and slotted lever mechanism and whit worth quick return mechanism analysis, Intermediate motion mechanism

Chapter 2: Kinematic Analysis 10 Hrs

Locating instantaneous centers for different mechanisms, Numericals. Velocity and acceleration analysis of links. velocity and acceleration analysis of 4 bar mechanisms and slider crank mechanisms.
Velocity and acceleration analysis of quick return motion mechanisms Numericals
Velocity analysis and Acceleration analysis of four bar mechanism and engine mechanism by complex algebra. Numericals

Unit II

Chapter 3: Static and Dynamic analysis of Mechanisms 8 Hrs

Static force analysis of 4 bars mechanisms. Static force analysis of slider cranks mechanisms. Numericals
Inertia forces and torque, inertia forces on engine mechanism, TMD for different machines, Fluctuation of energy, Flywheel. Numericals

Chapter 4: Kinematic analysis of Gear and Gear Trains 6 Hrs

Classification and terminology of gears Involutometry, backlash in gears Law of gearing, velocity of siding, length of path of contact, arc of contact, Contact ratio Numericals.
Epicyclic gear train with numericals

Chapter 5: Balancing of masses 6 Hrs

Necessity of balancing, Static and Dynamic balancing, Balancing of revolving mass in single and multiple planes, Balancing of several masses in single planes, Balancing of several masses in multiple planes, Balancing of reciprocating masses, Balancing of multi cylinder inline engine. Numericals

Unit – III

Chapter 6: Belts and Chain drives 6 Hrs

Velocity ratio, effect of belt thickness and slip, Power transmitted by belt driving tension, centrifugal tension and initial tension, Belts. Numericals Classification of chains, length of chains, initial tension, creep. Numericals

Chapter 7: Cams and Gyroscope 4 Hrs

Introduction, classification of followers and cams. Displacement diagrams for roller follower with SHM and analysis, displacement diagrams for followers with UV&R and analysis. Numericals
Gyroscopic couple and precessional motion, effect of gyroscopic couple on airplane and Naval Ship during steering and Rolling.

Reference Book:

1. Machines and Mechanisms by Myzcka.
2. Theory of Machines and Mechanisms 4th Edition, by John Uicker , Gordon Ennock , Joseph Shigley
3. Design of Machinery by Robert L. Norton.
4. Theory of machines by S S Rattan.

Course Code: 15EMEF202 **Course Title: Engineering Materials**

L-T-P: 4-0-0	Credits: 4	Contact Hrs: 4
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 50		Exam Duration: 3 hrs

Unit – 1

Chapter 1: Introduction: 05 Hrs

An overview of materials science and engineering, classes of engineering materials, functional and advanced materials, Materials history and character, Design-limiting properties, Material property charts, Matching materials to design, Selection strategy- translation, screening, ranking and documentation.

Chapter 2: Structures of Metals and ceramics: 05 Hrs

Macro-Micro-Nano: The scale of structures, Crystal Structures- BCC, FCC, HCP structures; coordination number, atomic packing factor, Imperfections in solids and their roles in affecting the behavior of materials., Plastic deformation of single crystal by slip and twinning, dislocation theory.

Chapter 3: Mechanical Behavior of materials: 10 Hrs

Stress-strain diagrams to show ductile and brittle behavior of materials, linear and non linear elastic behavior of materials, mechanical properties in elastic and plastic range, Effect of strain rate and temperature on tensile properties, **Fatigue**: Types of fatigue loading with example, mechanism of fatigue, fatigue properties, fatigue testing and SN diagram; **Creep**: Description of phenomenon with examples, stages of creep, creep properties, stress relaxation; **Fracture**: Failure of engineering materials.

Unit – 2

Chapter 4: Solidification and phase diagrams: Mechanism of solidification, Homogeneous and heterogeneous nucleation, crystal growth, cast metal structures, Solid solutions, Hume Rothery rules, substitutional and interstitial solid solutions, intermediate phases, Gibbs phase rule, construction of equilibrium diagrams, equilibrium diagrams involving complete and partial solubility, lever rule, Iron carbon equilibrium diagram, description of phases, solidification of steels and cast irons, invariant reactions, Numericals. 07 Hrs

Chapter 5: Ferrous and Non ferrous materials: 06 Hrs

Properties, composition and uses of cast irons and steels, AISI and BIS designation of steels. Aluminum, Magnesium and Titanium alloys.

Chapter 6: Heat treatment of metals: 07 Hrs

Objectives, Annealing and its types, normalizing, hardening, tempering, austempering, martempering, hardenability, surface hardening methods like carburizing, cyaniding, nitriding, flame hardening and induction hardening; Age hardening of Aluminum -Copper alloys. Time-temperature-transformation (TTT) curves, continuous cooling curves.

Unit – 3

Chapter 7: Ceramic and Polymer Materials: 05 Hrs

An overview of ceramic materials, mechanical and thermal properties of ceramics, An overview of polymeric materials, thermoplastics and thermosets, elastomers, engineering applications of ceramic and polymer materials.

Chapter 8: Advanced materials: 05 Hrs

The need for advanced materials; Composite materials- classification, types of matrix materials and reinforcements, fundamentals of production of FRP's and MMC's, applications of composites, Smart materials, Nano materials and Exotic alloys.

Text Books:

1. Engineering Materials: An Introduction to Properties, Applications and Design- Michael Ashby and D R H Jones.
2. The Science and Engineering of Materials – Donald Askeland and Pradeep Phule, Thompson Learning.
3. Materials Science and Engineering – William Callister, John Wiley & Sons. Inc.

Course Code: 15EMEP201 **Course Title: Production Technology Lab**

L-T-P: 0-0-1 Credits: 1 Contact Hrs: 2

ISA Marks: 80 ESA Marks: 20 Total Marks: 100

Exam Duration: 2 hrs

Content

1 Machining practices involving machining time calculations and estimation of machining costs for the jobs for turning, milling, drilling, grinding. (3 slots)

2 Simulation of CNC programming on machining processes. (2 slots)

3 CNC programming practices on machining processes. (2 slots)

4 Machinability studies in turning, milling, drilling. (3 slots)

5 Design, Modeling and Analysis of Bulk deformation and Sheet Metal forming processes. (2 slots)

Text books

1. Kalpakjian S., and Schmid S.R., Manufacturing Engineering & Technology, 7th edition, Pearson Education, 2014.
2. Mikell P. Groover, Fundamentals of Modern Manufacturing, 5th edition, John Wiley & Sons, 2012.

Reference books

1. John A. Schey, Introduction to Manufacturing Processes, 3rd edition, Tata McGraw Hill, 1999.
2. Juneja B. L. and Sekhon G. S., Fundamentals of Metal Cutting and Machine Tools, 3rd edition, New Age International Limited, 2008.
3. Mikell P. Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, 4th edition, Prentice Hall, 2014.
4. Pandey P. C. and Shan H. S., Modern Machining Processes, 1st edition, Tata McGraw Hill, 2013.

Course Code: 15EMEP204 **Course Title: Machines & Mechanisms Lab**

L-T-P: 0-0-1 Credits: 1 Contact Hrs: 2

ISA Marks: 80 ESA Marks: 20 Total Marks: 100

Exam Duration: 2 hrs

Sl No	Content	Type
1	Converting a machine in to its Kinematic model	Structured enquiry
2	Velocity and Acceleration of complex mechanisms	Structured enquiry
3	Analysis of Gear and Gear trains	Structured enquiry
4	Design of cam profile	Exercise
5	Balancing of rotating masses	Exercise
6	Balancing of reciprocating masses	Exercise
7	Belt Drive	Structured enquiry
8	Dynamic force analysis	Structured enquiry
9	Develop the mechanism for the given objective	Open Ended problem

Reference Book:

1. MSC ADAMS Manual.
2. Machines and Mechanisms by Myzcka.
3. Theory of Machines and Mechanisms 4th Edition, by John Uicker , Gordon ennock ,Joseph Shigley
4. Design of Machinery by Robert L. Norton.
5. Theory of machines by S S Rattan

Course Code: 15EMEP202 **Course Title: Engineering Materials Lab**

L-T-P: 0-0-1 Credits: 1 Contact Hrs: 2

ISA Marks: 80 ESA Marks: 20 Total Marks: 100

Exam Duration: 2 hrs

Expt. No.	Brief description about the experiment	No. of Lab. Slots
01	Introduction to the Laboratory-Overview of Destructive and Non Destructive Testing methods. (Awareness about the ASM hand books and ASTM standards)	01
02	Non destructive test experiments a. Ultrasonic flaw detection. b. Magnetic particle inspection. c. Dye penetration testing, To study the defects of castings and welded specimens.	01
03	Evaluation of the tensile strength, Compression strength, Shear strength, Bending/ Torsion strength and Impact strength.	01
04	Ex: Should be able to Describe the differences between the tensile behavior of the metal sample and that of polymer sample, considering that the student performs the test on two different materials family.	01
05	To study wear characteristics of ferrous, non-ferrous and composite materials for different loading. Computation of wear parameters: wear rate, wear resistance, specific wear rate, frictional force, coefficient of friction, wear coefficient.	01
06	To study the microstructure of the ferrous and nonferrous alloy and to perform grain size analysis and volume fraction analysis. • Familiarization with the procedure for preparation of a material specimen for microscopic examination. • Familiarization with compound optical microscopes and metallography. • Examination of surface characteristics of engineering materials. • Grain size determination of metals and analysis.	01
07	To analyze given SEM Micrographs (Microstructure and fracture surface morphology) and conclude on the structure and mode of fracture. (Familiarization with the advanced characterization of metals by Scanning electron microscopy).	01
08	Computer Modeling of Stress Concentration, Crack Opening and Crack Propagation Understand the occurrence of stress concentration at geometrical discontinuities. Determine the stress concentration factor at a geometrical discontinuity.	01
09	Design an experiment to investigate the spring characteristics of any given spring.	02
10	Synthesize a novel composite material which is reinforced with a natural fiber in a polymer matrix and perform the mechanical characterization for investigation of mechanical properties, which is desirable for specified engineering applications. Perform a parametric analysis which affects the mechanical properties of prepared composites using a statistical approach and find the correlation of those parameters with properties of composites.	02

Course Code: 15EMEP203 **Course Title: Engineering Design Practice**

L-T-P: 0-1.5-1.5 Credits: 3 Contact Hrs: 6

ISA Marks: 80 ESA Marks: 20 Total Marks: 100

Exam Duration: 3 hrs

Part - A

1. **Introduction to Engineering Design Process**
Introduction to engineers design, Generic design process, good design and bad design, types of design process, managing project and professionalism

2. **Need analysis and problem definition**
Need Analysis- Why-Why analysis, VOC- Interaction with stake holders- Customers, experts etc. (through well-defined questionnaires), and Market analysis- How to Conduct a Market Analysis, Relevant Information Resource, Intellectual property rights (Patents, Copyrights etc.)

3. **Functional analysis**
Identifying functions, Functional Decomposition, Function Structure -Procedure to Establish Functional Structures, Methods- Black box & transparent box, reverse engineering

4. **Design specifications**
VoE: Establishing product specifications - QFD Method, Human Factors in design and Safety Considerations

5. **Conceptualization**
Brainstorming, Develop Concepts from Function- Morphological analysis, Expanding design space, applying metrics to objectives: Selecting the preferred design

6. **Evaluating design alternatives/ alternative concepts**
Sketch Assembly of Alternatives, Conceptual design evaluation and decisions- Decision Matrix- Pugh method

7. **Detailed design & costing**
Product Drawings, Bill of Materials, Prototyping techniques
Cost estimating in design- Cost Classifications, Cost Estimate Methods, Product Pricing

8. **Concept testing& Documentation**
Purpose of concept test, choose survey population/format, and communicate the concept to measure customer response, interpret the results and document

Part – B

	Content	Hrs
	Part – B1(2D Drafting)	
1.	**Orthographic Projections – Sectional [MANUAL drawings]** Conversion of pictorial views into orthographic projections, Sectional views such as half section, full section, local section, removed section and offset section.[1st and 3rd angle projection]	08 Hours / 4 sessions
2.	**Thread forms and Threaded Fasteners: [MANUAL drawings]** **Thread forms:** Thread terminology, thread profiles, [ISO Metric, BSW, Square and Acme, Sellers thread, American Standard thread]. **Fasteners:** Hexagonal headed bolt and nut with washer (assembly), square headed bolt and nut with washer (assembly).	08 Hours / 4 sessions
3.	**2D Assembly Drawings:** Part and Assembly Drawings, Generating bill of materials for assembly. [Creating sectional views of parts and assembly of protected type flanged coupling, machine vice, screw jack etc.]	10 Hours / 5 sessions
	Part – B2(3D Modeling)	
4.	**Introduction to 3D Modeling and different work benches:** Sketcher Workbench: Demonstration of sketch tools, modifying tools, geometrical constraints and dimensional constraints.	4 Hours / 2 sessions
5.	**Part Modeling:** Shape toolbar for adding materials, shape toolbar for removing materials, modifying tools, types of views etc.,	10Hours / 5 sessions
6.	**Assembly:** Component placement, Placement types (Surface, Axis, and Planes), Feature settings etc.	4 Hours / 2 sessions
7.	**Drawing:** Drawing properties, Adding drawing models, View types, Scale factors, Section apply, View display	4 Hours / 2 sessions

Text Book/Reference Books:

1. YosefHaik, Engineering Design process, 2004, Cengage Learning India Pvt. Ltd
2. Clive L. Dym& Patrick Little, Engineering design, 3rd edition, John Wiley and Sons
3. Engineering Design Principles Ken Herst, Elsevier Publication, 2010, Indian Edition
4. Product Design and Development – Karl T Ulrich & Steven D Eppinger, Tata McGraw Hill 3rd Edition 2004

Course Code: 15EMEC202 **Course Title: Engineering Thermodynamics**

L-T-P: 3-0-0 Credits: 3 Contact Hrs: 3

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Teaching Hrs: 40 Exam Duration: 3 hrs

Unit – 1

Chapter No. 1. Introduction 5 hrs

Basic concepts, Zeroth law, 1st law of thermodynamics applied to non flow system and flow system

Chapter No. 2. Second Law of Thermodynamics 10 hrs

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, coefficient of performance. Classical statements of second law of thermodynamics, PMM I and PMM II, factors that make a process irreversible, reversible heat engines, Carnot cycle, Carnot theorem, thermodynamic temperature scale. Entropy, a property of a system, Clausius theorem and Clausius inequality, Principle of increase of entropy, calculation of entropy change during various processes, Tds relations, Exergy and Aenergy, Exergy analysis

Unit – 2

Chapter No. 3. Gas and Vapour Power Cycles 9 hrs

Gas power cycles: Otto, Diesel, Dual cycles, expression for mean effective pressure and cycle efficiency, comparison of Otto, Diesel and Dual cycles. Vapour power cycle: Carnot cycle, work done and cycle efficiency, draw backs, ideal and actual Rankine cycle, network done, cycle efficiency and work ratio, regenerative cycle and reheat cycle

Chapter No. 4. Internal Combustion Engines and their Testing 6 hrs

Introduction to I C engines, Thermodynamic testing of internal combustion engines, measurement of air supplied, fuel supplied to the engines, measurement of power and efficiencies, preparation of heat balance sheet

Unit – 3

Chapter No. 5. Combustion thermodynamics 5 hrs

Stoichiometric air for combustion of fuels, excess air, combustion equations, air - fuel ratio, combustion efficiency, analysis of products of combustion, volumetric and gravimetric basis, enthalpy of formation, enthalpy and internal energy of combustion, adiabatic flame temperature. Energy and environment.

Chapter No. 6. Refrigeration 5 hrs

Vapour compression refrigeration system; description, analysis, refrigerating effect, capacity, power required, units of refrigeration, COP. Refrigerants and their desirable properties. Air cycle refrigeration; reversed Carnot cycle, reversed Brayton cycle. Vapour absorption refrigeration system. Steam jet refrigeration. Cryogenics and applications. Psychrometry: Atmospheric air and psychometric properties; Dry bulb temperature, wet bulb temperature, dew point temperature; partial pressures, specific and relative humidity and the relation between the two. Enthalpy and adiabatic saturation temperature

Text Book (List of books as mentioned in the approved syllabus)

1. Michael J Moran & Howard N Shapiro, Fundamentals of engineering thermodynamics, 6th, Wiley Stud, 2007

Cenegal Y. A. and Boles M. A, Thermodynamics an Engineering approach, 7th, Tata McGraw Hill, 2011

Course Code: 15EMEC203 **Course Title: Fundamentals of Machine Design**

L-T-P: 3-1-0 Credits: 4 Contact Hrs: 5

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Teaching Hrs: 50 Exam Duration: 3 hrs

Unit – 1

1 Introduction to Machine Design 4 Hrs

Machine Design, Basic Procedure of Machine Design, Design of Machine elements, Traditional design methods, Design synthesis, Use of Standards in Design, Selection of prepared sizes, Aesthetic considerations in design, Ergonomic considerations in design, Concurrent Engineering.

2 Design against Static Load 6 Hrs

Modes of failure, factor of safety, eccentric axial loading, design of machine parts, Stress Concentration, Stress Concentration Factors, Reduction of Stress Concentration. Theories of Elastic failure, Maximum Principal Stress Theory, Maximum Shear Stress Theory, Distortion-Energy Theory, Selection and use of failure Theories.

3 Design against Reversing load 5 Hrs

Fluctuating Stresses, Fatigue Failure, Endurance Limit, Low cycle and High Cycle Fatigue, Notch Sensitivity, Endurance Limit- Approximate Estimation, Reversed Stresses-Design for Finite and Infinite Life

Unit II

4 Design against Fluctuating load 3 Hrs

Cumulative Damage in Fatigue, Soderberg and Goodman equations. Fatigue design under combined stresses. Impact Stresses.

5 Design of Belt Drives 5 Hrs

Introduction to Belt drives, Materials for Belts, Flat belt drives, Length of open/ cross belt drives, Velocity ratio, centre distance, ratio of driving tensions in flat belts, centrifugal tension, power transmitted by flat belt drives, design procedure for belt drives.

6 Shafts and Keys 8 Hrs

Transmission Shafts, Shaft Design on Strength Basis, Shaft Design on Torsional rigidity Basis, ASME Code for shaft design, Design of Shafts subjected to combined bending and twisting. Keys ,Saddle and Sunk keys, Design of square and flat Key.

Unit III

7 Temporary Joints 4 Hrs

Bolted joint –simple analysis, eccentric load perpendicular to axis of bolt, eccentric load parallel to axis of bolt

8 Permanent Joints 5 Hrs

Welded Joints, Strength of Butt Welds, Strength of Parallel fillet Welds, Strength of Transverse Fillet Welds, Eccentric Loaded welded joints, Riveted Joints, Types of riveted joints, Types of failures, Design of butt and lap joints for Boilers.

Tutorials

Session 01: Load Determination
Session 02: Problems on Design against Static Load
Session 03: Problems on Design against Static Load (contd.)
Session 04: Problems on Design against Static Load (contd.)
Session 05: Problems on Design against Reversing Load
Session 06: Problems on Design against Reversing Load (contd.)
Session 07: Problems on Design against Fluctuating Load
Session 08: Problems on Design of Belt Drives
Session 09: Problems on Shafts and Keys

Session 10: Problems on Shafts and Keys (contd.)
Session 11: Problems on Temporary Joints
Session 12: Problems on Permanent Joints
Session 13: Problems on Permanent Joints (contd.)

Text Book (List of books as mentioned in the approved syllabus)

1. V.B. Bhandari, Design of Machine Elements, Third Edition, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2010

References

1. T. Krishna Rao, Design of Machine Elements (Volume I), Second Edition, I K International Publishing House Pvt. Ltd., New Delhi, 2011
2. Farazdak Haideri, Mechanical Engineering Design (Volume I), Second Edition, Nirali Prakashan, Pune, 2000

Design Data Hand Book:

Design Data Hand Book by K. Mahadevan and Balaveera Reddy, CBS Publication

Course Code: 15EMEC205		**Course Title: Instrumentation & Control Engineering**
L-T-P: 4-0-0	Credits: 4	Contact Hrs: 4
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 50		Exam Duration: 3 hrs

Unit – 1

1 INTRODUCTION: 4 Hrs

Generalized configurations and functional descriptions of measuring instruments, performance characteristics of instruments, instrument categorization, measurement quantities and control.

2 FORCE, TORQUE, AND SHAFT POWER MEASUREMENT: 8 Hrs

Basic methods of force measurement, characteristics of elastic force transducers, bonded-strain-gage transducers, differential-transformer transducers, piezoelectric transducers, and variable-reluctance/fm-oscillator, elastic force meters, load cells, torsion meters, dynamometers, gyroscopic force and torque measurement.

3 PRESSURE, VIBRATION AND SOUND MEASUREMENT: 8 Hrs

Basic methods of pressure measurement, deadweight gages and manometers, elastic transducers, dynamic testing of pressure-measuring systems, principles of seismic instruments – vibrometer and accelerometer using this principle, sound measurement.

Unit – 2

4 MATHEMATICAL MODEL: 8 Hrs

Concept of automatic controls, open and closed loop systems, concepts of feedback, requirement of an ideal control system. Mechanical system (both translation and rotational), Electrical system, D. C. Motors, Hydraulic systems (liquid level and fluid power systems), Thermal systems.

5 SYSTEM RESPONSE: 6 Hrs

First order subjected to step and ramp input, second order system response to step input, concepts of time constant and its importance in speed of response. Mathematical concept of stability-Routh Hurwitz Criterion

6 CONTROL ACTION: 6 Hrs

Types of controllers – proportional, integral, proportional integral, proportional integral differential controllers, system compensations.

Unit – 3

7 FREQUENCY RESPONSE TECHNIQUES: 5 Hrs

Definition of root loci, Rules for rapid plotting, constructing of root loci, Stability analysis. Problems solving using software.

Bode attenuation diagrams, stability analysis using Bode diagrams, simplified Bode diagrams. Problems solving using software.

8 INTRODUCTION TO STATE VARIABLE CHARACTERISTICS OF LINEAR SYSTEMS: 5 Hrs

Introduction to the state concepts, state equation of linear continuous data system. Matrix representation of state equations

Text Book:

1. Ernest O. Doebelin, 'Measurement Systems', McGraw-Hill Publication.
2. Dr.D.S.Kumar, 'Measurements Systems: Applications & Design', Anuradha Agencies.
3. B.C.Nakara & K.K.Choudhary, 'Instrumentation, measurement & analysis', Tata McGraw-Hill Publication.
4. Richard C Dorf and Robert H. Bishop, 'Modern Control Systems', Addison Wesley.
5. Control systems' by I. J. Nagarath & M. Gopal, New age International publishers.

References:

1. FR K Jain, 'Mechanical and Industrial Measurements', Khanna Publishers.
2. A. K. Ghosh, ' Introduction to Instrumentation and Control', PHI Learning Pvt. Ltd.
3. B.C. Kuo, F. Golnaraghi, 'Control Systems', John Wiley & Sons.
4. Norman S. Nise, 'Control. Systems', John Wiley & Sons
5. Eronini Umez, 'System Dynamics & control' , Thomson Learning.
6. M. Gopal, 'Control Systems Principles and Design', Tata McGraw-Hill Publication.

Course Code: 15EMEC206 **Course Title: Mechatronics**

L-T-P: 3-0-0 Credits: 3 Contact Hrs: 3

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Teaching Hrs: 40 Exam Duration: 3 hrs

Unit – 1

1 Introduction to Mechatronics: Definition & overview of Mechatronics, Key elements, Mechatronics Design approach, Mechatronics and sustainability, examples of mechatronic systems. 6 Hrs

2. Sensors : Proximity Sensor; Displacement/Distance-Potentiometer, encoder, resolver, LVDT, PZT, ultrasonic, Light Sensor; Force-load cell; Temp etc 4 Hrs

3 Signal conditioning: Overview of BJT, MOSFET, SCR, TRIAC, IGBT, Optoisolators; Review of analog(OP-Amp based) and digital(ADC, DAC, MUX) signal conditioning; Signal Filters (Analog/Digital, Active/Passive); Application of Bridge Circuits- strain measurement; Data Acquisition System(DAQ); virtual instruments. 5 Hrs

Unit – 2

4 Microcontroller Introduction to Memory Hierarchy; Address/Data lines; microprocessor and microcontroller ; Introduction to open Hardware Architecture(Arduino/Rasberipy); Basic programming; interfacing Digital I/O, PWM and Analog inputs. Introduction to communication protocols-RS232, I2C, Ethernet Etc. 9 Hrs

5 Programmable logic controller(PLC): Introduction to PLC and it's Architecture; PLC I/O; examples of applications; Ladder diagrams, logic functions, latching; Programming on industrial applications like conveyor belt control, water/oil level controller, sequencing of 3 motors, washing machine sequencing, automatic bottle filling system etc. 6 Hrs

Unit – 3

6 Actuators and its applications: Review of electrical actuators like relay, solenoid etc; Resolver, DC & AC motors, DC & AC servo motors; power drives, IPM; VFD; Servo drives-AC, DC 5 Hrs

7 Machine Vision System&3D printing: Introduction to Machine Vision; Image Acquisition; Image Processing; Visual Navigation; Introduction to 3D printing Hardware and Software. 5 Hrs

Text Books:

1. Devdas Shetty, Rechard A. Kolk, Mechatronics System Design, Cengage Learning – 2nd edition 2011 .
2. W. Bolton, 'Programmable Logic Controllers', Elsevier – 4th edition 2006.

Reference for Mechatronics:

1. David Bradley · David W. Russell, Mechatronics in Action: Case Studies in Mechatronics – Applications and Education, Springer 2010
2. Robert H Bishop, Mechatronics -an Introduction, Taylor & Francis Group 2006
3. W. Bolton, Mechatronics, Pearson Education Asia – 2nd edition 2001
4. Jacob Fraden, Handbook of Modern Sensor, Springer Science Business Media -Fourth Edition 2010
5. http://www.arduino.cc
6. Garry Dunning, 'Introduction to Programmable Logic Controllers' Thomson

Course Code: 15EMEP205 **Course Title: Mechatronics & Control Engineering Lab**

L-T-P: 0-0-2 Credits: 2 Contact Hrs: 4

ISA Marks: 80 ESA Marks: 20 Total Marks: 100

Exam Duration: 2 hrs

Part1

1. Introduction to FG, DSO – Measurement of frequency, Voltage etc.
2. Active Analog Filters (Op-Amp) & Passive Filter
3. Arduino Basics and Programming
4. Interfacing Pot, Switch, LED and
5. LabVIEW_ DAQ : pot, Switch and LED
6. Interfacing LM35, Ultrasonic, LCD
7. DC motor Speed & Direction and keypad
8. Stepper , BLDC motor control and RC servo(pot feedback)
9. DC motor speed Control (with Potentiometer/encoder)
10. Vfd Drives – Induction motor speed control(Demo)
11. PLC – Basics : Logic gates execution , On delay and Off delay timers, Sequencing of 3 motors using CoDeSys software.

Part 2

1. Introduction to MATLAB/ Simulink/ Python
2. MATLAB based application- 1^{st} , 2^{nd} & higher order sym response
3. System response with additional poles, zeros- MATLAB
4. Python based application – Telescopic position control
5. LabVIEW based control- root locus, bode.
6. Compensator Design Via Root locus supported by MATLAB
7. Compensator design with Op-Amp
8. **Demonstration** - Inverted pendulum control, VTL, PID temperature controller.
9. PLC control applications: Automatic water level controller, Bottle filling plant fluid control
10. PLC control applications: Automatic conveyor belt controller, Lift Sequencing/DC motor Control

- **Books/References:**
  - Refer to theory
- **Manuals:**
  - Mechatronics and Control Lab Manual prepared by Lab-incharge.
- **Others:**
  - Course material provided by National Instruments
  - Data Sheets of IC's/ Components.

Course Code: 15EMEC301 **Course Title: Fluid Mechanics and Hydraulic Machines**

L-T-P: 4-0-0 Credits: 4 Contact Hrs: 4 hrs/week

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Teaching Hrs: 50 Exam Duration: 3 hrs

Unit – 1

2. Fluid Continuum 8 hrs

Introduction, A brief history of fluid mechanics, Classification of fluid flows, Systems and control volume, Properties of fluids, Pascal's law, Hydrostatic laws, Manometry, Fluid forces on submerged plane and curved surfaces, Buoyancy and stability.

3. Fluid Kinematics and Fluid Dynamics 10 hrs

Lagrangian and Eulerian description, Flow patterns – stream lines and stream tubes, path lines, streak lines, Time lines, Differential analysis of fluid flow – Conservation of mass – Continuity equation, Velocity potential function and Stream function, Rotational and Irrotational flows. Bernoulli's equation, General energy equation, Linear momentum equation and its application to pipe bends.

Unit – 2

3. Fluid flow measurement 8 hrs

Pitot and pitot static probe, Obstruction flow meters – orifice, venturi and notches, Laminar flow in pipes, Energy losses – major and minor losses, Darcy- Weisbach equation, Chezy's formula, Energy and hydraulic gradient line.

4. Laminar flow and Viscous effects 9 hrs

Introduction, Reynold's number, Laminar flow through circular pipes (Hagen poiseulle's equation), Parallel flow over flat plate, Couette flow. Boundary layer and separation phenomenon.

Dimensional analysis: Rayleigh's method and Buckingham's π theorem, Model testing.

Unit – 3

5. Hydraulic Pumps 8 hrs

Centrifugal pumps – Work done, Heads and efficiencies, Priming, specific speed, NPSH, Cavitations, Multistage centrifugal pumps.

Reciprocating pumps: Working principle, discharge, work done and power, slip, Air vessels.

6. Hydraulic Turbines 7 hrs

Classification, Heads and efficiencies of turbines, Pelton, Francis and Kaplan turbines, Velocity triangles and work done, specific speed, Unit quantities, Draft tube, Characteristic curves.

Text Book:

1. Yunus A Cengel, John M Cimbala: Fluid Mechanics – Fundamentals and Applications, 3rd Edn, McGraw-Hill Publications, 2014.

References:

1. White F M: Fluid Mechanics, 5th Edn, McGraw Hill International Publication, 2003.
2. Dr.R.K. Bansal: Fluid Mechanics and Hydraulic Machines, 9th Edn, Laxmi Publications, 2010.

Course Code: 15EMEC302 **Course Title: Metrology and Quality Engineering**

L-T-P: 4-0-0 Credits: 4 Contact Hrs: 4 hrs/week

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Teaching Hrs: 50 Exam Duration: 3 hrs

Unit – I

Chapter 1: Fundamentals of Metrology

Objectives of metrology, Standards of physical quantities (mass, length, time, temperature, force, Velocity, density) types of standards, line and end standard, Slip gauges, Angle Gauges, Linear and Angular Measurements, Performance characteristics of measuring instruments, Calibration of instruments, The Process of Measurement, Significance of measurement process , Methods of measurement, generalized measurement system, errors in measurement, gauges, comparators (mechanical and optical), Numericals — 06 hrs

Chapter 2: Dimensional Metrology

Measurement of screw thread parameters, Terminology of screw threads, types of threads , Toolmakers microscope, profile projector, Gear terminology, Measurement of gear parameters. Gear tooth vernier , Introduction to Surface Texture, Terminology as per Indian standard, Methods of measurement of surface finish, Working of Tomlinson surface meter, Taylor-Hobson Talysurf, Analysis of surface traces (RMS value, CLA value). — 07 hrs

Chapter 3: Limits, Fits and Gauges

Introduction, limits, tolerance, and fits, types of fits, allowance. Hole basis and shaft basis systems, Indian standard system for limits and fits (IS 919-2709), types of gauges, Taylor's principle and gauge design. Numericals — 07 hrs

Introduction to GD&T Terminology, Maximum Material control (MMC) & Least Material Control (LMC), Form and orientation tolerances in detail with application examples, Interpretation of drawings with GD & T and exercises,

Unit – II

Chapter 4: Advanced Metrology

CMM Coordinate Measuring Machine: Co-ordinate metrology, CMM configurations, hardware components, Software, Probe sensors, Displacement devices, applications — 07 hrs

Laser Metrology: Free electron laser – optical alignment, measurement of distance – interferometry, reversible counting, refractive index correction, reversible counting, refractive index correction, surface topography and optical component testing,

Chapter 5: Analysis of Experimental Data

Causes and Types of Experimental Errors, Error Analysis on a Common sense Basis, Uncertainty Analysis and Propagation of Uncertainty, Evaluation of Uncertainties for Complicated Data Reduction, Statistical Analysis of Experimental Data, Probability Distributions, The Gaussian or Normal Error Distribution, Comparison of Data with Normal Distribution, The Chi-Square Test of Goodness of Fit, Method of Least Squares, The Correlation Coefficient, Multivariable Regression, Standard Deviation of the Mean, Students t-Distribution — 07 hrs

Chapter 6: Quality Engineering

Quality concepts, Dimensions of quality, Inspection, Objectives of Inspection Difference between Inspection & Quality Control,7 QC tools, Statistical methods for quality control and improvement Basic Principles of control charts, control charts for variables, process capability and six sigma — 07 hrs

Unit – III

Chapter 7: Control charts for attributes and acceptance sampling

Control chart for fraction non-conforming, variable sample size, Number of defective chart, Control chart for Non conformities (defects) and Control chart for defects Average number of nonconformities. — 05 hrs

Types of sampling plans, operating characteristic (OC) curves

Chapter 8: TQM — 05 hrs

Basic approach, TQM framework, TQM principles-Leadership, Employee involvement, Empowerment, Team and Teamwork, Quality circles ,Continuous process improvement – PDCA cycle, 5S, Kaizen – Supplier partnership – Partnering, TQM techniques- Bench marking, FMEA, QFD, TPM

Text Books:

1. Beckwith Marangoni and Lienhard, Mechanical Measurements, Pearson Education
2. Doebelin E.O., Measurements Systems, Applications and Design, McGraw –Hill 1990
3. Montgomery D. C., Introduction to Statistical Quality Control, John Wiley & Sons, Inc

Reference Books:

1. Holman J P, Experimental Methods for Engineers, McGraw-Hill. Eighth edition.
2. I.C. Gupta, Engineering Metrology, Dhanpat Rai Publications, Delhi.
3. Dotson C. Cengage, Fundamentals of Dimensional Metrology.
4. Bosch J A, Giddings and Lewis Dayton, Marcel Dekker. Co-ordinate Measuring Machines and Systems
5. Grant and Leavenworth, Statistical Quality Control, McGraw Hill

Course Code: **15EMEC303** **Course Title: Introduction to Finite Element Methods**

L-T-P: 3-0-0 Credits: 3 Contact Hrs: 3 hrs/week

ISA Marks:50 ESA Marks: 50 Total Marks: 100

Teaching Hrs: 40 Exam Duration: 3 hrs

Unit - 1

1. Introduction to FEM:

FEM paradigm : History, present/future, Research, Application, stress at a point, stress components on arbitrary plane, Equilibrium equations, compatibility equations, Generalized Hook's law, Plane stress and plain strain, principle of minimum potential energy and virtual work, RR method and Galerkin's methods, FEM steps, Advantages , disadvantages and limitations. 07 hrs

2 Interpolation Functions For General Element Formulation :

Discreatisation process, types of elements, size of elements, location of node, node numbering scheme and mesh requirements in finite element method, polynomial form of interpolation functions, convergence requirements, Pascal triangle, shape functions (1D, 2D, LST, CST, Quad, Higher order elements), Stiffness matrix and its properties. 08 hrs

Unit - 2

3. Basic FEA:

Illustrate the concept of linear static analysis, Non-linear analysis: Material, Geometry and Contact nonlinearity, Linear buckling analysis, Dynamic analysis, and Thermal analysis using practical applications. 10 hrs

4. Advanced FEA:

Optimization - Shape/Material, Crash/Impact/Drop test analysis, Fatigue analysis: Stress based and Strain based approach, Modeling & Analysis of Composite (Coupons, Laminates, particulate form). Iso-parametric and Axi-symmetric elements. 07 hrs

Unit - 3

5. Post processing techniques:

Validate and interpret the results, Average and Un-average stresses, Special tricks for post processing, Design modification, CAE Reports 04 hrs

6. Experimental Validation and Data Acquisition:

Strain gauge, Photo elasticity, Load cells, Torque Sensors/Transducers, Dynamic tests, Acceleration test, Fatigue life measurement, Natural Frequency measurements. 04 hrs

Text Book

1. K. H. Huebner, D. L. Dewhirst, D. E. Smith and T. G. Byrom, The Finite Element Method for Engineers, 4th edition, Wiley, New York, 2001.
2. T. R. Chandraputala and A. D. Belegundu, Introduction to Finite Elements in Engineering, Third Edition, Prentice Hall of India, 2004.
3. Nitin Ghokale, Practical finite element analysis, Finite to infinite, 2008.

Reference Book:

1. N. S. Ottosen and H. Petersson, Introduction to the Finite Element Method,. Prentice-Hall, Englewood Cliffs, 1992.

Course Code: 15EMEC304 **Course Title: Design of Machine Elements**

L-T-P: 3-1-0 Credits: 4 Contact Hrs: 5

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Teaching Hrs: 40+24 Exam Duration: 3 hrs

Unit – 1

Chapter 1: Spur Gears 08 hrs

Mechanical Drives, Gear Drives, Classification of Gears, Selection of Type of Gears, Terminology of Spur Gear, Standard Systems of Gear Tooth, Force Analysis, Gear Tooth Failures, Selection of Material, Number of Teeth, Face Width, Beam Strength of Gear Tooth, Permissible Bending Stress, Effective Load on Gear Tooth, Estimation of Module Based on Beam Strength, Wear Strength of Gear Tooth, Estimation of Module Based on Wear Strength

Chapter 2: Helical and Bevel Gears 07 hrs

Helical Gears, Terminology of Helical Gears, Virtual Number of Teeth, Tooth Proportions, Force Analysis, Beam Strength of Helical Gears, Effective Load on Gear Tooth, Wear Strength of Helical Gears. Bevel Gears, Terminology of Bevel Gears, Force Analysis, Beam Strength of Bevel Gears, Wear Strength of Bevel Gears, Effective Load on Gear Tooth.

Unit – 2

Chapter 3: Springs 08 hrs

Types of springs, Terminology of Helical spring, styles of ends, stress and deflection equations, series and parallel connections, spring materials, Design of helical springs, spring design –trial and error method, design against fluctuating load, optimum design of helical spring, surge in spring, multi-leaf springs, nipping of leaf springs.

Chapter 4 Clutches and Brakes 07 hrs

Clutches, Torque Transmitting Capacity, Multi-disk Clutches, Friction Materials, Block Brake and Disc Brakes

Unit – 3

Chapter 5: **Rolling Contact Bearings** 05 hrs

Bearings, Types of Rolling Contact Bearings, Selection of Bearing Type, Static Load Carrying Capacity, Dynamic Load Carrying Capacity, Equivalent Bearing Load, Load-Life Relationship, Selection of Bearing Life, Load Factor, Selection of Bearing From Manufacturer's Catalogue, Bearing failure – Causes and Remedies.

05 hrs

Chapter 6: Sliding Contact Bearings

Basic Modes of Lubrication, Viscosity, Measurement of Viscosity, Viscosity Index, Petroff's Equation, Mckee's Investigation, Bearing Design- Selection of Parameters, Comparison of Rolling and sliding Contact Bearings, Bearing failure – Causes and Remedies

Text Book:

1. Robert L. Norton, Machine Design , An integrated Approach, , Pearson Education, 2004
2. V.B. Bhandari, Design of Machine Elements:, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2nd Edition 2007.

References:

1. S.K. Somani, Machine Design: Hall, Holowenko, Laughlin (Schaum's Outlines series) Tata McGraw Hill Publishing Company Ltd., New Delhi, Special Indian Edition, 2008.

Design Data Hand Books:

1. K. Mahadevan and Balaveera Reddy, Design Data Hand Book, CBS Publication

Course Code: 15EMEP301 **Course Title: Metrology and Quality Engineering Lab**

L-T-P: 0-0-1 Credits: 1 Contact Hrs: 2 hrs/week

ISA Marks: 80 ESA Marks: 20 Total Marks: 100

Teaching Hrs: 24 Exam Duration: 2 hrs

Expt. No.	Brief description about the experiment	No. of Lab. Slots
01	Introduction to the Laboratory-Overview of standards of measurement for Linear and angular dimensions.	01
02	Analysis of performance characteristics of measuring instruments using Hypothesis testing.	01
03	Analysis of Repeatability and Reproducibility using gauge R& R test.	01
04	Measurement of Screw thread and Gear parameters, surface roughness	01
05	Machine Tool Alignment Test (Lathe, Drilling, Milling).	01
07	Measurement of Dimensions and GD&T parameters of given components using CMM (Coordinate Measuring Machine).	01
08	Reverse engineering of the given component by extraction of 2-Dimensions of the given part using 3D scanner.	02
09	Testing the goodness of fit for the given quality characteristics by Chi Square test	01
10	Construction of control chart for variables and Analysis of process capability for the different components manufacturing.	01
11	Construction and Analysis of control charts for defectives.	01
12	Open ended experiment- Error analysis , Gauge Design	01

Reference books:

1. Hume K.J.& Sharp G.H, ”Practical metrology”, ELBS &Macdonald
2. Montogomery D. C., Introduction to statistical Quality control, John wiley and sons.
3. Juran J.M. & F.M. Gryna, Quality Planning & Analysis, TMH

Course Code: 15EMEP302 **Course Title: Computer Aided Engineering Lab**

L-T-P: 0-0-1 Credits: 1 Contact Hrs: 2 hrs/week

ISA Marks: 80 ESA Marks: 20 Total Marks: 100

Teaching Hrs: 24 Exam Duration: 2 hrs

LAB Details:

Category: Demonstration		**No. of Lab. Sessions per batch (estimate)**
1	Scientific Research Exposure (Research Education): Methods to search/extract Journal papers (Reputed journal paper), Referring papers, Drafting a paper. Introduction to ANSYS Workbench and familiarity. Real time Current/future field issues : Problem Identification	**03**

Category: Exercises

Expt./Job No.	**Experiment/job Details**	**No. of Lab. Sessions per batch (estimate)**
1.	Static Structural analysis a) Uniform bar, b) Bracket, c) Machine Components	01
2.	Non-Linear Structural Analysis a) Geometric Nonlinearity b) Material Nonlinearity c) Contact Nonlinearity	01
3.	Dynamic Analysis (Modal/Harmonic/Transient Analysis) a) Beam (Different Boundary Conditions) b) Machine components	01
4.	Linear Buckling a) Columns & Struts (Different Boundary Conditions) b) Machine Component	01
5.	Thermal Analysis a) Fins b) Heat Exchangers c) Machine component	01
6.	Fatigue Analysis & Fatigue life Prediction a) Plate with hole or Bracket b) Machine components such as Shafts, Bearing etc.	01
7.	Drop Test & Impact Analysis a) Mobile drop test b) TV, Refrigerator etc.	01
8.	Optimization	01
9.	Composite Analysis - Laminate/Dispersed Coupon model	01

Category: Structured Enquiry

Execute all the FEM Analysis modules which are dealt under the lab exercise.
Identify the component (Sub-assembly need have Minimum 3 to 4 components)
Start from scratch

- Measure the dimensions of component
- Generate the Solid Modeling of components with overall assembly (In any of the CAD Software)
- Import the model in neutral form to ANSYS Workbench
- Collection of data relevant to Material Properties
- Understand the physics of the problem (Working Principle with load's and boundary conditions)

- Interpretation of Results with conclusion.

Category: Open ended

Identify field issue pertaining to any component/product in today's industry.

1. Collect the information/literature on earlier worked project through external/internal search (Journal Paper/Patent/reports)
2. Comprehend the physics of the problem with working principle.
3. Prepare the abstract and apply to a national/international conference
4. Identify material properties, boundary conditions and load steps.
5. Carryout the analysis as per the FEA steps.
6. Provide engineering solutions to the identified sub assembly (deformation and stresses, material change, weight reduction, increasing load bearing capacity, fatigue life calculation, prediction of endurance limit of component and damage factor).
7. Prepare the draft on the worked out problem and apply to a national/international conference

Materials and Resources Required:

1. Books/References: Nitin Ghokale, Practical finite element analysis
2. Manuals: Sham Tickoo, ANSYS for Engineers and Designers.

Course Code: 15EMEP303 **Course Title: Automation Lab**

L-T-P: 0-0-2 Credits: 2 Contact Hrs: 4 hrs/week

ISA Marks: 80 ESA Marks: 20 Total Marks: 100

Teaching Hrs: 48 Exam Duration: 2 hrs

Chapter No. 1. Automation Using Hydraulic Systems 08 hrs

Introduction to Fluid Power, Advantages and application of Fluid Power, Types of Fluid Power System, Properties and Types of Fluids. Pascal's Law, Continuity Equations, Structure of Hydraulic Control System. The Source of Hydraulic Power: Pumps Pumping Theory, Pump Classification, Gear Pumps, Vane Pumps, Piston Pumps, Pump Selection, Hydraulic Actuators and Motors. Control Components In Hydraulic Systems: Symbolic representation as per ISO 1219 and ISO 5599. Directional Control Valves – Symbolic representation, Constructional features, pressure control valves, flow control valves. **Hydraulic Circuit Design (Simulation of circuits in Automation studio):** 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 circuits, speed control of hydraulic cylinder, accumulator circuits.

Chapter No. 2. Automation using Pneumatic Systems 05 hrs

Choice of working medium, characteristics of compressed air. Structure of Pneumatic control system. Linear cylinders, Simple Pneumatic Control: Direct and indirect actuation pneumatic cylinders, use of memory valve. Flow control valves and speed control of cylinders supply air throttling and exhaust air throttling, use of quick exhaust valve. Signal processing elements: Use of Logic gates – OR and AND gates pneumatic applications.

Chapter No. 3. Automation Using Electronic Systems 05 hrs

Control of hydraulic and pneumatic elements through PLC, Programmable automation controllers(PAC)

Chapter No. 4. Robot programming & Control 05 hrs

Introduction to robotics, robot anatomy, work volume, robot drive systems, control systems and dynamic performance, precision of movements, end effectors Robot physical configuration and basic robot motions, Types of manipulators- constructional features, servo and non-servo manipulators.

Text Book

1. Mikell.O. Groover , Automation, Production system and Computer Integrated Manufacturing, 2nd, PHI, 2002
2. Anthony Esposito, Fluid power with applications, 5th, Pearson Ed, 2000
3. Mikell P. Groover& Mitchell Weiss, Industrial Robotics, 2nd, Mc Graw H, 2003
4. William Bolton, Programmable Logic Controllers, 4th, Newnes, 2006

References

1. S R Majumdar, Hydraulic systems, Principles and Maintenance, 5th, TMH, 2002
2. S R Majumdar, Pneumatic Systems, 2nd, TMH, 1995
3. Labrotaory manual prepared by inhouse team.

Laboratory:

Sl. No	Name of Experiments	Duration
1	Characteristic Curve of Variable Displacement Hydraulic Pump	1/2
2	Carryout pressure intensification of a single-rod cylinder	1/2
3	Carryout Meter-in and Meter-out circuits using Single-rod cylinder and 4/2 DCV	1/2
4	Center Configuration of 4/3 DCV	1/2
5	Application of Regenerative Circuit	1
6	Direct control of Double Acting Cylinder	1/2
7	Indirect control of Double Acting Cylinder	1/2
8	Speed Control of Single Acting Cylinder	1/2
9	Position Dependent Control of a Double Acting Cylinder with Mechanical Limit	1/2

	Switches	
10	Design of PLC system to control single acting cylinder, double acting cylinder, meter-in, meter-out and regenerative action.	1
11	To control extension/retraction with or without delay using ladder logic	1
12	Design of PLC system for, i. Clamping and punching operation (punching press machine) ii. Clamping and movement of tailstock (CNC machine)	1
13	To build and simulate arc/spot welding process in robotic environment	1
14	To build and simulate pick and place mechanism in robotic environment	1

Course Code: 15EMEC305 **Course Title: Heat & Mass Transfer**

L-T-P: 3-0-0 Credits: 3 Contact Hrs: 3 hrs/week

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Teaching Hrs: 40 Exam Duration: 3 hrs

Unit –I

Chapter 1.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, 06 hrs

Mass transfer; Definition and terms used in mass transfer analysis, Fick's first law of diffusion. Boundary conditions of 1^{st} , 2^{nd} and 3^{rd} kind Conduction: General 3D- heat conduction equation in Cartesian coordinate, discussion on 3-D conduction in cylindrical and spherical coordinates (No derivation). 1-D conduction through plane and composite walls. Overall heat transfer coefficient. Mathematical formulation

Chapter 2 One dimensional Steady State Conduction: Heat flow and temperature distribution in plane wall. Critical thickness of insulation, Thermal resistance concept. Steady state conduction in slab, cylinder and spheres with heat generation. Heat transfer in extended surfaces of uniform cross-section without heat generation [No Derivations]Fin efficiency and effectiveness. Numericals 05 hrs

Chapter 3.One-dimensional transient conduction: Conduction in solids with negligible internal temperature gradient (Lumped system analysis), Use of Transient temperature charts (Heisler's charts) for transient conduction in slab, long cylinder and sphere Numerical Problems 04 hrs

Unit – II

Chapter 4. Concepts and basic relations in boundary layers: 05 hrs

Flow over a body velocity boundary layer, general expressions for drag coefficient and drag force, thermal boundary layer. general expression for local heat transfer coefficient; Average heat transfer coefficient; Nusselt number. Flow inside a duct, Numerical problems based on empirical relation given in data handbook.

Free or Natural Convection: Dimensional analysis for free convection- significance of Grasshoff number, correlations for free convection over vertical, horizontal and inclined flat plates, vertical and horizontal cylinders and spheres

Chapter 5. Forced Convection: Dimensional analysis for forced convection, significance of Reynolds, Prandtl, Nusselt and Stanton numbers. Correlations for hydrodynamically and thermally developed duct flows, Correlations for flow over flat plate, cylinder and sphere. 05 hrs

Chapter 6.Heat Exchangers: Classification of heat exchangers; overall heat transfer coefficient, fouling and fouling factor; LMTD, Effectiveness-NTU methods of analysis of heat exchangers. Numerical problems 05 hrs

Unit – III

Chapter 7. Condensation and Boiling: Types of condensation (discussion only) Nusselt's theory for laminar condensation on a vertical flat surface [No Derivation]; use of correlations for condensation. Regimes of pool boiling pool boiling correlations [Theory]. 05 hrs

Chapter 8. Radiation heat transfer: Thermal radiation; definitions of various terms used in radiation heat transfer; Stefan-Boltzman law, Kirchoff's law, Planck's law and Wein's displacement law. Radiation heat exchange between two parallel infinite black surfaces, between two parallel infinite gray surfaces, intensity of radiation and solid angle; Lambert's law; radiation heat exchange between two finite surfaces configuration factor or view factor. Numerical problems 05 hrs

Text Book

1. Nicati Ozisik - Heat transfer-A basic approach, Tata Mc Graw Hill, 2002
2. M.Tirumaleshwar – Fundamentals of Heat & Mass Transfer, Pearson education 2009

References

1. Yunus A. Cengel - Heat transfer, a practical approach, Tata Mc Graw Hill, 4^{th} Edn, 2011
2. Frank Kreith, Raj M. Manglik, Mark S. Bohn, Principles of heat transfer, Cengage Learning, 7^{th} Edn. 2011
3. Frank P. Incropera and David P. Dewitt- Fundamentals of Heat and mass transfer, John Wiley, 6^{th} Edn., 2011
4. P.K. Nag - Heat and Mass transfer, Tata Mc Graw Hill, 3^{rd} Edn.,2002

Course Code: 15EMEC307 **Course Title: I C Engines**

L-T-P: 2-0-0 Credits: 2 Contact Hrs: 2 hrs/week

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Teaching Hrs: 26 Exam Duration: 3 hrs

Unit – 1

Chapter 1: Introduction to I C Engines: 7 hrs

Internal Combustion Engine Classification, Operating Cycles, Spark Ignition and Compression-Ignition Engines.

Combustion in Spark Ignition Engines

Ignition limits, Normal combustion, Thermodynamic Analysis of SI Engine Combustion - stages, ignition lag, and effect of engine variables on ignition lag Causes of Cycle-by-Cycle and Cylinder-to-Cylinder Variations and flame propagation phase, detonation, Abnormal Combustion: Knock Fundamentals and fuel factors, Factors affecting knock.SI engine combustion chambers.

Chapter 2: Combustion in Compression Ignition Engines 5 hrs

Types of Diesel Combustion Systems, Direct and Indirect-Injection Systems, Comparison, Combustion Efficiency, Normal combustion – stages, delay period, variables affecting delay period. Diesel knock, comparison between diesel and petrol engine knocks. CI engine combustion chambers, Fuel spray behavior. HRR analysis.

Unit – 2

Chapter 3: Engine Exhaust Emission Control 5 hrs

Formation of NO_X, HC/CO mechanism , Smoke and Particulate emissions, Green House Effect, Methods of controlling emissions , Three way catalytic converter and Particulate Trap, Emission (HC, CO, NO and NO_X) measuring equipments, Smoke and Particulate measurement, Indian Driving Cycles and emission norms.

Chapter 4: Recent Trends in IC Engines 6 hrs

Dual fuel Engine, Common Rail Direct Injection Diesel Engine (CRDI), Homogeneous Charge Compression Ignition Engine (HCCI), Reactivity controlled compression ignition engine (RCCI) Lean Burn Engine, Surface Ignition alcohol CI Engine, VVT engines, Gasoline Direct Injection Engine.

Unit – 3

Chapter 5: Overall Engine Performance: 4 hrs

Operating Variables that Affect SI Engine Performance, Efficiency, and Emissions: Spark Timing, Mixture Composition, Load and Speed, Compression Ratio. Variables that Affect CI Engine Performance, Efficiency, and Emissions: Load and Speed, Fuel-Injection Parameters.

Chapter 6: Alternate Fuels for IC Engines 3 hrs

Alcohols, bio-diesel, Natural Gas, Hydrogen, Properties, Suitability, Engine Modifications

TEXT BOOK:

1. John B Heywood, Internal Combustion Engine Fundamentals, Tata McGraw-Hill, 1988
2. Heinz Heisler, Advanced Engine Technology, SAE International Publications, USA,1998
3. Patterson D.J. and Henein N.A, Emissions from combustion engines and their control, Ann Arbor Science publishers Inc, USA, 1978

REFERENCES:

1. Ganesan V. Internal Combustion Engines, Third Edition, Tata Mcgraw-Hill, 2007.
2. Gupta H.N, Fundamentals of Internal Combustion Engines, Prentice Hall of India, 2006.
3. Ultrich Adler, Automotive Electric / Electronic Systems, Published by Robert Bosh GmbH, 1995.

Course Code: 17EMEC308 **Course Title: CAD Modeling, Analysis & PLM**

L-T-P: 2-0-5 Credits: 7 Contact Hrs: 15 hrs/week

ISA Marks: 80 ESA Marks: 20 Total Marks: 100

Teaching Hrs: 80 Exam Duration: 2 hrs

Sl no	Work benches	description	No of weeks
1	Sketcher	Brief introduction on Sketcher work bench environment Structure of users and saving of files. **Exercises on Sketch** Tools, Profile Tool bar and Constraint Tool bar: Generate the following 2D sketches and make them Iso-constrained.	1
2	Part Design	Exercise on 3d models using pad, slot, shaft, groove, hole ,rib and stiffener commands, cut revolve, Dress up commands like chamfer, fillets etc. (Multi-Sections Solid and Removed Multi-Sections Solid Commands)	2
3	Generative Shape Design (GSD)	Exercises using GSD to generate complicate surfaces using sub tool bars: Extrude-Revolution, Offset Var and Sweeps Extrude, Revolve, Trim, Transformation and Fillet tools Exercises on Wireframe, Surfaces and Operations Tool bar: (Conversion of Surface model into Solid model	2
4	Sheet Metal	Setting Sheet Metal Parameters, Bend Extremities Tab, Creating the Base Wall, Creating the Wall On Edge, Creating extrusions, Creating swept walls, Creating Hems on Sheet Metal part, Creating A Bend. Development of sheet metal drawings.	1
5	Assembly design	Introduction to Assembly Design Work bench Bottom-Up and Top-Down assembly approaches Invoking existing components into assembly work Exercise to demonstrate Top-Down assembly approach.	2
6	Drafting	Converting existing 3D models into 2d drawings with all relevant details, sectional views, sheet selection, indicating GD&T symbols and dimensioning.	3
7	Enovia	Introduction to CATIA V6 PLM Import the existing CATIA V5 data and store in V6 Search and identify the data located in V6 database Modify the data in any PLM process Sharing information with users Analyze and Identify impacts of modifications Save the modifications into database	1

Course Code: 15EMEP304 **Course Title: Thermal Engineering Lab.**

L-T-P: 0-0-1 Credits: 1 Contact Hrs: 2 hrs/week

ISA Marks: 80 ESA Marks: 20 Total Marks: 100

Teaching Hrs: 24 Exam Duration: 2 hrs

1. **Fluid mechanics and hydraulic machines**
   i. To obtain the performance characteristics of centrifugal blower
   ii. To study the effect of speed on the performance of centrifugal pump
   iii. To study the effect of speed / gate opening on the performance of Pelton turbine
   iv. To study the effect of speed / gate opening on the performance of Francis turbine

2. **Heat transfer**
   i. To determine the emissivity of given surface
   ii. To determine the thermal conductivity of metal bar and to study the effect of temperature on thermal conductivity
   iii. To study the performance of pinfin
   iv. To study the performance of vapour compression refrigeration (VCR) system

3. **I C Engines**
   i. To study the performance of two stroke engine
   ii. To obtain the performance characteristics of multicylinder engine using Morse test
   iii. To study the effect of engine operating variables (Injection pressure/ injection timing/ compression ratio)

Materials and Resources Required:

1. White, F.M., Fluid Mechanics, 5ed., McGraw Hill International, 2003
2. Nicati Ozisik - Heat transfer-A basic approach, Tata Mc Graw Hill, 2002
3. Yunus A. Cengel - Heat transfer, a practical approach, Tata Mc Graw Hill, 4th Edn, 2011
4. John B. Heywood, Fundamentals of Internal Combustion Engines, McGrawHill, Singapore.
5. Ganesan.V, Internal Combustion Engines, Tata McGraw Hill, 2nd Edition, 2003
6. Manuals: Lab manual prepared by the Department

Course Code: 15EMEW303 **Course Title: Mini Project -- II**

L-T-P: 0-0-3 Credits: 3 Contact Hrs: 3 hrs/week

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Exam Duration: 3 hrs

Minor Project Theme

The minor project is designed to help students develop practical ability and knowledge to understand basics of Machine tool design. This course project involves practically designing a given specifications of a machine develop alternate designs carry out design calculations. The theoretical knowledge gained from the MACHINE TOOL DESIGN course helps in providing the necessary foundation/principles to develop effective solutions. Students shall apply methodologies learnt in Engineering Design Course. A batch of 10 students each will be given specifications of a machine or system.

The students will have to develop proficiency in 2D and 3D modeling, Geometrical dimensioning & tolerancing. He/she should be well versed in material selection based on applications and develop assembly and part drawings as per industry standard,

Individual team has to prepare final model in 2D and 3D with proper documentation for the entire project. Progress of the project work will be presented by student's periodically to the panel of reviewers.

The project given will be CNC lathes, CNC milling or any other project like development of a lathe headstock and feedbox etc

Phases of Project Work:

- Students will first be given an assignment to showcase their proficiency in Auto CAD, Solid modeling and application of GD&T on manufacturing drawings.
- For projects, specifications will be provided for each batch of 10 students. They have to prepare layouts of assemblies, and convert the specifications into layouts taking due accounts of standards from ISO, IS, ASTM & Machine testing.
- Prepare alternate designs wherever required and select the most optimal design.
- Carry out design calculations to select various machine tool elements like servo motor, spindle motor, keys, poly-v belts, ball-screws etc.
- Prepare assembly drawings of various assemblies with all part drawings as per industry standards and prepare Bill of Material.
- Carry out aesthetics, ergonomics and safety standards and incorporate them in the drawings.
- Prepare a final detailed report explaining the various stages and give a presentation.

Course Code: 15EMEE301 **Course Title: Mechanical Vibrations**

L-T-P: 3-0-0 Credits: 3 Contact Hrs: 3 hrs/week

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Teaching Hrs: 40 Exam Duration: 3 hrs

Unit – 1

1. Undamped Free Vibrations 6hrs

Introduction, Importance of vibration and its physical significance, Types of vibrations, Mechanical system components, Equivalent stiffness of spring combinations, Derivation of differential equation and Natural frequency for undamped free vibrations of single degree freedom systems, Newton's method and Energy method, Torsional vibrations, Transverse vibrations of beams.

2.Damped Free Vibrations 5hrs

Introduction, types of damping, study of response of single degree freedom viscous damped systems for cases of under damping, critical damping and over damping, Logarithmic decrement, Torsional system with viscous damping.

3.Whirling of Shafts

Introduction, Whirling of shafts with and without damping, Discussion of speeds above and below critical speeds, Introduction to Noise. 5hrs

Unit – 2

4. Forced Vibrations

Introduction, Forced vibrations of single degree freedom viscous damped system due to harmonic excitation, Response of a rotating and reciprocating unbalance system, Support excitation, Vibration isolation and transmissibility. 7 hrs

5. Two Degree of Freedom Systems

Introduction, Principal modes and Normal modes of vibration, Vibrations of undamped systems, Torsional vibrations, Forced harmonic vibration, Systems with damping, Co-ordinate coupling; applications in vehicle suspension, Dynamic vibration absorber. 7 hrs

Unit – 3

6. Multi Degree of Freedom Systems

Introduction, Influence coefficients, Maxwell reciprocal theorem, Orthogonality principle, Matrix iteration method to determine all the natural frequencies of multi degree freedom systems, Dunkerley's method, Rayleigh's method. 5 hrs

7. Vibration Measurement and Condition Monitoring

Introduction, Vibrometer and accelerometer, Frequency measuring instruments. Signal analysis: Spectrum analyzers, Dynamic testing of machines and structures, Experimental modal analysis, Machine maintenance techniques, Machine condition monitoring techniques, Vibration monitoring techniques. Demonstration of experimental modal analysis using Sakshat Virtual lab. 5 hrs

Text Book

1. S. S. Rao, Mechanical Vibrations, Pearson Education , 6th Edition, 2017
2. W.T. Thomson and Marie Dillon Dahleh - Theory of Vibration with Applications, Pearson Education 5th edition, 2007

References

1. S. Graham Kelly, Adopted by: Shashidhar K Kudari - Mechanical Vibrations, Schaum's Outlines, The McGraw-Hill, 2007.
2. Mechanical Vibration Practice with Basic Theory- V. Ramamurti, Narosa, 2000

Course Code: 15EMEE302 **Course Title: Failure Analysis in Design**

L-T-P: 3-0-0	Credits: 3	Contact Hrs: 3 hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 50		Exam Duration: 3 hrs

Unit – 1

1. Introduction: Study of Failure criteria and its importance, 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. 8hrs

2.Surface Failure: Introduction, Surface geometry, Mating surface, Friction, Adhesive wear, Abrasive wear, Corrosion wear, Surface fatigue spherical contact, Cylindrical contact, General contact, Numerical examples. 7hrs

Unit – 2

3. Fatigue of Materials: History of failure due to fatigue loads and development of fatigue failure, Concepts and terminology, High cycle and low cycle fatigue, Fatigue design models, Fatigue design methods, Fatigue design criteria, Fatigue testing, Fatigue fracture surfaces and macroscopic features, Fatigue mechanisms and microscopic features. 5hrs

4. Stress-Life (S-N) Approach: S-**N** curves, Statistical nature of fatigue test data, General S-N behavior, Different factors influencing S-N behavior, S-N curve representation and approximations, Constant life diagrams, Fatigue life estimation using S-N approach, Case study. 5hrs

5. 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. 5hrs

Unit – 3

6. **Creep deformation:** The evolution of creep damage, primary, secondary and tertiary creep. Stress dependence of creep – power law dependence. Comparison of creep performance under different conditions – extrapolation and the use of Larson-Miller parameters. Creep-fatigue interactions. Numerical examples. 5hrs

7. Buckling Analysis of rectangular palates: Governing differential equation and boundary conditions, plate with all edges simply supported, plates with other boundary conditions, buckling under in-plane shear, post buckling analysis. 5hrs

Text Book

1. Ralph I. Stephens, Ali Fatemi, "Metal Fatigue in Engineering", John Wiley New York, 2nd edition, 2001.
2. Robert L. Norton, Pearson, "Machine Design- An Integrated Approach", 2nd edition, 2000.
3. Jack A Collins, Failure of Materials in Mechanical Design John Wiley & Sons, 1993.
4. Gambhir, M.L, Stability Analysis and Design of Structures, Springer-Verlag, 2004.

Course Content

Course Code: 15MEE303 | **Course Title: Piping systems Design**

L-T-P: 3-0-0	Credits: 3	Contact Hrs: 3
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 3		Exam Duration: 3 hrs

Unit - 1

Chapter No. 01. Introduction to piping — 2 hrs
Role of piping design engineers, Inputs and outputs of piping department, Scope and prospects in various industries, trends in piping industry.

Chapter No. 02. Piping systems Basics — 3 hrs
Process Design, Block Flow diagrams, Process flow diagrams (PFD), Piping and Instrumentation Diagrams(P&ID's), Commonly used symbols in PFD and P & ID, Lines/signals, Piping: services, equipments, Fluid codes (process), Insulation.

Chapter No. 03. Codes and Standards — 2 hrs
Standards, major organizations for standards, Design code-ASTM standards, ASME standards

Chapter No. 04. Piping elements and symbolic representations — 4 hrs
Fittings used to join pipes, Fittings used to change pipe direction, Fittings used to join different sizes of pipes, Fittings used for various purposes –such as flange, gaskets, Fittings used for branching, special fittings used for Branching.

Unit - 2

Chapter No. 05. Valves — 3 hrs
Types of valves, control valves, safety valves, constructional features. Criteria for selection. Piping components, pressure relieving devices, constructional features, selection criteria. Gate valve, globe valve, ball valve, check valve, Butterfly valve, Diaphragm Valves, Needle valve, Piston valve, Knife Gate valve.

Chapter No. 06. Process Equipments used in plants — 3 hrs
Pumps, storage tanks, vertical vessels, Horizontal dryer, Heat Exchangers, filters, blowers, Industrial boilers, steam turbines, compressors,

Chapter No. 07. Process Instruments — 3 hrs
Pressure Gauge, Temperature Gauge, Level indicators, flow metering/indicators, Safety valves, breather valves.

Chapter No. 08. Plot Plan Development — 2 hrs
Plot plan development, Basic data, steps to be considered while developing the plot plan. Layout of Liquid storage, Layout considerations for explosive tank farm, Layout of gas Storage.

Unit - 3

Chapter No. 09. Piping Layouts — 3 hrs
Introduction to P&I Diagrams, process flow diagrams, standard symbols and notations. Introduction to various facilities required. Guidelines for plot plan/ plant layout. Introduction to equipment layout, piping layout, piping isometrics and bill of material. Typical piping system layout considerations. Piping arrangements, clearances and access, pipe rack, valve location, tower piping,

Chapter No. 10. Conversion of orthographic to isometric view — 3 hrs
Introduction to isometric view, symbolic representation of elements in isometric environment, Pipe layout exercises,

Chapter No. 11. Plant Layout Design software - LAB — 12 hrs
Introduction to CADMATIC Software, 15 most important shortcut commands and practice Construction of Pipe line Route, 4 (Pipe D)(refer to the drawing in the next subsequent pages),

Construction of Pipe line Route 6 (Pipe F) , Construction of Pipe line Route 8.(Pipe H) , Construction of Pipe line Route 9(Pipe I), Construction of Pipe line Route 11 (Pipe K), Construction of Pipe line Route No 14 (Pipe M). Construction of Pipe line Route No 3, 1, 2, (Pipe C, A, B) , Construction of Pipe line Route No 5 ,7, 10,(Pipe E, G, J) , More features of software namely ladder, pipeline rack, and cable tray construction. Construction of all the pipeline network and Practice session

Text Books (List of books as mentioned in the approved syllabus)

1. Ed. Baushbacher, Roger Hunt, Process Plant Layout and Piping Design, 1993, Prentice Hall , 1993

References

1. Suvidya Institute of Technology Pvt. Ltd, Manual on Piping Engineering, Suvidya Institute of Technology Pvt. Ltd. Mumbai

2. Yunus A. Cengel, John M. Cimbala,, Fluid Mechanics Fundamental and Applications, 2nd, MGH,, 2006

Course Code: 15EMEE304 **Course Title: Product Innovation**

L-T-P: 2-1-0	Credits: 3	Contact Hrs: 4 hrs/week
ISA Marks: 70	ESA Marks: 30	Total Marks: 100
Teaching Hrs: 24	Tutorial Hrs : 24	Exam Duration: 3 hrs

Unit – 1

1. Innovation Types, Drivers and Enablers

Definition and different types of innovations shall be discussed with live examples in the product development industry. Innovation drivers and enablers which lead to product innovations shall be elucidated with case studies. 8hrs

Unit – 2

2.Innovation Tools and Methods

Though it might sound like contradiction, innovations can be developed systematically by using tools and methods. Innovation methods such as TRIZ, ToC shall be explained with relevant examples. Innovation tools to explore opportunities such as brain-storming, contextual mapping, demographic studies and fore-sighting shall be discussed 8hrs

Unit – 3

3. Innovation Opportunity - Customer and Market Analysis

Customer mapping, demographics and persona shall be explained with examples and tutorials. Market potential and opportunity analysis for different innovations. Technology and demographic trends which shape the market, Competition analysis 5hrs

4. Intellectual Property

Tools and methods to protect IP – Patents, Design Patents, copyrights etc 3hrs

References

1. Playbook for strategic foresight and Innovation – Stanford University
2. R. T. Krishnan and V. Dabholkar- 8 Steps of Innovation
3. TRIZ and ToC – Handouts
4. Skogstad, P., Leifer, L.edited by Meinel, C., Leifer, L., Plattner, H. Springer Berlin Heidelberg. 2011: 19–43, A Unified Innovation Process Model for Engineering Designers and Managers **(**In Design Thinking)

Course Code: 15EMEE305 **Course Title: Advanced Machining Processes**

L-T-P: 3-0-0	Credits: 3	Contact Hrs: 3 hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 40		Exam Duration: 3 hrs

Unit – I

Chapter 1: Introduction to Advanced Machining Processes 03 hours

Introduction to new methods of production; Need and Capability analysis of various processes, Classification and Selection of Non-Traditional Machining Technologies, Hybrid Processes, Cases.

Chapter 2: Mechanical Advanced Machining Processes 12 hours

Abrasive Jet Machining (AJM): Machining setup, parametric analysis, Process capabilities. Ultrasonic machining (USM): Machining setup, Mechanics of Cutting - Model Proposed by Shaw, Parametric analysis, Process capabilities, Abrasive Flow Machining, Magnetic Abrasive Finishing. Water jet cutting (WJC).

Unit – II

Chapter 3: Thermal Advanced Machining Processes 08 hours

Plasma Arc Machining (PAM): Working System, Elements of PAM, Process Performance, PAM Parameters, Process Characteristics, Safety Precautions, Electric Discharge Machining (EDM): Working Principle, Analysis, Process Variables, Process Characteristics, Applications

Chapter 4: Thermo-electric Advanced Machining Processes 07 hours

Electron Beam Machining (EBM): Working Principle, Process Parameters, Characteristics of The Process, Application of EBM, Laser Beam Machining (LBM): Working Principle, Types of Laser, Process Characteristics, Applications, Ion Beam Machining (IBM): Working Principle, Process Parameters, Applications

Unit – III

Chapter 5: Chemical Machining Processes 06 hours

Chemical Machining: Elements of process, Process Characteristics of CHM. Electro Chemical Machining: Elements and Characteristics and Theory of ECM

Chapter 6: Hybrid Processes 05 hours

Electro chemical grinding (ECG), Electrochemical spark machining (ECSM), electrochemical arc machining (ECAM) and electro discharge abrasive grinding (EDAG).

TEXT BOOKS:

1. Jain V. K. “Advanced Machining Processes”, Allied Publishers, Private Limited.
2. Pandey P. C. and Shan H. S., “Modern Machining Processes”, TATA McGraw Hill Publishing Company Limited, New Delhi.

REFERANCES:

1. HMT, “Production Technology”, TATA McGraw Hill.
2. Adithan M, “Modern Machining Methods”, S. Chand & Company, New Delhi.

Course Code: 15EMEE306 **Course Title: Computer Integrated Manufacturing**

L-T-P: 3-0-0 Credits: 3 Contact Hrs: 3 hrs/week

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Teaching Hrs: 40 Exam Duration: 3 hrs

Unit – I

Chapter 1: Manufacturing operations: 08 hrs

Production system facilities, manufacturing support systems, automation in production systems, manual labor in production systems. Automation principles and strategies, manufacturing industries and products, product/production relationships, production concepts and mathematical models, costs of manufacturing operations

Chapter 2: Manufacturing systems: 08 hrs

Components, classification, manufacturing process functions, single station manufacturing cells, applications. Group Technology Part families, classification and coding, production flow analysis

Unit – II

Chapter 3: Cellular Manufacturing, Flexible Manufacturing Systems: 05 hrs

Cellular manufacturing quantitative analysis in cellular manufacturing, FMS components, planning and implementation, quantitative analysis of FMS

Chapter 4: Material handling and storage: 05 hrs

Material handling equipment, considerations in material handling system design, principles of material handling, material transport systems:, storage systems: automated storage systems, automatic data capture, automatic identification methods

Chapter 5: PLM and IIoT: 05 hrs

Areas of Product Life cycle Management (PLM), phases of product life cycle and technologies, benefits of PLM.

Definition of Industrial Internet of Things (IIoT), Evolution, Enablers for IIoT platform, drivers, Benefits, protocols, challenges, future

Unit – III

Chapter 6: Robot fundamentals: 05 hrs

Robot anatomy and related attributes, classification, robot control systems, end effectors, sensors in robotics, robot programming

Chapter 7: Robot kinematics: 05 hrs

Matrix representation, Homogeneous transformation matrices, Representation of transformations, Inverse transformation matrices, forward and inverse kinematics of robots, D-H representation of forward kinematic equations, degeneracy and dexterity

Text Books:

1. Grover M.P., “Automation, Production Systems and Computer Integrated Manufacturing”, Prantice Hall, India.
2. Chris McMahon & Jimmie Browne, “CAD & CAM Principles”, Practice & Mfg. Mngt.’, Pearson Education.

Reference Books:

1. Radhakrishnan P., “CAD/CAM/CIM”, New Age International Private Limited.
2. Zeid Ibrahim, “CAD/CAM”, McGraw Hill International.
3. Rao P.N., ‘CAD/CAM Principles and Applications’, Tata McGraw-Hill.
4. Vajpayee S. K., “Principles of CIM”, Prentice Hall of India.
5. Saeed B. Niku, “Introduction to Robotics”, Prentice Hall of India.

Course Code: 15EMEE307 **Course Title: Sustainable Energy Conversion**

L-T-P: 3-0-0 Credits: 3 Contact Hrs: 3 hrs/week

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Teaching Hrs: 40 Exam Duration: 3 hrs

Unit – I

Chapter No. 1. Energy Analysis of Thermodynamic Systems: 5hrs
Energy Analysis of flow and non-flow processes (Nozzles - Diffusors, Turbine and Compressors, Throttling Valves, Mixing Chambers, Heat Exchangers, Pipe and Duct flow), Isentropic Efficiencies of steady flow devices.

Chapter No. 2.Exergy: A Measure of Work Potential: 4hrs
Exergy associated with kinetic and potential energy, Reversible work and Irreversibility, Second Law efficiency, Second law analysis for non-flow and flow processes.

Chapter No. 3. Vapour and Combined Power Cycles:
Criteria for the comparison of cycles; overall efficiency of a plant: combustion efficiency, mechanical efficiency, generator efficiency; work ratio; specific steam consumption; improvement of Rankine cycle, Reheat cycle, Regenerative cycle - with open and closed heaters; Second Law analysis of Vapour Power Cycles, Combined Gas - Vapour Power Cycles. 6hrs

Unit – II

Chapter No. 4. Reciprocating Compressors: 6hrs
Machine cycle analysis, work and heat transfer; performance parameters of compressors: volumetric efficiency, isothermal efficiency, intercooling, intercooling pressure; reciprocating expanders.

Chapter No. 5. Centrifugal compressors: 6hrs
Velocity diagram, torque, work, power and general heat expression; total or stagnation pressure ratio; mass flow ratio; special considerations: no prewhirl, radial exit effect of blade shape on performance, pressure ratio and volume flow.

Chapter No. 6. Nozzles: Isentropic flow in convergent and convergent - divergent nozzles; critical pressure ratio; effects of varying back pressure. 3hrs

Unit – III

Chapter No. 7. Axial Flow Turbines: 5hrs
Velocity diagram; impulse and reaction turbines; h-s diagram for a stage; frictionless one dimensional flow impulse stage; diagram efficiency, blade speed ratio, optimum blade speed ratio; velocity compounded stage.

Chapter No. 8. Reaction Turbines: 5hrs
Temperature drop across turbines; isentropic efficiency and expansion ratio; degree of reaction and its expression in term of velocity diagram parameters; 50% reaction turbine; multi - staging; losses in turbines.

Text Books

1. Rogers. G.F.C. and Mayhew. Y.R., Engineering Thermodynamics, Longman, 1980.
2. Gordon J. Van Wylen and Richard E. Sonntag, Fundamentals of Classical Thermodynamics, Jenson Books Inc.

Reference Book

1. Yunus. A. Cengel and Michael. A. Boles, Thermodynamics: An Engineering Approach, McGraw Hill.

Course Code: 15EMEC401 **Course Title: Operation Research**

L-T-P: 3-1-0 Credits: 4 Contact Hrs: 5 hrs/week

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Teaching Hrs: 50 Exam Duration: 3 hrs

Unit – I

1.Introduction to operations research: 03 hrs

Introduction to O. R.: System orientation, use of interdisciplinary teams in OR, necessity of OR in business and industry, scope of OR in modern management, OR and decision-making, overview of OR.

2. Linear programming (LP): 12 hrs

Formulation: identification of decision variables, constructing objective functions and constraints, assumptions, practical examples, methods of solution: graphical method, simplex method (Big M and 2-phase methods), by computer, examples.

Unit – II

3. Duality theory and sensitivity analysis: 08 hrs

Duality theory: Existence of dual of a LP problem, economic interpretation of duality, primal dual relationships in formulation and their solutions, Sensitivity analysis or post optimality analysis: Dual simplex method, changes affecting feasibility, changes affecting optimality, examples.

4. Transportation models: 08 hrs

The transportation algorithm: Formulation as a LP problem, determination of initial solution, stepwise improvement to obtain optimal solution, special cases such as multiple, unbalanced, degeneracy etc., the assignment model: Formulation as a LP problem, the Hungarian method of solution examples.

Unit – III

5. Network models: 05 hrs

Critical Path Method (CPM) and Program Evaluation & Review Technique (PERT): Network representation of simple projects, critical path computation, construction of time schedule, crashing of project duration, examples.

6. Game theory: 05 hrs

Formulation of games, two person zero sum game, dominance property, games with and without saddle point, graphical solutions (2 x n, m x 2 game).

Text Book :

1. F.S. Hillier and Lieberman G.J., 'Introduction to Operations Research',9e, McGraw Hill, India, 2017
2. Taha H. A., 'Operations Research: An Introduction', 8e, pearson prentice hall, 2009, .

Reference Book :

1. Wayne L. Winston, 'Operations Research', Brooks/Cole – Thomson Learning.
2. Vohra N. D., 'Quantitative Techniques in Management', Tata McGraw Hill.

Course Code: 15EMEC402 **Course Title: Design of Thermal Systems**

L-T-P: 3-0-0	Credits: 3	Contact Hrs: 3 hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 40		Exam Duration: 3 hrs

Unit - I

1	**Heat Exchangers Classification and Selection** Introduction, Recuperation and Regeneration, Transfer process, Geometry and Construction, - Tubular Heat Exchanger, Plate Heat Exchanger, Extended Surface heat exchanger, Heat Transfer Mechanisms, Flow arrangements, Applications and Selection of Heat Exchangers	5 hrs
2	**Design of Shell and Tube Heat Exchanger** Construction of shell and tube exchanger, specifications and classification of S&T Heat Exchanger, some Typical operating limits for heat exchangers of S&T Type, Analysis of Shell and Tube Heat Exchangers for Temperature Distribution, Design of Shell and Tube Heat Exchangers	10 hrs

Unit - II

3	**Modeling of Thermal Equipment** Counter flow heat exchanger, Evaporators and Condensers, Heat exchanger effectiveness, Effectiveness of a counter flow heat exchanger, NTU, Pressure drop and pumping power, Numerical Problems	6 hrs
4	**Pump and Piping System Design:** Introduction, Physical Fundamentals, Hydraulic fundamentals, Technical fundamentals- Installation, connection, suction pipe, Delivery pipe, NPSH, suction and delivery conditions, Cavitation, Q-H characteristic diagram, Flow rate, flow head, plant characteristic curve operating point	5 hrs
5	**Optimization** Mathematical representation of optimization problems, A water chilling system, Optimization procedure, Setting up the mathematical statement of the optimization problem	4 hrs

Unit - III

5	**LagrangeMultipliers** The Lagrange multiplier equations, unconstrained optimization, Constrained optimization	5 hrs
6	**Dynamic Programming** Characteristic of the Dynamic programming solution, Apparently constrained problem, Application of Dynamic programming to energy system problems	5 hrs

Text Book

1. W.F.Stoecker, Design of Thermal Systems, 3rdedn., MGH, 1989.
2. Sarit K. Das., Process heat transfer, Narosa Publishing House 1st Edition, 2005
3. SadikKakac, Hongtan Liu, Heat Exchanger Selection, Rating and Thermal Design, 2ndedn., CRC Press, 2002.
4. Yunus A. Cengel, John M. Cimbala, Fluid Mechanics Fundamental and Applications, 2nd Edition, MGH, 2006.
5. Manual for the Design of Pipe Systems and Pumps, GEA Tuchenhagen.

References

1. Hodge B.K., Analysis and Design of Thermal Systems, 1stedn., PHI, 1990.
2. CRI pump manufacturers catalog.

Course Code: 15EMEE401 **Course Title: Mechanics of Composite Materials**

L-T-P: 3-0-0 Credits: 3 Contact Hrs: 3

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Teaching Hrs: 40 Exam Duration: 3 hrs

Unit - I

Chapter No. 1: Introduction to Composite Materials 05 Hrs

Introduction, Matrix materials-polymers, metals and ceramics; Reinforcements, Interfaces-wettability, interactions at the interface, types of bonding at the interface, optimum interfacial bond strength.

Chapter No. 2: Polymer Matrix Composites 05 Hrs

Types, characteristics ,processing of PMCs, Layup and curing, fabricating process, open and closed mould process, hand layup techniques; structural laminate bag molding, production procedures for bag molding; filament winding, pultrusion, pulforming, thermo-forming, injection molding, blow molding.

Chapter No. 3: Metal and Ceramic Matrix Composites 05 Hrs

Types of MMCs, base metals selection; important metallic matrices; processing-liquid state and solid state processes; interfaces in MMCs; Need for production of MMC's and its applications; Types of CMCs, processing of CMCs-cold pressing and sintering, hot pressing, reaction bonding processes, liquid infiltration, directed oxidation, in-situ chemical reaction techniques, sol-gel and polymer pyrolysis, applications of CMCs.

Unit - II

Chapter No. 4: Macro Mechanics of a Lamina 08 Hrs

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 - Invariant properties. Numerical problems.

Chapter No. 5: Micro Mechanics of a Lamina: Introduction, volume and weight fractions, Assumption and limitations of micromechanical analysis, Elastic properties of a lamina, longitudinal strength and stiffness, Transverse young's modulus, major Poisson's ratio and in-plane shear modulus. Problems on micromechanical analysis.Numerical problems. 07 Hrs

Unit - III

Chapter No.6: Macro Mechanics of Laminate 05 Hrs

Macro Mechanics of Laminate: Introduction, Laminate code, Stress–Strain Relations for a Laminate, Classical Lamination theory, assumptions of CLT, Stress- Strain equation and variation in a laminate, force and moment resultants related to midplane strains and curvatures , Numerical problems.

Chapter No.7:Applications: 05 Hrs

Aircrafts, missiles, Space hardware, automobile, Electrical and Electronics, Marine, Recreational and sports equipment, future potential of composites.

Text Books

1. Krishan K. Chawla, Composite Materials - Science and Engineering, 3rd Edition, Springer, 2012.
2. Robert M.Jones, Mechanics of Composite Materials, 2nd Edition, Tailor & Francis Inc. 1999.

References

1. D. Hull and T. W. Clyne, An Introduction to Composite Materials (Cambridge Solid State Science Series), 2nd Edition, Cambridge University Press, 1996.
2. Autar K. Kaw, Mechanics of Composite Materials, 2nd Edition, CRC Press, Taylor and Francis Group, 2006.

Course Code: 15EMEE402 **Course Title: Design of Automotive Power Train**

L-T-P: 3-0-0 Credits: 3 Contact Hrs: 3 hrs/week

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Teaching Hrs: 40 Exam Duration: 3 hrs

Unit – I

Chapter No.1:Vehicle Performance Parameters 5 hrs

Vehicle drag, power for propulsion, resistances to vehicle motion, traction and tractive effort, relation between engine revolutions and vehicle speed, road performance curves(acceleration, grade ability and drawbar pull), numericals.

ChapterNo.2:General Considerations in Engine Design 4hrs

Selection of type: Process, Cycle, Number of Cylinders, Arrangement of Cylinders, Single and Double acting, Engine Speed, Rotational Speed, Piston Speed, Speed Factor, Stroke to Bore Ratio, Principle of Similitude, General Design Consideration

ChapterNo.3:Cylinder, Cylinder Head and Piston 6hrs

Function, construction, materials and design of cylinder, cylinder head and piston, piston pin and piston rings.

Unit – II

ChapterNo.4:Connecting rod and Crankshaft: 5hrs

Function, construction, materials and design of connecting rod, lubrication in connecting rod, design of crankshaft and its types.

ChapterNo.5: Flywheel 5 hrs

Function, construction, material, types. Stresses in flywheel rim and arms. design of flywheel

ChapterNo.6:Manual gear boxes and overdrives 5 hrs

Necessity of gear box, sliding mesh gear box, constant mesh gear box and reverse synchromesh gear box, gear synchronization and engagement. Over drive splitter and range gear boxes, Problems.

Unit – III

ChapterNo.7:Propeller shaft, Final Drive and Differential 5hrs

Construction & types of propeller shafts, universal joints, Final drive – construction details, types, Differential-Principle, conventional and non-slip differentials, differential lock. Skid reducing differentials. Double reaction axles. Two speed axles. Third (central) differential. Four wheel drive arrangements. Electro/hydraulic limited slip differential, Problems

ChapterNo.8:Hydrokinetic fluid couplings and torque converters 5hrs

Hydrokinetic fluid couplings. Hydrokinetic fluid coupling efficiency and torque capacity. Fluid friction coupling. Hydrokinetic three element torque converter. Torque converter performance terminology. Over run clutches. Three stage hydrokinetic torque converter. torque converter with lock-up and gear change friction clutches

Text Books

1. Heinz Heisler, Advanced Vehicle Technology, 2nd Edition, 2002,Butterworth Heinemann,
2. Sharma & Aggarwal, Machine Design, 12th Edition,2012,S.K.Kataria &Sons, New Delhi

References

1. Dr. N.K. Giri, Automotive Mechanics, 8th Edition,2008,Khanna Publication, New Delhi,

Course Code:15EMEE403 **Course Title: Design and Analysis of Experiments**

L-T-P: 3-0-0	Credits:3	Contact Hrs: 40
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 40 hrs		Exam Duration: 3hrs

Unit I

Chapter 1. Introduction 04hrs

Need for Research, Need for Design of Experiments, Experimental Design Techniques, Applications of Experimental Design.

Chapter 2. Taguchi's Approach to Quality 04hrs

Taguchi's Approach to Quality and Quality loss function, Noise Factors and Average Quality Loss, Exploiting Non Linearity, Classification of Parameters, Exercises.

Chapter 3. Analysis of Variance 08hrs

Test of Hypothesis using t-test, Z –test, Chi square and F-tests, No-Way and One-Way ANOVA, Exercises.

Unit II

Chapter 4. Full Factorial Design of Experiments 08hrs

Two-Factor Complete Factorial Experiments, Complete Factorial experiment with Three Factors and 2^n Factorial Experiments, Exercises.

Chapter 5. Fractional Factorial Design of Experiments 04hrs

Half Fraction of 2^2 Factorial Experiments, Half Fraction of 2^3 Factorial Experiments, Half Fraction of 2^4 Factorial experiments, Exercises.

Chapter 6. Robust Design 04hrs

Control Factors and their Levels, Matrix Experiment and Data Analysis Plan, Conducting the Experiment using Orthogonal Array and Data analysis, Exercises.

Unit – III

Chapter 7. Response Surface Methodology 04hrs

Central Composite Design and Box-Behnken Design, Case Studies

Chapter 8. Signal to Noise Ratio 04hrs

Relationship between Signal to Noise Ratio and quality loss after adjustment, Signal to Noise Ratios for static problems, Signal to Noise Ratios for dynamic problems, Exercises.

Text Books:

1. Douglas C. Montgomery, "Design and Analysis of Experiments", John Wiley and Sons.
2. Madhav S. Phadke, "Quality Engineering using Robust Design", Prentice Hall PTR, Englewood Cliffs, New Jersey.
3. R. Panneerselvam, "Design and Analysis of Experiments- R PHI Learning Private Limited ,New Delhi.

References:

1. R. H. Myers and D. C. Montgomery and Anderson-Cook C. M. "Response Surface Methodology: Process and Product Optimization Using Designed Experiments", John Wiley & sons, Inc., New York.
2. Philips .J. Ross, "Taguchi Techniques for Quality Engineering", McGraw Hill, New York.

Course Code: 15EMEE404 **Course Title: Product Design & Development**

L-T-P: 2-1-0	Credits: 3	Contact Hrs: 5 hrs/week
ISA Marks: 70	ESA Marks: 30	Total Marks: 100
Teaching Hrs: 24	Tutorial Hrs : 24	Exam Duration: 3 hrs

Unit – 1

Product Development Process 8hrs

Part manufacturing processes, Design and functional review methods, Assembly process and virtual builds, Quality goals and control plans

Unit -2

Product Verification and Validation 8hrs

Load goals and duty cycle definition, Reliability and durability goals, Virtual prototyping techniques, Accelerated product verification methods

Unit – 3

Product family management 8hrs

Product lifecycle management; Evolution of product models and families, Modeling of product family lifecycle, Product Strategy, Product market positioning, Product positioning – psychological, Brand, customer segment.

Technology management

Technology management methods, Technology as a competitive tool, Critical Component Development Process, Technology Development Process

References:

1. Karl Ulrich and Steven Eppinge, Product Design and Development
2. Kenneth B. Kahn, The PDMA Handbook of New Product Development, Second Edition
3. Monica Bordegoni (Editor), Caterina Rizzi (Editor)Innovation in Product Design: From CAD to Virtual Prototyping

Course Code: 15EMEE405 **Course Title: Operations Management**

L-T-P: 3-0-0 Credits: 3 Contact Hrs: 3 hrs/week

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Teaching Hrs: 40 Exam Duration: 3 hrs

Unit – I

Chapter 1: Operations management & operations decision making: 08 hrs

Introduction, importance of operations management in manufacturing and service industries, Information and Non-manufacturing systems. Factors affecting productivity. The environment of operations. Characteristics of decisions, framework for decision-making, decision methodology, decision support systems, economic models and statistical models. Numericals

Chapter 2: Forecasting demand 06 hrs

Forecasting objectives and uses, forecasting variables, opinion and judgmental methods, time series methods, exponential smoothing, regression and correlation methods, application and control of forecasts. Numericals

Chapter 3: Aggregate planning and master scheduling 04 hrs

Introduction- Planning and scheduling, objectives of aggregate planning and Aggregate planning methods, master scheduling objectives, master scheduling methods, Numericals

Unit – II

Chapter 4: Material and Capacity Requirements Planning 04hrs

Overview: MRP and CRP, MRP: Underlying concepts, System parameters, MRP logic, System refinements, Capacity management, and CRP activities. MRP, MRP-II and ERP, Numericals

Chapter 5: Scheduling, single machine scheduling & flow –shop & Job shop scheduling 08 hrs

Production activities, PAC objectives and data requirements, concept, measures of performance, SPT rule, Weighted MFT, EDD rule, minimizing the number of tardy jobs. Numerical problems, Johnson's rule for 'n' jobs on 2 and 3 machines. Numericals.

Job-shop scheduling: Types of schedules, heuristic procedure, scheduling 2 jobs on 'm' machines. Numericals

Unit – III

Chapter 6: Lean manufacturing: 05 hrs

Introduction, Japanese concept of continuous improvement (Kaizen), innovation concept of improvement, need for continuous improvement, steps in implementing continuous improvement, 5S principles, Lean manufacturing history

Chapter 7: Just in time- an introduction 05 hrs

Spread of JIT movement, the new production system research association of Japan, core Japanese practices of JIT, creating continuous manufacture, Enabling JIT to occur, basic element of JIT, benefits of JIT.

Text Books:

1. Monks, J.G., Operations Management, McGraw-Hill International Edition, 1987.
2. Pannerselvam. R., Production and Operations Management, Prentice Hall India, 2003.

Reference Books:

1. Krajewski E. J. and Ritzman, 'Operations Management', Strategy and Analysis, Pearson Education, 2002.
2. Chary, S.N., 'Production and Operations Management', Tata-McGraw Hill, 2004
3. Nicholas J. Aquilano, 'Fundamental of Operations Management', Irwin/McGraw-Hill; 4th edition.

Course Code: 15EMEE406 **Course Title: Supply Chain Management**

L-T-P: 3-0-0 Credits: 3 Contact Hrs: 3 hrs/week

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Teaching Hrs: 40 Exam Duration: 3 hrs

Unit – I

1. Understanding supply chain: 05 hrs

Meaning of SCM, supply chain stages, decision phases in supply chain (SC), process view of SC, examples of supply chain, competitive and supply chain strategies, achieving strategic fit and expanding strategic scope.

2. Supply Chain drivers and metrics: 05hrs

Drivers of SC performance, framework for structuring drivers, facilities, transportation, information, inventory, obstacles to achieve strategic fit.

3. Designing the supply chain network: 05 hrs

Role of distribution in SC, factors influencing distribution network design, design options for a distribution network, role of network design in sc, factors influencing network design decisions.

Unit – II

4. Transportation in supply chain: 05 hrs

Role of transportation in SC & factors affecting transportation decisions, modes of transportation and their performance characteristics, design options for a transportation network, trade-offs in transportation design, tailored transportation.

5. Logistics metrics: 05 hrs

Logistics data, statistical methods of process monitoring, logistics performance metrics.

6. Facility location and layout design : 05 hrs

Design aggregation and granularity level, space representation, qualitative proximity relationship, illustrative layout design, dealing with uncertainty, dealing with an existing design**.**

Unit – III

7. Material handling system: 05 hrs

Ten principles of material handling, material handling equipment, how to choose the right equipment, analytical model for material handling, equipment selection

8. Warehousing: 05 hrs

Warehousing functions, role of warehouse in supply chain, functional departments and flows, storage department description and operation, sorting, packing, consolidation and staging description, warehouse management.

Text Books:

1. Sunil Chopra and Peter Meindl, 'Supply Chain Management – Strategy, Planning and Operation', Pearson Education Inc.
2. G. Don Taylor, 'Introduction to Logistics Engineering'.CRC press, Taylor & Francis group Douglas Lambert and James Stock, 'Strategic Logistics Management', Irwin McGraw Hill.

Reference Books:

1. Robert B. Handfield and Ernest L. Nichols, 'Supply Chain Redesign-Transforming Supply Chain into Integrated Value Systems', Pearson Education Inc.
2. Jeremy F. Shapiro and Duxbury, 'Modeling the Supply Chain', Thomson Learning.
3. David Simchi Levi, Philip Kaminsky and Edith Simchi Levi, 'Designing and Managing the Supply Chain', McGraw Hill.
4. Sahay B.S., 'Supply Chain Management', Mc Millan
5. Bhattacharya S. K., 'Logistic Management', S. Chand Publication.
3. Kapoor, 'Marketing Logistics: A Supply Chain Approach', Pearson Education

Course Code: 15EMEE407 **Course Title: Computational Heat transfer and Fluid Flow**

L-T-P: 3-0-0 Credits: 3 Contact Hrs: 3 hrs/week

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Teaching Hrs: 40 Exam Duration: 3 hrs

Unit - I

1. Computational Fluid Dynamics (CFD) Solution Procedure: 7 hrs

CFD applications in Research and Design, CFD Problem set-up-Creation of geometry, Mesh generation, Specification of boundary conditions. CFD Solver- Initialization and Convergence monitoring. Post Processor-Plots, data reports and Animation

2. Governing Equations for CFD: 8 hrs

Continuity Equation, Momentum Equation, Energy Equation- Physical Interpretation and comments. The additional equations for turbulent flow, Generic form of Governing equations, Physical Boundary conditions

Unit – II

3. CFD Techniques: 7 hrs

Discretization of Governing Equations- Finite difference method, Finite volume method, Converting governing equations into algebraic equations, Direct and Iterative solutions, Pressure- velocity coupling- SIMPLE scheme

4. CFD Solution Analysis: 8 hrs

Consistency, Stability, Convergence, Accuracy and Efficiency of CFD solutions. Accelerating convergence, controlling solution errors, verification and Validation. Case studies related to fluid flow through channel and pipe bend

Unit - III

5. Practical Guidelines for CFD Simulation and Analysis: 5 hrs

Grid generation- Guidelines on grid quality and grid design, Local refinement and solution adaption. Guidelines on Boundary conditions – Setting inlet, outlet and wall boundary conditions. Symmetric and Periodic Boundary conditions. Turbulence Modelling- Approaches, selection strategies, Case study: modeling of hydrofoil flows

6. Advanced Topics in CFD: 5 hrs

Advances in Numerical methods and Techniques- Moving grids, Multigrids, Parallel Computing and Immersed boundary methods. Advances in computational models- Direct numerical Simulation(DNS), Large Eddy Simulation(LES), RANS-LES, Lattice Boltzmann method, Monte-Carlo method, Particle methods

Text books:

1. Jiyuan Tu, Guan Heng Yeoh, Chaoqun, Computational Fluid Dynamics, Butterworth- Heinemann, 1st Edition 2008
2. Dale A. Anderson, John C. Tannehill and Richard H. Platcher.. Computational Fluid Mechanics and Heat Transfer; McGraw Hill Book Company, 2001

References:

1. Suhas V. Patankar, Numerical Fluid flow and Heat transfer, Hemisphere Series on Computational Methods in Mechanics and Thermal Science, 2nd Edn. 2000
2. Joel H. Ferziger and Milovan Peric, Computational Methods for Fluid Dynamics, 3rd Edition, Springer-Verlag, Berlin, 2001
3. Anderson J D, Computational Fluid Dynamics- The Basics with Applications, MGH, 2nd Ed. 2001

Course Code: 15EMEE408		**Course Title: Fundamentals of Gas Turbines**
L-T-P: 3-0-0	Credits: 3	Contact Hrs: 3 hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 40		Exam Duration: 3 hrs

Unit - I

1 Principles of Gas Turbine and Applications 4 hrs

Introduction to turbo machines, history of gas turbines, gas turbine cycles and applications – (Land, Water/Marine and Air/Aero) Components of Gas Turbines (Compressors, Combustors, Turbines, Exhaust systems). Working of Gas Turbines.

2 Compressor 7 hrs

Types of compressors, (Centrifugal and Axial), relative merits and demerits, Criteria for selecting type of compressors.

Centrifugal Compressors: Principle of operation, work done and pressure rise diffuser, compressibility effects, compressor characteristics and design procedures.

Axial Flow Compressor: Basic operations, elementary theory, factors affecting stage pressure ratio, Blockage in the compressor annulus, effect of compressibility, pre-whirl, supersonic flow, degree of reaction, design process, blade design, calculation of stage performance, off-design performance.

3 **Fuel System** 4 hrs

Fuel specifications, Properties, Manual and automatic control, Fuel control systems, Fuel spray nozzles, Fuel heating, Effect of a change of fuel, Gas turbine fuels, Fuel requirements, Vapor locking and boiling, Fuel contamination control.

Unit – II

4 Combustion System 5 hrs

Introduction, Combustion process, Enthalpy of formation, Fuel supply, Types of combustion chamber, Can-annular combustion chamber, Tube-annular combustion chamber, Annular combustion chamber, Combustion chamber performance, Combustion intensity, Combustion efficiency, Combustion stability Emissions, Materials.

5 Axial Flow Turbines 5 hrs

Types of Turbines, spool shafts in aero engines, Advantages and disadvantages, Turbine geometry, Thermodynamic and Aerodynamic theory, velocity diagrams, Impulse turbine, turbine blade cooling. **Exhaust System**: Introduction, Exhaust gas flow, environmental considerations, construction and materials.

6 Prediction of Performance of Simple Gas Turbines 5 hrs

Component characteristics, off design operation of the single shaft gas turbine, off-design operation of free turbine engine.

Unit - III

7 Cooling, Seals and Lubrication System 5 hrs

The cooled turbine, methods of blade cooling, **Seals**: Non contacting seals - labyrinth seals, ring seals, Mechanical seals, Seal system, and dry gas seals, attrition coatings. **Lubrication Systems:** Basic oil system, lubrication management program, selection, oil contamination, filter selection, cleaning and flushing, oil sampling and testing

8 Materials of Gas turbine and Maintenance 5 hrs

Introduction, Super alloys-Nickel based iron-nickel, Cobalt, Thermal barrier coating for jet engine alloys, advanced materials for jet engines**. Maintenance:** Introduction, On-wing maintenance, Scheduled maintenance, Unscheduled maintenance, Condition monitoring, Flight deck indicators, In-flight recorders, Ground indicators, Maintenance precautions, Trouble shooting, Adjustments, Ground testing.

Text Books

1. Rolls Royce - "The Jet Engine" 5th edition, ISBN 0 902121 2 35, © Rolls-Royce plc 1986
2. Saravanamutto H.I.H, Rogers G.F.C., Cohen H, Gas Turbine Theory, 5th Edn., Pearson 2006

Reference Books

1. Meherwan P. Boyce "Aircraft Propulsion and Gas Turbine Engines", CRC press, Taylor and Francis Group, London

New York.ISBN 978-0-8493-9196-5
2. Meherwan P. Boyce “Gas Turbine Engineering Handbook (Fourth Edition)”, 2012, Elesevier, ISBN-978-0-12-383842-1

Course Code: 18EMEE301 **Course Title: Advanced CAE - I**

L-T-P: 0-0-3 Credits: 3 Contact Hrs: 6 hrs/week

ISA Marks: 80 ESA Marks: 20 Total Marks: 100

Teaching Hrs: 80 Exam Duration: 2 hrs

Sl No	Details
1	**Introduction** to Finite Element Method and Altair Hyper works.
2	**Hypermesh workbench** Getting started with Hypermesh Interacting with panels
3	**Geometry Clean up - Theory** **Tools used to geometry clean up** (Edge edit, Create Surface and Surface edit, Line and Line Edit, Delete …..) Theory and Demo Exercise – 04 No
4	**2-D mesh Explanation -Theory** Auto mesh and Different types of auto mesh Types of 2 D mesh (Ruled, Spline, Rotate……) Quality Parameters checking. Normals and Edge Checking and adjusting. Theory and Demo Exercise – 04 No
5	**3-D mesh Explanation -Theory** Volume mesh Creation Types of 3 D mesh (Hexa Penta Type, Tetra mesh……) Quality Parameters checking. Normals and Edge Checking and adjusting. Theory and Demo Exercise – 03 No
6	**1-D mesh Explanation -Theory** Creation of 1 D elements (Bar, Beam Mass….) Creation of Rigid elements (Rbe2 and Rbe3) Creation of Weld elements between two adjacent components Demo Exercise - 03 No
7	Execute Linear Static Analysis using optistruct solver Theory and Demo Exercise - 01 No Assignment - 01 No
8	Perform Buckling Analysis using optistruct solver Theory and Demo Exercise - 01 No
9	Carryout Modal Analysis using optistruct solver Theory and Demo Exercise - 01 No
10	Analyze Thermal Analysis using optistruct solver Theory and Demo Exercise - 01 No
11	Execute Non Linear Analysis using optistruct solver (Geometry, Material and Contact Non-Linear) Theory and Demo Exercise - 03 No

***Materials and Resources Required*:**

1. Books/References: Practical Finite Element Analysis by Nitin Ghokale
   3rd Edition Released 05/2015

Course Code: 19EMEE304 **Course Title: Advanced CAE- II**

L-T-P: 0-0-3 Credits: 3 Contact Hrs: 6 hrs/week

ISA Marks: 80 ESA Marks: 20 Total Marks: 100

Teaching Hrs: 80 Exam Duration: 2 hrs

Experiment wise plan

List of exercises planned to meet the requirements of the course.

Serial No.	Details	Category	No. of Sessions
1.	Finite Element Methods: A conceptual introduction, Failure criteria of materials	Demonstration	01
2.	Ansys workbench ➢ Getting started with Ansys ➢ Interacting with panels Case Study: Beam, Pneumatically Actuated PDMS Fingers, Spur Gears and Micro gripper etc.	Exercise/Tutorial	02
3.	Design Modeler Geometry clean-up tools: De-features, Projection. Case Study: Bar, Beam, Triangular plate.	Exercise/Tutorial	02
4.	Case study on One dimensional/Two dimensional/Three dimensional components ➢ 1D: Rod, Bar, Link, Spring, Beam ➢ 2D: Bellows Joints, Gearbox etc. ➢ 3D: Beam bracket, Cover of pressure cylinder, Lifting fork and LCD display support.	Exercise/Tutorial	03
5.	Convergence study in FEA Quality parameters for 1D/2D/3D elements, Convergence Study of 2D and 3D Solid Elements ➢ Pneumatic fingers ➢ Cover of pressure cylinder	Exercise/Tutorial	03
6.	Case study on Static structural analysis ➢ Refrigerator handle ➢ Shell –Automotive panels (Fender, Bonnet) Assignments ➢ Wooden chair ➢ Crain hook	Exercise/Tutorial	03
7.	Case study on Modal analysis ➢ Compact disk ➢ Machine tool structures- Bed, Column. ➢ Guitar string Assignments ➢ Human skeleton ➢ Car chassis ➢ Engine housing	Exercise/Tutorial	02

8.	Case study on Structural dynamic Analysis ➢ Lifting fork ➢ Ball and rod ➢ Base of compressor in Refrigerator Assignments ➢ Leaf spring ➢ Steering wheel ➢ Railway track	Exercise/Tutorial	03
9.	Case study on Non linear analysis Geometry, Material and Contact analysis ➢ Fisher rod(Geometry) ➢ snap lock(Material) ➢ Translational joint(Contact) Assignments ➢ Gasket(Contact) ➢ Advanced metal plasticity(Material) ➢ Visco-plasticity(Material)	Exercise/Tutorial	04
10.	Case study on Explicit Dynamics ➢ High-Speed Impact : Bird Crash	Exercise/Tutorial	01
11.	Case study on Buckling and Stress stiffening ➢ 3D Truss ➢ Beam Bracket Assignments ➢ Machine column(Milling/ Drilling) ➢ Dovetail guide way	Exercise/Tutorial	02
12.	Case study on Thermal analysis Steady state thermal analysis Transient thermal analysis ➢ Heat exchanger ➢ Fin Assignments ➢ PCB Panel ➢ Telephone/power cables	Exercise/Tutorial	02
13.	Case study on Fatigue Analysis Stress based approach Strain based approach ➢ Connecting rod ➢ Fin Assignments ➢ Radial tire ➢ Battery of laptop/mobile	Exercise/Tutorial	04
14.	Case study on Sub-Modeling ➢ Motor cover	Demo	01
15.	Case study on Multi Body Dynamics (MBD) ➢ Applications of Four bar mechanism ➢ Sun planet gear mechanism Assignments ➢ Power cylinder in a diesel engine ➢ Screw jack	Exercise/Tutorial	03
16.	Analysis of Composite ➢ Applications on automotive components(fender, hood, dashboard) ➢ Applications on aerospace components (wings, window panels, tale) Assignments	Exercise/Tutorial	01

	➢ Polymer matrix composite ➢ Metal matrix composite		
17.	Case study on Optimization ➢ Triangular plate ➢ Flexible gripper Assignments ➢ Electronic Fuse ➢ Radiating system ➢ Tractor trailer	Exercise/Tutorial	01
18.	Case study on Couple Field Analysis ➢ Electromagnetic-thermal (Induction heating) ➢ Electromagnetic-thermal-structural (Peltier coolers) ➢ Electrostatic-structural, electrostatic-structural-fluidic (MEMS)	Demo	02

Text Book

1. Nitin Ghokale, Practical finite element analysis, Finite to infinite, 2008.

References

1. Chen, Xiaolin_ Liu, Yijun-Finite Element Modeling and Simulation with ANSYS Workbench-CRC Press (2014)
2. Erdogan Madenci, Ibrahim Guven (auth.)-The Finite Element Method and Applications in Engineering Using ANSYS®-Springer US (2015)
3. Barbero, Ever J.-Finite Element Analysis of Composite Materials Using ANSYS®-CRC Press (2013)

Course Code: 18EMEE302		**Course Title: Programming**
L-T-P: 0-0-3	Credits: 3	Contact Hrs: 6 hrs/week
ISA Marks: 80	ESA Marks: 20	Total Marks: 100
Teaching Hrs: 40		Exam Duration: 2 hrs

Course Contents: Core Java and Database Management System

Introduction to java: History and Features of Java ,Internals of Java Program, Difference between JDK,JRE and JVM, Variable and Data Type, Naming Convention, JDK installation and configuration

OOP Concepts: Advantage of OOPs, Object and Class, Method Overloading, Constructor, static variable, method and block, this keyword, Package and Access Modifiers, Encapsulation, Object class, Java Array, Call By Value and Call By Reference, Inheritance, Method Overriding, final keyword, Runtime Polymorphism, static and Dynamic binding, Abstract class and Interface, Downcasting with instanceof operator.

String Handling: String, , Immutable String, String Comparison, String Concatenation, Substring, Methods of String class, StringBuffer class , StringBuilder class, toString method, StringTokenizer class.

Exception Handling: Introduction, try and catch block, Multiple catch block, Nested try, finally block, throw keyword, Exception Propagation, throws keyword, Exception Handling with Method Overriding, Custom Exception

Collection framework: ArrayList class, LinkedList class, ListIterator interface, HashSet class, LinkedHashSet class, TreeSet class, PriorityQueue class, ArrayDeque class, Map interface, HashMap class.

Database concepts: SQL(DDL, DML), PL-SQL, JDBC Drivers, Steps to connect to the database, Connectivity with DB, DriverManager, Connection interface, Statement interface, ResultSet interface, PreparedStatement, ResultSetMetaData.

HTML: Tags, Attributes and Elements, Links, Images, Tables, Forms.

JSP: JSP - Overview, JSP - Lifecycle, JSP - Syntax, JSP - Directives, JSP - Actions, JSP – Client Request, JSP - Server Response.

Javascript/Jquery: JavaScript Output, JavaScript Statements, JavaScript Syntax, JavaScript Variables, JavaScript Operators, JavaScript Arithmetic, JavaScript Strings, JavaScript Events, JavaScript Loop, JavaScript Objects, JavaScript functions.

CSS: CSS basics, styles, CSS syntax

Design patterns: Singleton pattern, Factory pattern

References

1. Herbert Schildt, Java: The Complete Reference, Seventh Edition, The McGraw-Hill.
2. E Balagurusamy, Programming with Java, Third edition, McGraw-Hill.
3. Ramez Elmasri, Shamkant B. Navathe, FUNDAMENTALS OF Database Systems, Sixth edition, Addison-Wesley.
4. Jim Keogh, "J2EE - The Complete Reference", Tata McGraw Hill, 28th reprint, 2010.
5. Eric Elliott, Programming JavaScript Applications, O'Reilly Media, 2014.

Course Code: 19EMEE305 **Course Title: PLM -Technical**

L-T-P: 0-0-3 Credits: 3 Contact Hrs: 6 hrs/week

ISA Marks: 80 ESA Marks: 20 Total Marks: 100

Teaching Hrs: 40 Exam Duration: 2 hrs

Course Contents: PLM- Technical (On Enovia Platform)

Introduction to PLM: Understanding PLM: Product, Product Lifecycle, Product Data, Process Data, Product Relationship Issues in Product Development What is PLM? Evolution of PLM PLM Vendors Understanding PLM with Example PLM Terminologies

Fundamentals: Introduction to ENOVIA Components: Matrix Navigator, Business Modeler, System Manager, MQL Business Objects Attribute, Type, Relationship, Policy User Management: Person, Group, Role, Association Document Management: Files and File Format, File Check-in and Check- out Icon Mail Automating Processes: Triggers & JPOs Vaults & Stores Introduction to 3DEXPERIENCE ENOVIA Modules ENOVIA Architecture ENOVIA Licensing

Installation: Difference between CAS & No-CAS Setup Installation Procedure for No-CAS Mode: Installation of Database (SQL Server), Creation of Tables & User in Database, Installation of Studio Modelling Platform, Installation of 3DSpace, Installation of ENOVIA Modules, No-CAS Deployment of ENOVIA, Post Installation Configurations, Working with ENOVIA Services

Functional

Collaboration & Approvals: People and Organization Setup: Company, Business Unit, Department, Location, Region, User Creation Team Central: Workspaces, Folders, Subscriptions Routes: Route Templates, Routes, Route Tasks

Engineering Part, BOM and Change Management: Part Families Part Series Part Definition: Development Part & Production Part, Equivalent Part, Alternate Part, Spare Parts, Substitute Parts, Manufacturer Equivalent Part (MEP) Part Revisions Part Specifications Bill of Material (BOM) BOM Markups Engineering Change: Fast Track Change, Formal Change

Program and Project Management: Project Templates & Questions Program Project Creation & Scheduling: Phase, Gate & Checklists, Milestone, Task Project Work Calendars Project Task Dependencies & Task Constraints Meetings Project Folders & Documents Project Risk & Issue Management Project Budgets Project Baselines & Project Experiments Project Timesheets

Configuration

Business Modeler: Attribute: Attribute Types & Ranges Dimension Type Policy: Policy States, Access, Signature User Management: Person, Role, Group, Association Relationship Interface

Matrix Navigator: Search Business Objects Create Business Objects Modify & Delete Business Objects Connect Business Objects Expand Business Objects View Business Object Basics & Attributes Promote & Demote Business Object Business Object File Check-in and Check-out Business Object Signature Approvals

MQL: Queries for Admin Objects: List, Create, Modify Queries for Business Objects: temp query, print, expand, add, delete, connect, disconnect, promote, demote, eval expression Help Commands

Schema/Data Model: Understanding ENOVIA OOTB Schema Model: PnO, Project Management, Common Document Model Schema Design Symbolic Names & Registration Understanding ENOVIA Access

Precedence Auto-Naming Configuration

UI Configuration: Command Menu Categories/Tree Menu Portals & Channels Inquiry Tables: Flat Tables & Structure Browser Tables Editable Tables Settings for Table Columns Web Forms Settings for Web Form Fields Configuration of Create, Edit & View Business Object Details using Web Form

Customization:

ADK: Understanding ENOVIA BusinessObject & DomainObject classes ENOVIA StringList & MapList classes ENOVIA APIs for Business Object Creation, Modification, Deletion ENOVIA APIs for business object querying, for getting business object details, for getting the connected business objects & their details

JPOs: Creating JPOs Exporting & Importing JPOs JPO Macros JPO Method Invocation from JSP, from JPO and from UI Component settings JPO Compilation & Debugging

Triggers: Trigger Configuration in Policy Creation of OOTB Trigger objects Understanding OOTB Events Understanding check, override and action triggers Disabling Triggers

Data Model Customization: Understanding Unified Typing Principles Specialize Data Model: Packages, Types & Customer Extensions Administrate Data Model Importing & Exporting Packages.

Course Code: 15EMEE413 **Course Title: Aircraft Systems and Design**

L-T-P: 3-0-0	Credits: 3	Contact Hrs: 40
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 40		Exam Duration: 3 hrs

Unit – 1

Chapter No. 1: Aircraft industry overview

Evolution and History of Flight, Types Of Aerospace Industry, Key Players in Aerospace Industry, Aerospace Manufacturing, Airline deregulation, Structure of the industry, Airline economics, Aircraft design process, Aerospace Industry Trends. — 3 hrs

Chapter No. 2: Introduction to Aircrafts

Basic components of an Aircraft, Structural members, Aircraft Axis System, Aircraft Motions, Control surfaces and High lift Devices. Types of Aircrafts - Lighter than Air/Heavier than Air Aircrafts Conventional Design Configurations based on Power Plant Location, Wing vertical location, intake location, Tail Unit Arrangements, Landing Gear Arrangements. Unconventional Configurations-Biplane, Variable Sweep, Canard Layout, Twin Boom Layouts, Span loaders, Blended Body Wing Layout, STOL and STOVL Aircraft, Stealth Aircraft. Advantages and disadvantages of these Configurations. — 5 hrs

Chapter No. 3: Introduction to Aircraft Mechanical Systems

Types of Aircraft Systems, Mechanical Systems: Environmental control systems (ECS), Pneumatic systems, Hydraulic systems, Fuel systems, Landing gear systems, Engine Control Systems, Ice and rain protection systems, Cabin Pressurization and Air Conditioning Systems, Steering and Brakes Systems Auxiliary Power Unit. — 8 hrs

Unit – 2

Chapter No. 4: Basic Principles of Flight

Significance of speed of Sound, Air speed and Ground Speed, Properties of Atmosphere, Bernoulli's Equation, Forces on the airplane, Airflow over wing section, Pressure Distribution over a wing section, Generation of Lift, Drag, Pitching moments, Types of Drag, Lift curve, Drag Curve, Lift/Drag Ratio Curve, Factors affecting Lift and Drag, Center of Pressure and its effects. Aero foil Nomenclature, Types of Aero foil, Wing Section- Aerodynamic Center, Aspect Ratio, Effects of lift, Drag, speed, Air density on drag, — 6 hrs

Chapter No. 5: Overview of the Aircraft Design Process

Introduction, Phases of aircraft Design, Aircraft conceptual Design Process, Conceptual stage, Preliminary Design, Detailed Design, Design Methodologies. Aerodynamic loads, Inertial loads, Loads due to engine, Actuator loads, maneuver loads, VN diagrams, Gust loads, Ground loads, Ground conditions, Miscellaneous loads. Sample problems. — 7 hrs

Chapter No. 6: Aircraft materials

Introduction, Basic construction, material forms- Metallic materials and forms. Alloy designations, Mechanical properties- strength, static, stress strain curves, fatigue properties, crack growth. — 3 hrs

Unit – 3

Chapter No. 7: Analysis of plates

Theory of plates- Analysis of plates for bending, stresses due to bending, plate deflection under different conditions, Plate buckling, Compression buckling, shear buckling and buckling due to in plane bending moments. Sample exercises. — 4 hrs

Chapter No. 8: Analysis of Beams

Theory of beams- Symmetric beams in pure bending, deflection of beams, Unsymmetrical beams in bending. Sample exercises. Torsion in closed section beams, torsion in open section beams, multi cell sections. Sample exercises. — 4 hrs

Text Books

1. Daniel P.Raymer, Aircraft Design- A conceptual Approach, 6, AIAA education series, 2012
2. T.H.G. Megson, Aircraft Structures for Engineering Students, 5, Elsevier science publications, 2012

Course Code: 15EMEE414 **Course Title: Industrial Engineering Methods and Practices**

L-T-P: 3-0-0 Credits: 3 Contact Hrs: 3 hrs/week

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Teaching Hrs: 40 Exam Duration: 3 hrs

Unit – I

1. Industrial engineering and productivity: 06 hrs

Evolution of industrial engineering, industrial engineering functions, recent advances in industrial engineering, productivity of materials, land, buildings, machines and manpower, measurement of productivity, factors affecting the productivity.

2 Methods engineering: 04 hrs

Objective and scope of work-study and method-study. human factor in work-study, work-study and management, work-study and supervisor, work-study and worker.

3 Methods analysis techniques: 05 hrs

Types of recording techniques, process chart symbols, construction of charts (*operation process chart, flow process chart, two hand process chart, multiple activity chart, travel chart, string diagram etc*.), applications of various charts with examples.

Unit – II

4 Micro motion study: 05 hrs

Purpose of micromotion study, fundamental hand motions, therbligs, micromotion study equipments, cycle graph and chronocyclegraph, simo-chart construction, memomotion study.

5 Work measurement & time Study practice*:* 06 hrs

Concept of human work, terminology used in work measurement, theory of work measurement, work measurement techniques, definition of time study , time study equipments, basic time study procedure, conducting the time study

6 Performance rating & computing standard time: 04 hrs

Necessity of performance rating, factors influencing rating, rating systems and their details, allowances and their details, problems in time study and time standards, standard time computation with examples.

Unit – III

7 Ergonomics: 05 hrs

Areas of study under ergonomics, system approach to ergonomics model, man-machine system, work capabilities of industrial worker, general principles for carrying out physical activities.

8 Design of man-machine system interface: 05 hrs

Concept of fatigue in industrial worker, relationship between controls and displays, design of work place and effect of environment (*influence of climate on human efficiency, influence of noise, vibrations and lighting system*).

Text Books:

1. Jhamb L. C., 'Work Study & Ergonomics', Everest Publishing House.

Reference Books:

1. ILO, 'Introduction to Work Study'. International Labour Office.
2. S Dalela and Sourabh, 'Work Study and Ergonomics', Standard Publishers Distributors.
3. Vijay Sheth, 'Industrial Engineering Methods and Practices', Penram International Publishing (India) Pvt. Ltd.

Course Code: 15EMEE415 **Course Title: Advanced Energy Technology**

L-T-P: 3-0-0	Credits: 3	Contact Hrs: 3 hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 40		Exam Duration: 3 hrs

Unit - I

1. Solar Radiation, Measurement of Solar Radiation, Solar Radiation Geometry 8 hrs

Energy source, India's production and reserves of commercial energy sources, need for non-conventional energy sources.Solar Radiation : Extra-Terrestrial radiation, spectral distribution of extra terrestrial radiation, solar constant, solar radiation at the earth's surface, beam, diffuse and global radiation, solar radiation data. Measurement of Solar Radiation : Pyrometer, shading ring pyrheliometer, sunshine recorder, schematic diagrams and principle of working. Solar Radiation Geometry : Flux on a plane surface, latitude, declination angle, surface azimuth angle, hour angle, zenith angle, solar altitude angle expression for the angle between the incident beam and the normal to a plane surface (No derivation) local apparent time. Apparent motion of sum, day length, numerical examples.

2. Radiation Flux on a Tilted Surface, Solar Thermal Conversion 8 hrs

Radiation Flux on a Tilted Surface : Beam, diffuse and reflected radiation, expression for flux on a tilted surface (no derivations) numerical examples. Solar Thermal Conversion : Collection and storage, thermal collection devices, liquid flat plate collectors, solar air heaters concentrating collectors (cylindrical, parabolic, paraboloid) (Quantitative analysis); sensible heat storage, latent heat storage, application of solar energy water heating. Space heating and cooling, active and passive systems, power generation, refrigeration. Distillation (Qualitative analysis) solar pond, principle of working, operational problems.

Unit – II

3. Solar Photovoltaic Energy Conversion and PV System Applications 8 hrs

Principles - Physics and operation of solar cells. Classification of solar PV systems, Solar cell energy conversion efficiency, I-V characteristics, effect of variation of solar insolation and temperature, losses. Solar PV power plants.Building-integrated photovoltaic units, grid-interacting central power stations, standalone devices for distributed power supply in remote and rural areas, solar cars, aircraft, space solar power satellites. Socio-economic and environmental merits of photovoltaic systems.

4. Fuel Cell Technology 8 hrs

Fuel cell electrochemistry - Reaction rate - Butler Volmer equation-implications and use of fuel cell polarization curve - Conversion of chemical energy in electricity in a fuel cell. Cogeneration - Fuel cell electric vehicles - Fuel cell vehicles - Motor cycles and bicycles-airplanes - Fueling stations - Fuel cell power plant structure - Fuel processor and fuel cell stack. Advantages and disadvantages. Problems with fuel cells. Research related to fuel cell development in the world and in India.

Unit - III

5. Energy Storage 4 hrs

Introduction, energy demand, energy storage devices, types of battery, basic principle, components, cathode and anode materials, effect of nano-size on energy storage and electrode materials performance, electrochemical energy storage, super-capacitors, advantage of nanotechnology in energy storage devices.

6. Energy Policy 4 hrs

Energy policy issues - Fossil Fuels, renewable energy, power sector reforms, restructuring of energy supply sector, energy strategy for future. Energy conservation act and National electricity policy and plan.

Reference books

1. David Merick, Richard Marshall, (2001), Energy, Present and Future Options, Vol. I and II, John Wiley and sons.
2. Twidell, J.W. and Weir, A., Renewable Energy Sources, EFN Spon Ltd., 1986
3. Peter Gevorkian, Sustainable Energy Systems Engineering, McGraw Hill,2007
4. Bagotsky .V.S, "Fuel Cells", Wiley, 2009.
5. Ibrahim Dincer and Marc A. Rosen, "Thermal Energy Storage Systems and Applications", 2nd Edition, John Wiley

and Sons Ltd., 2011.

Course Code: 15EMEE416 **Course Title: Thermal Management of Electronic Equipment**

L-T-P: 3-0-0 Credits: 3 Contact Hrs: 3 hrs/week

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Teaching Hrs: 40 Exam Duration: 3 hrs

Unit – I

Chapter No. 1. Introduction 5 hrs

Semiconductor Technology Trends, Temperature-Dependent Failures, Importance of Heat Transfer in Electronics, Thermal Design Process, Energy and Work, Macroscopic and Microscopic Energies, Energy Transfer and Heat Transfer, Equation of State.

Chapter No. 2. Thermal Resistance Network 5 hrs

Thermal Resistance Concept, Series Thermal Layers, Parallel Thermal Layers,
General Resistance Network, Thermal Contact Resistance, Thermal Interface Materials, Spreading Thermal Resistance, Thermal Resistance of Printed Circuit Boards (PCBs).

Chapter No. 3.Thermal Specification of Microelectronic Packages 5 hrs

Importance of Packaging, Packaging Types, Thermal Specifications of Microelectronic Packages, Package Thermal Resistance Network, Parameters Affecting Thermal Characteristics of a Package.

Unit – II

Chapter No. 4. Cooling methods 10 hrs

Conduction Cooling, Convection Cooling, Selection Of Fan, Liquid Immersion Cooling, Flow-Through Cooling Of CCAs, Cold wall Cooling, Cold Plates, Jet Impingement Cooling, Synthetic Jet Cooling, Thermoelectric Or Solid State Coolers, Cooling Using Phase Change– Cooling With PCM Materials, Micro/Mini Channel Cooling, Cooling Using Heat Pipes– Working Principle, Selection Of Heat Pipe Working Fluid; Selection Of Cooling Technique– Ranges Of Cooling Rates Of Different Cooling Methods, Selection Criteria.

Chapter No. 5. Fins and Heat Sinks 5 hrs

Fin Equation, Fin Thermal Resistance, Effectiveness, and Efficiency, Fins with Variable Cross Sections, Heat Sink Thermal Resistance, Effectiveness, and Efficiency, Heat Sink Manufacturing Processes.

Unit – III

Chapter No. 6. Experimental Techniques and Thermal Design 5 hrs

Flow Rate Measurement Techniques, System Impedance Measurement, Fan and Pump Curve Measurements, Velocity Measurement Methods, Temperature Measurement Techniques, Acoustic Noise Measurements, Importance of Experimental Measurements in Thermal Design.

Chapter No. 7. Computer Simulations and Thermal Design 5 hrs

Heat Transfer and Fluid Flow Equations: A Summary, Fundamentals of Computer Simulation, Turbulent Flows, Solution of Finite-Difference Equations
Commercial Thermal Simulation Tools, Importance of Modeling and Simulation in Thermal Design.

Text Books

1. Younes Shabany, Heat Transfer: Thermal Management of Electronics, CRC Press Inc, 2010.
2. Ravi Kandasamy and Arun S. Mujumdar, Thermal Management of Electronic Components, Lambert Academic Publishing, 2010.

References

1. Dave S. Steinberg, Cooling Techniques for Electronic Equipment, Wiley, 1991.
2. Sung Jin Kim, Sang Woo Lee, Air Cooling Technology for Electronic Equipment, Taylor & Francis, 1996.
3. Rao R. Tummala, Fundamentals of Microsystems Packaging, McGraw-Hill, 2001.
4. Yunus A. Cengel, Heat Transfer: A Practical Approach. McGraw-Hill, 2003.

Course Code: 15EMEO401 **Course Title: Introduction to Nanoscience and Nanotechnology**

L-T-P: 3-0-0 Credits: 3 Contact Hrs: 3 hrs/week

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Teaching Hrs: 40 Exam Duration: 3 hrs

Unit – I

1 Introduction: 5 Hrs

Nanotechnology, Frontier of future- an overview

Length scales, Variation of physical properties from bulk to thin films to nanomaterials, - confinement of electron energy states (LDOS) in 0D, 1D,2D and 3D systems (qualitative treatment) ; Surface, size, shape and assembly effects.

Bonding and crystal structure in solids, colloids and core-shell structures. Chemical and molecular interaction, functionalziation, basis for biological self-assembly and self-organization.

2 Synthesis of nanomaterials: 6 Hrs

Top-down approach: Lithography and soft processes, Ball milling, chemical stamping.

Bottom-Up approach: Chemical Routes for Synthesis of Nanomaterials, Solvo-thermal and Sol-gel synthesis; Microemulsions, micelles and reverse micelles; Physical and Chemical Vapour Deposition, Sputtering, Laser ablation, Epitaxy.

Biological Methods: Role of plants and bacteria in metal (magnetic and non-magnetic) nanoparticle synthesis

3 Characterization: 5 Hrs

Electron Microscopy (SEM/TEM); Scanning Probes (STM, AFM), X-ray Photoelectron Spectroscopy (XPS), Optical Spectroscopy –IR/UV/VIS, Raman, Photoluminescence, X-ray Diffraction (including Debye-Scherrer method), Particle Size Analyser-light Scattering, Electrical (I-V and C-V), Porosity (BET method), Zeta potential, nano-indentation.

Unit – II

4 Properties: 6 Hrs

- Electronic and optoelectronic properties: Ballistic transport, Coulomb blockade, Diffusive transport,
- Dielectric properties: Polarisation, Ferroelectric behavior.
- Optical Properties: Photoconductivity, Optical absorption & transmission, Plasmons and Excitons, Luminescence and Phosphorescence.
- Magnetic properties: Nanomagnetism, magneto-resistance; Super Para Magnetism
- Thermal and Mechanical properties: changes in thermal transport, thermal transition temperatures, and interfaces with dissimilar materials. Improved hardness and toughness of metals and alloys

Biological: Permeability through biological barriers, molecular recognition and biological assemblies.

5 General Applications: 5 Hrs

- Electrical, Electronics & Photonics- Switching glasses, Semiconductor devices including LEDs and Solar Cells, Photonic Crystals.
- Computer Science- Storage devices and Quantum computing etc
- Mechanical and Civil: Composites and their properties.
- Environmental and Chemical: Porous materials, Catalysis, tracers etc
- Biotechnology- Interaction between bimolecular and nanoparticle surface, nano-bio assemblies, Nanosensors etc

Unit - III

6 Specific Applications: 13 Hrs

Part of this can be implemented as a student project that involves: literature-survey, project report and a Seminar (Power-Point) Presentations by groups of two students each (applications and students to be identified by teachers and monitored by one teacher each):

- Carbon and its allotropes: Fullerenes (C_{60}), Carbon nanotubes and Graphene:
- Applications of Carbon Nanotubes: Field emission, Fuel Cells, Display devices, Hydrogen storage.
- Nano-Medicine: Developments and protocols for diagnostics, drug delivery and therapeutics.
- Nanotribology: Friction at nanoscale, Nanotribology and wear-resistance, MEMS and NEMS
- Photo-electronics: Merger of photonics and electronics at nanoscale dimensions
- Single electron devices, molecular circuits
- Nanocomposites (i.e. metal oxide, ceramic, glass and polymer and core-shellbased);
- Biomemitics and Biomaterials, synthetic nanocomposites for bone, teeth replacement, DNA scaffolding.
- Nanosensors: Temperature Sensors, Chemical and gas Sensors, Light and radiation sensors

7 Demonstration through experiments: 4 Hrs

1. Chemical synthesis of Au and Ag nanoparticles and characterization by Optical spectroscopy of size dependence band-gap
2. Debye Scherrer analysis of XRD data of nanoparticles of different sizes.
3. Surface area and Pore size distribution of the BET data from a nano-porous material.
4. Some experiment to study mechanical strength of nanocomposites (nano-indentation)

8 Guest lectures from industries and research laboratory personnel: 1 Hrs

Societal issues of Nanotechnology: Prospects and Dangers; Commercial aspects, emerging industry and employment opportunities.

Text Book:

References:

1. Nano Materials- A.K.Bandyopadhyay/ New Age Publishers.
2. Nanocrystals: Synthesis, Properties and Applications.
3. C. N. R. Rao, P. John Thomas and G. U. Kulkarni, Springer Series In Materials Science.
4. Nano Essentials- T.Pradeep/TMH.
5. Plenty of Room for Biology at the Bottom-An introduction to bio-nanotechnology, E. Guzit, Imperial College Press

Books Recommended for extra reading:

1. Introduction to Nanotechnology, C P Poole & F J Owens, Wiley, 2003.
2. Understanding Nanotechnology, Scientific American 2002.
3. Nanotechnology, M Ratner & D Ratner, Prentice Hall 2003.
4. Nanotechnology, M Wildon, K Kannagara G Smith, M Simmons & B Raguse, CRC Press Boca Raton 2002.

Apart from the above, in view of the course being of advanced nature, the content of course will be supplemented with course material from the course instructors.

Course Code: 15EMEO402 **Course Title: Nanotechnology**

L-T-P: 3-0-0 Credits: 3 Contact Hrs: 3 hrs/week

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Teaching Hrs: 40 Exam Duration: 3 hrs

Unit - I

1. An overview of Nanoscience & Nanotechnology: 4 Hrs

Historical background – nature, scope and content of the subject – multidisciplinary aspects – industrial, economic and societal implications

2. Experimental Techniques and Methods: 5 Hrs

For investigating and manipulating materials in the nano scale – electron microscope – scanning probe microscope – optical and other microscopes

3. Fullerenes: 6 Hrs

Discovery, synthesis and purification – chemistry of fullerenes in the condensed phase – orientational ordering – pressure effects – conductivity and superconductivity – ferromagnetism – optical properties.

Carbon Nanotubes – synthesis and purification – filling of nanotubes – mechanism of growth – electronic structure – transport properties – mechanical and physical properties – applications

Unit – II

4. Self-assembled Monolayers: 5 Hrs

Monolayers on gold – growth process – phase transitions – patterning monolayers – mixed monolayers – applications

5. Semiconductor Quantum Dots: 5 Hrs

Synthesis – electronic structure of nanocrystals – how quantum dots are studied – correlation of properties with size – uses

6. Monolayer-protected Metal Nanoparticles: 5 Hrs

Method of preparation – characterization – functionalized metal nanoparticles –applications – superlattices

Unit - III

7. Nanobiology: 5 Hrs

Interaction between biomolecules and nanoparticle surfaces – materials used for synthesis of hybrid nano-bio assemblies – biological applications – nanoprobes for analytical applications – nanobiotechnology – future perspectives

8. Molecular Nanomachines:

Covalent and non-covalent approaches – molecular motors and machines – other molecular devices single molecular devices – practical problems involved

Text Books

1. NANO: The Essentials – Understanding Nanoscience and Nanotechnology; T Pradeep (Professor, IIT Madras); Tata McGraw-Hill India (2007)

Reference Books

1. Nanotechnology: Richard Booker & Earl Boysen; Wiley (2005).
2. Introduction to Nanoscale Science and Technology [Series: Nanostructure Science andTechnology]: Di Ventra, et al (Ed); Springer (2004).
3. Nanotechnology Demystified: Linda Williams & Wade Adams; McGraw-Hill (2007)

Introduction to Nanotechnology: Charles P Poole Jr, Frank J Owens, Wiley India Pvt. Ltd., New Delhi, 2007

Course Code: 15EMEO403 **Course Title: Design of Experiments**

L-T-P: **3-0-0**	Credits:3	Contact Hrs: 40
ISA Marks: **50**	ESA Marks: **50**	Total Marks: **100**
Teaching Hrs: **40 hrs**		Exam Duration: **3hrs**

Unit I

1 Chapter 1. Introduction 04hrs
Strategy of experimentation, applications of experimental design, basic principles, guidelines for designing the experiments.

2 Chapter 2. Taguchi's approach to quality 04hrs
Definition of quality, Taguchi's quality philosophy, Quality loss function, off-line and on-line quality control, Signal and Noise Factors.

3 Chapter 3. Motivation for using ANOVA 08hrs
Introduction to analysis of variance (ANOVA), test of hypothesis, limitations of testing of hypothesis for difference between the means of two samples, testing of hypothesis using chi-square, t-test and F-test, one-way ANOVA examples.

Unit II

4 Chapter 4. Factorial Experiments 08hrs
Two-Factor Factorial Design, General Factorial Design, 2^2, 2^3 and 2^4 Full Factorial Designs, Exercises

5 Chapter 5. Fractional Factorial Designs 04hrs
One half fraction of 2^k Design, One quarter fraction of 2^k Design, General 2^{k-p} Fractional Factorial Design , Exercises

6 Chapter 6. Regression Approach 04hrs
Simple Regression and Multiple regressions, Types of designs, Central composite design and Box-Behnken design, Exercises

Unit – III

7 Chapter 7. Orthogonal Array Experiments 04hrs
Introduction, Design of Orthogonal arrays, ANOVA for Orthogonal Array.

8 Chapter 8. Robust Parameter Design 04hrs
Introduction, Signal-to-Noise ratio, ANOVA for S/N ratio, Steps of S/N approach.

Text Books:

1. Douglas C. Montgomery, "Design and Analysis of Experiments", John Wiley and Sons.
2. Madhav S. Phadke, "Quality Engineering using Robust Design", Prentice Hall PTR, Englewood Cliffs, New Jersey.
3. R. Panneerselvam, "Design and Analysis of Experiments- R PHI Learning Private Limited,New Delhi.

References:

1. Robert H. Lochner and Joseph E. Matar, "Designing for Quality- an Introduction Best of Taguchi and Western Methods or Statistical Experimental Design", Chapman and Hall.
2. – Philips .J. Ross, "Taguchi Techniques for Quality Engineering", McGraw Hill, New York.

Course Code: 15EMEO404 **Course Title: Engine Management Systems**

L-T-P: 3-0-0 Credits: 3 Contact Hrs: 3 hrs/week

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Teaching Hrs: 40 Exam Duration: 3 hrs

Unit - I

Basics of Gasoline (SI) Engine 6 Hrs

Introduction, Operating concept, Valve timing, Stages of combustion, Combustion knock, Effect of engine variables on knock, Torque and power, Engine efficiency, Specific fuel consumption, Fuels for spark ignition engines.

Gasoline engine management 4 Hrs

Technical requirement, Cylinder charge control, Air-charge control, Variable valve timing, controlled charge flow, A/F –mixture formation, Ignition- Battery ignition systems, Electronic ignition system, Inductive ignition system, Ignition coils, Spark plugs.

Gasoline fuel injection 5 Hrs

Fuel supply for manifold injection, Operating concept, Electromagnetic fuel injectors, Types of fuel injection, Fuel supply for gasoline direct injection, Operating concept, Rail, High pressure pump, Pressure control valve, High pressure injector, Combustion process, A/F mixture formation, Operating modes
Motronic engine management, ME-Motronic, MED-Motronic.

Unit – II

Basics of Diesel Engine 5 Hrs

Method of operation, Stages of combustion, Operating statuses, Fuel-injection system, Combustion chambers-Di and IDI, Diesel fuels-properties, Alternative fuels- Alcohols, Vegetable oils.
Cylinder Charge Control - Intake air filters, Swirl flaps, Superchargers & Turbochargers, Exhaust Gas Recirculation.

Diesel fuel injection 5 Hrs

Requirements of ideal fuel injection system, Basic Principles of fuel supply - Mixture distribution, Start of fuel injection and delivery, Injected fuel quantity, Injection characteristics, Injection pressure, Injection direction and number of injection jets. Fuel supply system.

Fuel injection pumps 5 Hrs

Design and method of operation of in-line fuel injection pump systems, Distributor fuel injection pump systems, Unit injector system and unit pump system, Common rail system.
Nozzles and Nozzle holders - Pintle nozzles, Hole type nozzles, future development.

Unit - III

Engine Exhaust Emission Control 5 Hrs

Formation of NO_X, HC/CO mechanism , Smoke and Particulate emissions, Methods of controlling emissions- Thermal converter, Catalytic converter and Particulate Trap, Diesel Smoke and its control, Emission (HC, CO, NO and NO_X) measuring equipments, Emission norms.

Recent Trends in IC Engines 5 Hrs

Dual fuel Engine, Homogeneous Charge Compression Ignition Engine (HCCI), Reactivity controlled compression ignition engine (RCCI), Lean Burn Engine, VVT engines.

Text Books:

1. Gasoline Engine Management – Published by Robert Bosch Gmbh, 2004 – 2nd Edition
2. Diesel Engine Management " – Published by Robert Bosch Gmbh, 2004 – 3rd Edition

Reference Books:

1. A Course in I.C.Engine – Mathur and Sharma, Dhanpal Rai & sons, New Delhi
2. Internal Combustion Engine Fundamentals – John B. Heywood, McGraw- Hill

Course Code: 16EMEC201 **Course Title: Instrumentation & Control Engineering**

L-T-P: 3-1-0	Credits:4	Contact Hrs: 64
CIE Marks: 50	SEE Marks: 50	Total Marks: 100
Teaching Hrs: 40		Exam Duration: 3 hours

Unit - I

1. Introduction to Instrumentation & Control Engineering 05 Hrs

Generalized configurations and functional description of measuring instruments, Generalized configurations and functional description of control systems. Control system design, Design examples - Open loop and Close loop automatic control

2. Mathematical Modelling of Physical Systems: 10 Hrs

Introduction, Differential equations of physical systems, The Laplace Transform, Order of system; The transfer function of linear and rotational Mechanical systems, Gear Train, Electrical systems, Electro-mechanical System, Thermal systems, Hydraulic System; Block representation of system elements, Reduction of block diagrams to get transfer function.

Unit - II

3. System Response 08 Hrs

Introduction, Poles, Zeros, and System Response, First-order system response to step, ramp and impulse inputs , Second-order system response to step input; Un-damped, Under damped, Critical damped and Over damped systems, Time response specifications. Design of 1st and 2nd order system.
Introduction to PID controller design. Types of Controllers, Mathematical modeling of PID, ON-OFF controller, Effect of Proportional, Derivative and Integral elements on system behavior, Design of Controller for given simple applications.

4. System Stability 07 Hrs

Introduction to stability and the stability analysis by Routh-Hurwitz Criterion. Defining the Root locus, General rules for constructing root loci, Sketching the Root locus, Effect of gain adjustment, addition of pole and addition of zero on system response and system stability. Frequency Response Techniques: Bode Plots. Stability analysis using bode plots.

Unit - 3

6. Instrumentation 05 Hrs

Quality Prameters of an instrument. Static and Dynamic Performance Characteristics instrument. Introduction to Signal Conditioning Processes; Motion measurement - Displacement: Translation and Rotational, Velocity: Translation and Rotational, Acceleration measurements

7. Instrument and Display 05 Hrs

Temperature measurement, Force, Torque and Power measurement, Pressure and Flow rate measurement. Display: LED, 7-segment, TFT, Plasma.

Text Books

1. Katsuhiko Ogata, Modern Control Engineering, 5th edition, Pearson Publications
2. T.G Beckwith, R.D Marangoni and J.H Lienhard, Mechanical Measurements, 5th edition, Addison Wesley
3. W. Bolton, “Mechatronics”, 2nd edition , Pearson Ed, 2001

References

1. Richard C Dorf and Robert H. Bishop, Modern Control Systems, 12th edition, Addison Wesley
2. Norman S. Nise, Control. Systems, 6th edition, John Wiley & Sons
3. R.S Figiola and D.E Beasley, Theory and Design for Mechanical Measurement, 2nd edition, John Wiley
4. Ernest Doebelin and Dhanesh Manik, Measurement Systems, 6th edition, Tata McGraw-Hill Education Pvt. Ltd

Course Code: 16EMEP202 **Course Title: Instrumentation &Control Engineering Lab**

L-T-P: 0-0-2	Credits:2	Contact Hrs: 48
ISA Marks: 80	ESA Marks: 20	Total Marks: 100
Teaching Hrs: 48 (24 sessions)		Exam Duration: 2 hours

Sl. No	Content	No. of Sessions
1	MATLAB - UI introduction, Desktop tools, Matrices, Control and condition statements, script Basic plotting, MuPad, Building GUI for few problems like addition of two numbers	3
2	Simulink- addition of numbers, temperature conversion, creation of subsystem, 1st and 2nd order system modeling with elementary block diagram. Input data from workspace.	1
3	Study of Multimeter and use of it to measure voltage, Current, Resistance etc. Simulate and Measure the same from simscape physical modelling	1
4	Physical modelling, analytical and experimental study of Inverting and Non Inverting circuits. Measurement of amplitude and phase.	2
5	Study of system response for Impulse, Step and Ramp inputs	2
6	Physical modelling, analytical and experimental study of 2^{nd} order systems for varying zeta value	1
7	Physical modelling of electro-mechanical, Gear Train, hydraulic, Hydraulic lift and study the response for step input	2
8	Stability analysis using root locus and Bode plots	2
9	Introduction to virtual instrumentation using LabVIEW	3
10	Strain Measurement with LabVIEW and DAQ.	1
11	P, PI, PID controller design	1
12	Quancer hardware for control application	2
13	Study of LVDT, Load Cell, Tachometer, Thermocouple, Thermometer, Sound measurement	1

Course Code: 16EMEP203 **Course Title: Engineering Design**

L-T-P: 0-0-3 Credits: 3 Contact Hrs: 6 hrs/week

ISA Marks: 80 ESA Marks: 20 Total Marks: 100

Teaching Hrs: 72 Exam Duration: 2 hrs

Engineering Design [Part A]

1	Planning: Analyse Need, Formulate a Product Proposal, Clarify the Task, Requirements Modeling (SRS), Elaborate Requirements List, Design Specifications	6
2	Concept Development: Function to Architecture, Establish Functions Structure, Search for Working Principles & Working Structures, Combine & Firm-up into Concept Variants, Evaluate against Technical & Economic criteria, Best Feasible Design	9
3	System-level Design: Product Architecture -State Diagrams, Data-flow Diagrams, Configuration Design, Parametric Design, Construction Structure, Preliminary BOM, Co-simulation across domains	9
4	Detail Design: Geometry, Dimensions, Material, PCB Design, Component Selection, Class Diagrams, Code Generation, Design Verification, Detailed & Assembly Drawings Production & Assembly Instructions, Final BOM, Product Specifications	12

Text Books (List of books as mentioned in the approved syllabus)

1. Clive L Dym and Patrick Little, "Engineering Design: A Project Based Introduction", John Wiley & Sons
2. Yousef Haik, "Engineering Design Process", Cengage Learning India Private Limited, New Delhi

References

1. Pahl, G., Beitz, W., Feldhusen, J. and Grote ; "Engineering Design-A Systematic Approach" by, K.-H- Springer; 3rd ed. 2007

Laboratory Plan

Laboratory Title: **Engineering Design[Part B]**	Lab. Code: **15EMEP203[Part B]**
Total Hours: **40**	Duration of ESA Hours: -
ISA Marks: **40**	ESA Marks: **0**

Part – B

COURSE CONTENT

Course Code: **15EMEP203 [Part B]** Course Title: **Engineering Design Practice [Part B]**
L-T-P**: 0-0-1.5** Credits:**1.5**
Contact Hrs: **3hrs/week** ISA Marks: **40** ESA Marks: **00**
Teaching Hours**: 13 Sessions of 3 hours each (40hrs)**

Part – B1 [Machine Drawing]	**13 sessions**
8. 3D Modeling using CAD software 3D modeling of machine parts such as: (1) Body of screw jack (2) Valve body (3) Body of machine vice (4) Flange of protected type flanged coupling (5) Cone pulley	9 Hours / 3 sessions
9. Sectional Views Sectional views of machine parts involving half section, full section, offset section, revolved section, and local section	9 Hours / 3 sessions
10. Threaded Fasteners Drawing of bolts, nuts, screws and their conventional representation.	6 Hours / 2 sessions
11. Part and Assembly Drawing Drawing of part and assembly drawing of machines such as: (1) Screw jack (2) Protected type flanged coupling (3) Pipe vice (4) Clapper box (5) Non-return valve (6) Universal coupling (7) Pin and cotter joints	15 hours / 5 sessions

Books/References:

Text books:

1. Machine Drawing by K.R. Gopalakrishna, Subhas Publications, 22nd Edition - 2013.
2. Machine Drawing by N.D.Bhat&V.M.Panchal, Charotar Publishing House.

Course Code: 16EMEP201 **Course Title: Manufacturing Processes Lab**

L-T-P: 0-0-1	Credits: 1	Contact Hrs: 2 hrs/week
ISA Marks: 80	ESA Marks: 20	Total Marks: 100
Teaching Hrs: 24		Exam Duration: 2 hrs

1 Machining practices involving machining time calculations and estimation of machining costs for the jobs for turning, milling, drilling, grinding. (3 slots)

2 Simulation of CNC programming on machining processes. (2 slots)

3 CNC programming turning and machining centres. (5 slots)

4 Design, Modeling and Analysis of Bulk deformation and Sheet Metal forming processes. (2 slots)

5 Demonstration of Non-traditional machines such as laser cutting, plasma cutting, electro discharge machines

Text books

1. Kalpakjian S., and Schmid S.R., Manufacturing Engineering & Technology, 7th edition, Pearson Education, 2014.
2. Mikell P. Groover, Fundamentals of Modern Manufacturing, 5th edition, John Wiley & Sons, 2012.

Reference books

5. John A. Schey, Introduction to Manufacturing Processes, 3rd edition, Tata McGraw Hill, 1999.
6. Juneja B. L. and Sekhon G. S., Fundamentals of Metal Cutting and Machine Tools, 3rd edition, New Age International Limited, 2008.
7. Mikell P. Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, 4th edition, Prentice Hall, 2014.
8. Pandey P. C. and Shan H. S., Modern Machining Processes, 1st edition, Tata McGraw Hill, 2013.

Course Code: 16EMEP204 **Course Title: Mechatronics Lab**

L-T-P: 0-0-3	Credits:3	Contact Hrs: 60
ISA Marks: 80	ESA Marks: 20	Total Marks: 100
Teaching Hrs: 60 (30 sessions)		Exam Duration: 2 hours

Unit - I

1. Introduction to Mechatronics: Definition & overview of Mechatronics, Key elements, Real time Simualtion, Mechatronics Design approach, examples of mechatronic systems. 04 Hrs

2. Sensor, Actuators: Classification and application Sensors and Actuators: DC motor, Stepper motor, AC and DC Servo motor 04 Hrs

3. Signal conditioning: Introduction; Filters(Active/Passive, Analog/Digital); Encoder, Decoder; MUX, Demux; SR Latch, Flip Flop(SR, JK, D, T), Registers, Counters; ADC, DAC; Data Acquisition System(DAQ) simulation experiments. 02 Hrs

Unit - II

4. Basics of Microcontrollers/Microprocessor: Memory Hierarchy in Computer; Address/Data lines; Micro-controller Vs Microprocessor; RISC vs CISC, Harward Vs. Von neumann, Introduction to 8051 Architecture, Timer, Counter, interrupts; Different Architectures; 04 Hrs

5. Communication System 02 Hrs
Digital Communications, Centralized, hierarchical and distributed control, Networks, Protocols, Open System Interconnection Communication interface, Serial and Parallel communication interface, Wireless Protocols.

6. Programmable logic controller (PLC): Introduction, Architecture of PLC; Functional Block Diagram(FBD) and Ladder diagrams for logic functions, latching, interlocking, Timer/counter, web controlled applications. Experiments on the same. 02 Hrs

7. Applications of Mechatronics: Robotics: Introduction, Robotic terminology, Robotic configuration, Robot applications, Robots Co-ordinates System**;** Experiments. 02 Hrs
Machine Vision System: Introduction, Image Acquisition; Image Processing;

Text Book

1. W. Bolton, “Mechatronics”, 2nd edition , Pearson Ed, 2001
2. Petruzella D Frank, “Programming Logic Controllers”, 3rd edition, Mc Graw Hill Education, 2010
3. Mazidi Muhammd Ali et.al, “The 8051 Microcontroller and Embedded Systems”, 2nd edition, Pearson Education India, 2007.

References

1. David Bradley and David W., “Mechatronics in Action”, 2nd edition, Springer, 2010
2. Devdas Shetty, Richard Kolk, “Mechatronics System Design”, 2nd edition, Cengage Learning, 2010.
3. Robert H. Bishop, “MECHATRONICS an Introduction”, 1st edition, Taylor & F, 2006.
4. Garry Dunning, Introduction to Programmable Logic Controllers, 3, Thomson/Delmar Learning, 2005.
5. W. Bolton, Programmable Logic Controllers, 2, Elsevier, 2013.

Manuals:

1. Mechatronics Lab Manual prepared by Lab-incharge.

Others:

- Relevant Manuals and data sheets of different device/equipment manufacturers.

List of planned Experiments:

Sl. No	Name of Experiments	No. of Sessions
1	Realization of Logic gates and arithmetic circuits.	2
2	Realization of combinational circuits like Encoder, Decoder; MUX, Demux using software package. Use these circuit to understand signal conditioning concepts.	3
3	Realization of sequential circuits like SR Latch and Flip Flop (SR, JK, D, T) and build Registers and Counters using software package. Use these as basic building blocks for controller.	2
4	Simulate circuits of Filters (Active/Passive, Analog/Digital), ADC and DAC to understand the intricate details of Data Acquisition System (DAQ).	2
5	PLC software Familiarization and Basic Programming (Latching and interlocking).	1
6	Timer, Counter programming applications using PLC.	2
7	Building applications like Water level controller, Sequencing of 3 motors, Washing machine sequencing, Welding process/ conveyor controller, DCmotor controller using PLC.	2
8	Web server based control technique for remote control applications (give insight to IOT applications).	1
9	Machine vision concept realization using kits built In-house. Write a Program using Matlab to capture image, detect object and find its co-ordinates. Communicate this information to arduino to pick and place it to predefined position.	2
10	Build stand alone systems for image acquisition and processing applications using Raspberry pi. It is programmed using graphical programming (simulink).	2
11	Course Project (Open Ended Experiment.)	1

Course Code: 16EMEP205 **Course Title:** Product Realization

L-T-P: 0-0-2 Credits:2 Contact Hrs: 60

ISA Marks: 80 ESA Marks: 20 Total Marks: 100

Teaching Hrs: 60 (30 sessions) Exam Duration: 2 hours

Product Realization Week wise Schedule/ Planning:

Week #	Particulars
Week 1 and Week 2	➢ Introduction to Prototyping - Specifications, Part Drawings, Assembly Drawings, PCB Layout, Wireframe , Pseudocode, BOM, Process Plan, Fabrication and Test Plan Validation ➢ IOT Workshop
Week 3	➢ Identifying sub-assemblies ➢ Procurement of logistics for proof of concept testing. ➢ Selection of materials for all the parts and joining techniques ➢ Selection of UI and Core Component of Android
Week 4	➢ Process plan ➢ Identifying the proper machines, tools and operations required for prototyping. ➢ Selection of appropriate raw materials for prototyping. ➢ Demonstrate breadboard prototype of entire electronics in the system. (To have tested electronic circuit for PCB design) ➢ UI implementation using XML
Week 5	➢ Fabricate the parts for sub assembly ➢ Initiate schematic entry in PCB design software, also refine and optimize thesize of the board. ➢ UI implementation and validation
Week 6	➢ Fabricate the parts for sub assembly ➢ Generate gerber files for the optimal PCB design. ➢ Android core component implementation and Unit Testing
Week 7	➢ Fabricate the parts for sub assembly ➢ Fabricate PCB using MITS machine, solder components and test the design. ➢ Android core component implementation and Unit Testing
Week 8	➢ Assemble the sub assemblies and check for interference and functionality ➢ Revisit PCB testing for increasing reliability of the design. (test to avoid/eliminate lose connections, dry soldering, andbad electronic components) ➢ Android core components integration and testing
Week 9	➢ Test the functional prototype using proper identified test methods. ➢ Demonstrate working of fully functional PCB. ➢ Configuration of IoT Server
Week 10	➢ Integratesubsystems for prototype testing. ➢ Analyse the test results ➢ System modification ➢ System integration
Week 11	➢ Final concluding review ➢ Product catalog ➢ System Tesing.

References

1. Pahl, G., Beitz, W., Feldhusen, J. and Grote ; "Engineering Design-A Systematic Approach" by, K.-H- Springer; 3rd ed. 2007

Course Code: 15EMEE308 | **Course Title: HVAC Systems**

L-T-P: 3-0-0 | Credits: 3 | Contact Hrs: 3 hrs/week

ISA Marks: 50 | ESA Marks: 50 | Total Marks: 100

Teaching Hrs: 40 | Exam Duration: 3 hrs

Unit – I

Chapter 1: Introduction to HVAC Systems and Psychrometry 05 Hrs

Purpose, applications, definition and components of air conditioning - Need and methods of ventilation. Evolution of air properties and psychrometric chart - Basic processes such as sensible heating/cooling, humidification/dehumidification and their combinations, steam and adiabatic humidification, adiabatic mixing, etc. - Bypass factor and Sensible heat ratio, Numerical problems.

Chapter 2: Human Comfort, Summer and winter AC 05 Hrs

Heat transfer from body, convection, radiation, conduction, evaporation, clothing resistance, activity level - Concept of human comfort - Thermal response - comfort factors - Environmental indices - Indoor air quality. - Simple summer AC process, Room sensible heat factor, Coil sensible heat factor, ADP - Precision AC - Winter AC.

Chapter 3: AC Systems and Equipment 06 Hrs

Classification of air conditioning systems, Filters, types, efficiency – Fan laws, cooling coils and hearing coils, sizing and off design performance - Cooling and dehumidifying coil, dry and wet, sizing, performance.

Unit – II

Chapter 4: Heat Transfer 04 Hrs

Heat transfer in wall and roof, sol-air temperature, insulation, cooling load temperature difference - Fenestration, types of glass, sun shade, shading coefficient, maximum radiation, cooling load factor

Chapter 5: Cooling load and heating load estimation 06 Hrs

Thermodynamics of human body and mathematical model, Human comfort chart, Design conditions, outdoor, indoor - External load, wall, roof, glass - Internal load, occupancy, lighting, equipments - Ventilation, air quantity, loads - Load estimation methods. Vapour transfer in wall, vapour barrier, load estimation basics

Chapter 6: Air distribution, diffusion and Ventilation 06 Hrs

Ducts, types, energy equation for pipe flow, friction chart, methods of sizing, air distribution systems, ADPI, outlet/inlet selection.

Need, threshold limits of contaminants, estimation of ventilation rates, decay equation, air flow round buildings, Natural, wind effect, stack effect, combined effect - Mechanical, forced, exhaust, combined - Displacement ventilation

Unit – III

Chapter 7: Industrial ventilation 04 Hrs

Steel plants, car parks, plant rooms, mines, etc.

Chapter 8: Ventilation system design 04 Hrs

Exhaust ducts, filters, blowers, hoods, chimney, etc.

TEXT BOOK:

1. Faye C. McQuiston, Jerald D. Parker, Jeffrey D. Spitler, Heating, Ventilating and Air Conditioning: Analysis and Design, 6th Edition, July 2004,
2. W P Jones, Air Conditioning Engineering ELBS 3rd edn Edward Arnold (Publishers) ltd. Londan.

REFERENCES:

1. Harris, Modern Air Conditioning Practice 3nd Edn McGraw Hill Book Company
2. S. N. Sapali, Refrigeration and air conditioning 2nd Edn, PHI learning pvt ltd, Delhi 2016
3. C P Arora, Refrigeration and air conditioning 3rd edn

Course Code: 18EMEE303		Course Title: Turbo Machines
L-T-P: 3-0-0	Credits:3	Contact Hrs: 50
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 40		Exam Duration: 03

	Unit – I	
1.	**Principles of Turbo Machinery** Definition of turbo machine, Comparison with positive displacement machine, Classification; Application of first and second law to turbo-machines, Efficiencies. Dimensionless parameters and their physical significance, Effect of Reynolds number, Specific speed, Illustrative examples on dimensional analysis and model studies.	5 Hrs
2.	**Energy Exchange in Turbo Machines** Euler Turbine equation, Alternate form of Euler turbine equation-components of energy transfer, Degree of reaction, General Analysis of a turbo machine-effect of blade discharge angle on energy transfer and degree of reaction, General analysis of centrifugal pumps and compressors-effect of blade discharge angle on performance, Theoretical head-capacity relationship.	5 Hrs
3.	**Steam Turbines** Classification, single stage impulse turbine, condition for maximum blade efficiency, stage efficiency. Compounding-need for compounding, method of compounding, impulse staging-condition for maximum utilization factor for multi stage turbine with equiangular blades, effect of blade and nozzle losses, Reaction turbine, Parson's reaction turbine, condition for maximum blade efficiency, reaction staging, Problems on single stage turbines only.	6 Hrs
	Unit – II	
4.	**Compressible Flow Fundamentals** Energy and momentum equations for compressible fluid flows, various regions of flows, reference velocities, stagnation state, velocity of sound, critical states, Mach number, critical Mach number, types of waves, Mach cone, Mach angle, effect of Mach number on compressibility.	5 Hrs
5.	**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.	6 Hrs
6.	**Axial flow Compressors** Axial Flow Compressors: Basic operations, elementary theory, factors affecting stage pressure ratio, Blockage in the compressor annulus, degree of reaction, three-dimensional flow, design process, blade design, calculation of stage performance, compressibility effects, off-design performance.	5 Hrs
	Unit – III	
7.	**Flow through Variable Area Ducts** Isentropic flow through variable area ducts, T-s and h-s diagrams for nozzle and diffuser flows, area ratio as a function of Mach number, mass flow rate through nozzles and diffusers, effect of friction in flow through nozzles.	4 Hrs
8.	**Axial flow Turbines** Stage velocity triangles, single impulse stage, multi-stage velocity and pressure compounded impulse, reaction stages, blade-to-gas speed ratio, losses and efficiencies. Performance charts, low hub-to-tip ratio stages, partial admission turbine stages, supersonic flow.	4 Hrs

Text Book

1. Shepherd D.G., Principals of Turbo Machinery, Macmillan Publishers,1st Edn.1964
2. Yadav R., (2007) 'Steam & gas turbines and power plant engineering', Central Publishing House Allahabad, Vol. 1,
3. S. M. Yahya, Turbines, Compressors & Fans,Tata McGraw Hill Co. Ltd., 2nd edition, 2002.

E Rathakrishnan, Gas Dynamics, PHI- 2nd edition, 2009.

References

1. Kadambi V. Manohar Prasad, An Introduction to Energy Conversion, Vol-III Turbo Machinery, New Age International, 1st Edn, 2006.

Saravanamutto H.I.H, Rogers G.F.C., Cohen H, Gas Turbine Theory, 5th edn., Pearson Education, 2006.

Course Code: 15EMEE417 **Course Title: Modern Trends in Manufacturing**

L-T-P: 3-0-0 Credits: 3 Contact Hrs: 3 hrs/week

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Teaching Hrs: 40 Exam Duration: 3 hrs

Unit - I

1. Systematic Approach for Manufacturing Strategy: 4 Hrs

Seven Losses Regarding Productivity and Profitability, Feasibility Study of Productivity Improvement, Four Levels of Manufacturing Strategy.

2. Management and Productivity in Engineering: 8 Hrs

Definition of Engineering, Management and Management Engineering, Industrial Engineering and Productivity, Necessity of Facts and Work Measurement.

Productivity, Purpose of Productivity Improvement, Engineering Approach for Productivity, Three Levels of Improvement, Points of Successful Productivity, Relationship of Methods, Performance, and Utilization to Standard Time.

3. Concurrent Engineering: 3 Hrs

Introduction, importance of CE ,building blocks of CE, Important factors in concurrent engineering process , communication models, benefits and its tools.

Unit – II

4. Continuous Process Improvement: 8 Hrs

Introduction, Japanese concept of continuous improvement (kaizen), innovation concept of improvement, need for continuous improvement, tools for continuous improvement, steps in implementing continuous improvement, three pillars of continuous improvement, standardization, quality circles, suggestion systems, kaizen and management, kaizen umbrella, TPM, Six sigma, FMEA and discussion of few case studies**.**

5. Pull Production Systems: 7 Hrs

Introduction to TPS, KANBAN system, difference between pull and push system, other types of kanban, kanban rules, adapting to fluctuation in demand through kanban, a detailed kanban system example, supplier kanban and sequence schedule for kanban.

Unit - III

6. Quality Management Systems: 5 Hrs

Need for ISO 9000 and Other Quality Systems, ISO 9000:2000 Quality System – Elements, Implementation of Quality System, Documentation, Quality Auditing, QS 9000, ISO 14000 –Concept, Requirements and Benefits. Occupational Health & Safety Management (OSHAS -18001) standards, Environmental Management Certification (ISO 14001) and its benefits to stakeholders.

7. Six sigma: 5 Hrs

Principles of Six sigma, project selection for six sigma, six sigma problem solving, design for six sigma, six sigma in service and small organization, six sigma and lean production, statistical thinking and application, statistical foundation, statistical methodology, design of experiments, analysis of variances

Text books

1. Masaki Imai, 'KAIZEN', McGraw Hill International.
2. Shigeyasu Sakamoto , "Beyond World-Class Productivity", Springer-Verlag London Limited 2010.
3. Dale H. Besterfield, "Total Quality Management", Pearson Education, Asia.

Reference books

1. Richard J. Schonberger, 'Japanese Manufacturing Techniques', The Free Press – Macmillan Publication.
2. James R. Evans and William M. Lindsay, 'The Management and Control of Quality'.

Course Code: 18EMEW301 | **Course Title: Minor Project**

L-T-P: 0-0-3 | Credits: 6 | Contact Hrs: 3 hrs/week

ISA Marks: 50 | ESA Marks: 50 | Total Marks: 100

Exam Duration: 3 hrs

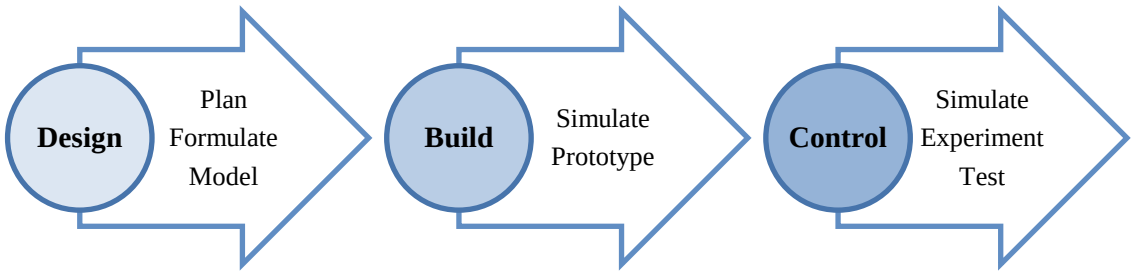
Themes for Minor Projects

Precision Agriculture	Factory Automation	Hospital Automation	Social Issues
▪ Observe, Measure, Act, ▪ Replacing human labor with automation ▪ Eg: Moisture control in soil	▪ Includes industry, workplace, assembly, machining operations, etc ▪ Eg: Automation of manual paper punching/ cutting machine	▪ Assistance for patients ▪ Hospital Logistics ▪ Medical instruments re/design ▪ Eg: Equipment to lift/ transfer patient from one place to another	▪ Issues concerned with water conversation, air pollution and public sanitation. ▪ Eg: An instrument to monitor, measure and control water pollution within a factory. (as per defined industry standards)

Any other Machatronics products

5

Methodology to be followed for carrying out the projects:



Role of Guide:

- The guide has to provide technical know-how from inception of project to execution
- Help students in identifying proper sources for raw materials, tools and other requirements
- Form a team and encourage students to take roles and responsibilities so that each one of them can enhance their knowledge and skills
- The Guide has to assess the student competencies with regard to his project work. More specifically to assess the student's individual contribution to the project
- Develop the clarity of assessment among the team in every phase of the project and advised to check for the formatting of the presentation and project report
- Continuous monitoring of project at different phases with the help of PLM e-NOVIA to work on paper-less office theme.

Evaluation of Minor-Project

The evaluation of project work shall be done in two stages as Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) having equal weightages in marks.

CIE Evaluation:

- The CIE evaluation of project work shall be done in stages by the expert review panel including guide. In addition the guide shall separately evaluate the progress of project till its completion.
- There shall be three reviews by the panel experts and marks shall be allotted as per the weightages given for each review. The student shall showcase the progress of work through the presentation, videos, models, prototypes, etc to the panel members during the reviews.
- Each of the micro activities involved in accomplishing a project have been identified and included in the evaluation criteria as performance indicators. These performance indicators are being made known to students from day one of the project which helps them to plan and be guided to reach the intended goal. The assessment of each of the performance indicators is carried out as per rubrics which are also shared with the students.
- The review panel will be given a detailed assessment rubrics for each review based on which the panel experts will award the marks.
- Project guide shall be having individual responsibility to assess the entire project work and award the marks as per the assessment rubrics.
- During each review the panel experts shall advice the students with various aspects of the work for continuous development and Implementation.

SEE Evaluation:

- Student shall prepare a detailed project report according to approved guidelines and duly signed by the guide(s) and the Head of the Department and submit it to the examiners.
- The SEE evaluation of the project work shall be based on the demonstration of the model/prototype, presentation, project report submitted and a Viva-Voce by a team consisting of the Guide, an Internal examiner (other than the guide) and an External Examiner appointed by the department.
- Student shall submit a copy of the approved project report after the successful completion of viva examinations to the department.

Course Code: 16EMEP201 **Course Title: Manufacturing Processes Lab**

L-T-P: 0-0-1 Credits: 1 Contact Hrs: 2 hrs/week

ISA Marks: 80 ESA Marks: 20 Total Marks: 100

Teaching Hrs: 26 Exam Duration: 2 hrs

Content

Lab Exercises

1. Machining practices involving machining time calculation and estimation of machining cost for the jobs for turning, taper turning, threading, knurling.	6 Hrs
2. To manufacture and assemble parts for ball valve which involves turning, milling, tapping/slot milling, etc.	14 Hrs
3. Design, Modeling and Analysis of Bulk deformation and Sheet Metal forming processes.	4 Hrs
4. Demonstration of CNC machines and Non-traditional machines such as laser cutting, plasma cutting, electro-discharge machine.	2 Hrs

Text Books:

1. Kalpakjian S., and Schmid S.R., Manufacturing Engineering & Technology, 7th edition, Pearson Education, 2014.
2. Mikell P. Groover, Fundamentals of Modern Manufacturing, 5th edition, John Wiley & Sons, 2012.

Reference Books:

1. Juneja B. L. and Sekhon G. S., Fundamentals of Metal Cutting and Machine Tools, 3rd edition, New Age International Limited, 2008.
2. Rosenthal, P., Heine L., Principles of Metal Casting, Tata McGraw Hill, 1997.
3. John A. Schey, Introduction to Manufacturing Processes, 3rd edition, Tata McGraw Hill, 1999.
4. Mikell P. Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, 4th edition, Prentice Hall, 2014.
5. Pandey P. C. and Shan H. S., Modern Machining Processes, 1st edition, Tata McGraw Hill, 2013.

Course Code: 18EMEP203 **Course Title: Machine Drawing Lab**

L-T-P: 0-0-1	Credits: 1	Contact Hrs: 2 hrs/week
ISA Marks: 80	ESA Marks:20	Total Marks: 100
Teaching Hrs: 26		Exam Duration: 2 hrs

Laboratory Content

1. Sectional views 8 Hrs

Sectional views of machine parts involving half section, full section, offset section, revolved section and local section (use 1st and 3rd angle of projection).

2. Threaded Fasteners 6 Hrs

Drawing of bolts, nuts, screws and their conventional representation.

3. Part and Assembly Drawing 8 Hrs

Drawing of part and assembly drawing of machines such as:
(1) Screw Jack. (2) Protected type flanged coupling. (3) Pipe vice. (4) Clapper box. (5) Non-return valve. (6)Universal coupling. (7) Pin and cotter joints.

4. Assembly Drawing using CAD tool 4 Hrs

Assembly drawing of machines such as:
(1) Screw Jack. (2) Protected type flanged coupling. (3) Pipe vice. (4) Clapper box. (5) Non-return valve. (6)Universal coupling. (7) Pin and cotter joints.

Text Books:

1. Machine Drawing by K. R. Gopalakrishna, Subhas Publications, 22nd Edition - 2013.
2. Machine Drawing by N. D. Bhat & V. M. Panchal, Charotar Publishing House.
3. A Text Book of Computer Aided Machine Drawing, S. Trymbaka Murthy, CBS Publishers, New Delhi, 2007 Edition.

Reference Books:

1. Engineering drawing practice for schools and colleges SP 46:2003 (BIS).

Course Code: 19EMEC201 **Course Title: Control Systems**

L-T-P: 2-1-0 Credits: 3 Contact Hrs: 4 hrs/week

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Teaching Hrs: 30 Exam Duration: 3 hrs

Unit – 1

1. Introduction to Control System 3 hrs

Generalized configurations and functional description of control systems. Control system design. Examples of Control System. Introduction to Linear, Nonlinear, Time Variant and Time Invariant systems.

2. Modeling of Physical Systems: 8 hrs

Introduction, Differential equations of physical systems, The Laplace Transform, Order of system; The transfer function of linear and rotational Mechanical systems, Gear Train, Electrical systems, Electro-mechanical System, Thermal systems, Hydraulic System; Block representation of system elements and Reduction of block diagrams.

Unit – 2

3. System Response 6 hrs

Introduction, Poles, Zeros, and System Response. First-order system response to step, ramp and impulse inputs. Second-order system response to step input; Un-damped, Under damped, Critical damped and Over damped systems, Time response specifications. Design of 1st and 2nd order system.

4. System Stability 5 hrs

Introduction to stability. Stability analysis by time response, S-plane and Routh-Hurwitz Criterion. Effect of gain adjustment, addition of pole and addition of zero on system response and system stability. Defining the Root locus, General rules for constructing root loci, Sketching the Root locus.

Unit – 3

5. Frequency Domain Analysis 4 hrs

Nyquist stability criteria, Bode Plots. Stability analysis using bode plots.

6. Control Action 4 hrs

Introduction to PID controller design. Types of Controllers, Mathematical modeling of PID, ON-OFF controller, Effect of Proportional, Derivative and Integral elements on system behavior, Design of Controller for given simple applications. Controller Design using root locus.

Text Book:

1. Richard C Dorf and Robert H. Bishop, Modern Control Systems, 12th edition, Addison Wesley
2. A. Anandkumar, Control Systems, 2nd edition, PHI Learning Private Limited, 2014.

Reference Book:

1. Katsuhiko Ogata, Modern Control Engineering, 5th edition, Pearson Publications.
2. Norman S. Nise, Control. Systems, 6th edition, John Wiley & Sons

Course Code: 19EMEP201 **Course Title: Control Systems Lab**

L-T-P: 0-0-2 Credits: 2 Contact Hrs: 4 hrs/week

ISA Marks: 80 ESA Marks: 20 Total Marks: 100

Teaching Hrs: 48 Exam Duration: 2 hrs

Experiment Number	Experiments	No of sessions
01	Scaffolding exercises to explore MATLAB / Simulink software package.	04
02	Modelling of physical systems and its response analysis	06
03	Design and investigate the effects of various controllers on a system.	03
04	Comparative study of Time response, root locus and Bode plot with respect to stability.	02
05	Control system analysis: Case Studies ✓ Hydraulic Lift ✓ DC servo motor	06
06	Case Study (Open Ended)	03

Text Book:

1. Richard C Dorf and Robert H. Bishop, Modern Control Systems, 12th edition, Addison Wesley
2. A. Anandkumar, Control Systems, 2nd edition, PHI Learning Private Limited, 2014.

Reference Book:

1. Katsuhiko Ogata, Modern Control Engineering, 5th edition, Pearson Publications.
2. Norman S. Nise, Control. Systems, 6th edition, John Wiley & Sons.
3. Data sheets provided by manufactures.

Course Code: 19EMEP301 **Course Title: CAD modelling and PLM Lab**

L-T-P: 2-0-2 Credits: 4 Contact Hrs:6hrs/week

ISA Marks: 80 ESA Marks: 20 Total Marks: 100

Teaching Hrs: 80 Exam Duration: 3 hrs

Sl. No.	Work Benches of 3D PLM	No of weeks
1	**Sketcher**- Brief introduction on Sketcher work bench environment Structure of users and saving of files. **Exercises on Sketch** Tools, Profile Tool bar and Constraint Tool bar: Generate the following 2D sketches and make them Iso-constrained.	1
2	**Part Design**-Exercise on 3d models using pad, slot, shaft, groove, hole ,rib and stiffener commands, cut revolve, Dress up commands like chamfer, fillets etc. *(*Multi-Sections Solid and Removed Multi-Sections Solid Commands	2
3	**Generative shape design (GSD)**- Exercises using GSD to generate complicate surfaces using sub tool bars: Extrude-Revolution, Offset Var and Sweeps Extrude, Revolve, Trim, Transformation and Fillet tools Exercises on Wireframe, Surfaces and Operations Tool bar: (Conversion of Surface model into Solid model	3
4.	**Assembly Design**- Introduction to Assembly Design Work bench Bottom-Up and Top-Down assembly approaches Invoking existing components into assembly work Exercise to demonstrate Top-Down assembly approach.	2
5	**Drafting**- Converting existing 3D models into 2d drawings with all relevant details, sectional views, sheet selection, indicating GD&T symbols and dimensioning**.**	3
6	**Enovia**- Introduction to CATIA 3D experience PLM Import the existing CATIA 3D experience data and store in Search and identify the data located in 3D experience database Modify the data in any PLM process Sharing information with users Analyze and Identify impacts of modifications Save the modifications into database	1

Reference Book:

Training material given by EDS on 3D experience

Course Code:19EMEP302 **Course Title: FEM Lab**

L-T-P: 0-0-1 Credits: 1 Contact Hrs: 2 hrs/week

ISA Marks: 80 ESA Marks: 20 Total Marks: 100

Teaching Hrs: 24 No of Sessions: 12 Exam Duration: 2 hrs

Category: Demonstration		**No. of Lab. Sessions per batch (estimate)**
1	Scientific Research Exposure (Research Education): Methods to search/extract Journal papers (Reputed journal paper), Referring papers, Drafting a paper. Introduction to ANSYS Workbench and familiarity. Real time Current/future field issues : Problem Identification	**03**
Category: Exercises		
Expt./Job No.	**Experiment/job Details**	**No. of Lab. Sessions per batch (estimate)**
10.	Static Structural analysis d) Uniform bar, e) Bracket, f) Machine Components	01
11.	Linear Buckling a) Columns & Struts (Different Boundary Conditions) b) Machine component	01
12.	Non-Linear Structural Analysis d) Geometric Nonlinearity e) Material Nonlinearity f) Contact Nonlinearity	02
13.	Dynamic Analysis (Modal/Harmonic/Transient Analysis) c) Beam (Different Boundary Conditions) d) Machine components	01
14.	Thermal Analysis d) Fins e) Heat Exchangers f) Machine component	01
15.	Drop Test & Impact Analysis c) Mobile drop test d) TV, Refrigerator etc.	01
16.	Optimization	01
17.	Model Test	01
Category: Structured Enquiry		

Execute all the FEM Analysis modules which are dealt under the lab exercise.

Identify the component (Sub-assembly need have Minimum 3 to 4 components)
Start from scratch

- Measure the dimensions of component
- Generate the Solid Modeling of components with overall assembly (In any of the CAD Software)
- Import the model in neutral form to ANSYS Workbench
- Collection of data relevant to Material Properties
- Understand the physics of the problem (Working Principle with load's and boundary conditions)

➢ Interpretation of Results with conclusion.
Category: Open ended
8. Identify field issue pertaining to any component/product in today's industry. 9. Collect the information/literature on earlier worked project through external/internal search (Journal Paper/Patent/reports) 10. Comprehend the physics of the problem with working principle. 11. Prepare the abstract and apply to a national/international conference 12. Identify material properties, boundary conditions and load steps. 13. Carryout the analysis as per the FEA steps. 14. Provide engineering solutions to the identified sub assembly (deformation and stresses, material change, weight reduction, increasing load bearing capacity, fatigue life calculation, prediction of endurance limit of component and damage factor). 15. Prepare the draft on the worked out problem and apply to a national/international conference

Materials and Resources Required:

3. Books/References: Nitin Ghokale, Practical finite element analysis
4. Manuals: Sham Tickoo, ANSYS for Engineers and Designers

Course Code:19EMEE302 **Course Title: Advanced Statistics and Machine Learning**

L-T-P: 0-0-3	Credits: 3	Contact Hrs: 6 hrs/week
ISA Marks: 80	ESA Marks: 20	Total Marks: 100
Teaching Hrs: 80		Exam Duration: 2 hrs

Unit - I

1. Introduction to Machine Learning 25 Hrs

Introduction to Supervised, Unsupervised, and Reinforcement Learning; Statistics for ML; Exploratory Data Analysis; Use of Python and working with CSV/XLS files.

Python hands on: Installation, Introduction to Python libraries (Pandas, Numpy, matplotlib and so forth)

Unit - II

2. Applied Statistics 15 Hrs

Statistics for ML; Data Wrangling; Exploratory Data Analysis; Visualization; Use of Python and working with CSV/DB

Hands on: Preprocessing techniques

18 Hrs

3. Machine Learning Methods

Introduction to ML Life Cycle; Regression – Predictive Modeling; Regularization; Feature Selection; Metrics for Prediction; Visualization;

Unit - III

4. ML – Classification 22 Hrs

Introduction to Classification; Logistic Regression; Random Forests; Metrics for Classification; Visualization; Use of Python and DB

Text Books

1. Trevor Hastie, Robert Tibshirani, and Jerome Friedman, “The Elements of Statistical Learning: Data Mining, Inference, and Prediction”, Springer, 2017.
2. Roger D Peng, “R Programming for Data Science”, Learnpub, 2015.

References

1. Geetha James, Trevor Hastie, Daniela Whitten, Robert Tibshirani, “An Introduction to Statistical Learning with Applications in R”, Springer, 2017.
2. Andrew Ng, “Machine Learning Yearning”, https://www.mlyearning.org/.
3. Michael Nielsen, “Neural Networks and Deep Learning”, http://neuralnetworksanddeeplearning.com/.

Course Code: 19EMEE307 **Course Title: Machine Learning Applications**

L-T-P: 0-0-3	Credits: 3	Contact Hrs: 6 hrs/week
ISA Marks: 80	ESA Marks: 20	Total Marks: 100
Teaching Hrs: 80		Exam Duration: 2hrs

Unit - 1

1. Unsupervised Learning 18 Hrs

Refresher week, Introduction to Unsupervised Learning, Clustering Analysis: K-Means, K-Medoid, DBSCAN, Hierarchical Clustering.

Unit - 2

2. Introduction to Deep Learning Frame-Work 15 Hrs

Introduction to DL, Exploring the popular DL frameworks, Getting started with TensorFlow, Introduction to Keras, Setting up the environment.

21 Hrs

3. Introduction to Deep Neural Network (DNN)

Introduction- What is Deep Learning, Why Deep Learning and Why now, Mathematical building blocks of NN, Examples on Regression, Classification.

Unit - 3

4. Deep Learning in practice 12 Hrs

Introduction to Convnets, Understanding Recurrent NN, Examples

Text Books

1. Deep Learning, Ian Goodfellow, Yoshua Bengio et.al
2. Trevor Hastie, Robert Tibshirani, and Jerome Friedman, “The Elements of Statistical Learning: Data Mining, Inference, and Prediction”, Springer, 2017
3. Deep Learning with Python, Francois Chollet

References

1. Andrew Ng, “Machine Learning Yearning”, https://www.mlyearning.org/.
2. Michael Nielsen, “Neural Networks and Deep Learning”, http://neuralnetworksanddeeplearning.com/.

Course Code: 19EMEE301 | **Course Title: Vehicle Structure and Design Optimization**

L-T-P: 0-0-3 | Credits: 3 | Contact Hrs: 3 hrs/week

ISA Marks: 80 | ESA Marks: 20 | Total Marks: 100

Teaching Hrs: 80 | Exam Duration: 2 hrs

PART A (Study of Vehicle Structure)		
Sl. No.	**Content**	**Teaching Hours**
1	Brief explanation of different types of Loads and its effect; Different types of stresses- Static and Thermal, Different types of beams, Struts and Columns, thick and thin cylinders;	02
2	Understanding vehicle structure based on application; (e.g: 3box, load body and chassis)	04
3	Choices for Preparation of Virtual Model (1D, 2D, 3D representation);	03
4	Importance of Joinery;	02
5	Common performance measures for vehicle structures; (Stiffness, Modal, Durability)	03
6	Understanding Data and Assumptions; (e.g. nominal and tolerance, etc.)	02
7	Baseline data; (Initial collection of data which serves as a basis for comparison with the subsequently acquired data.)	02
8	Quality control in virtual environment;	03
9	Example case of static stiffness of BIW, Chassis; (BIW (short for Body in White) is a stage in automotive design and manufacturing. BIW refers to the body shell design of an automotive product such as cars. It is just a sheet metal welded structure. BIWwill not have doors, engines, chassis or any other moving parts.)	05
10	Understanding effect of thermal loads on structure;	02
11	Understanding how to compute life based on stress results;	02
	Total-Theory	**30**
Hands on Session		
01	Demonstrate importance of geometric parameters on performance of structure	05
02	Demonstrate importance of cross members on performance of structure	05
	Total-Hands-on	**10**
	TOTAL	**40**

PART A (Design Optimization)		
Sl. No.	**Content**	**Teaching Hours**
1	Optimization in the Design Process, Engineering Design Practice, Characteristics of Different Industries, CAE and the Design Cycle, The impact of optimization on CAE, What is an Optimum Design?, Optimization terminology in a nutshell, Finding an Optimum, Formulation of an Optimization problem;	02
2	What is optimization in the context of EV structure;	02
3	Different types of design optimization;	02
4	How to plan and approach giving design guidance;	02
5	What is concept level design guidance (generative designs);	03
6	How to handle design guidance at a detailed design stage;	03
7	Examples - design guidance for stiffness attribute;	04
8	Examples - design guidance for durability attribute;	04

9	What is MDO, its application; (Medium density overlay-MDO is produced with a high-quality thermosetting resin-impregnated fiber surface bonded to one or both sides under heat and pressure to create an exterior-grade plywood panel.)	02
10	Watch-outs during design guidance process;	02
11	Examples - design guidance for NV & crash attribute;	04
	Total-Theory	**30**
	Hands on Session	
01	Optimize front control arm of a vehicle for all its performance criteria. FAW up by 10%	05
02	Optimize B-Pillar for roof crush if GVW goes up by 20% due to electrification Effect of wheel base increase on chassis stiffness and how to bring it back, Section optimization using morphing.	05
	Total-Hands-on	**10**
	TOTAL	**40**

PROJECTS:

Objective: To carry out Baseline Performance, Virtual Testing and Design Countermeasures		
Sl. No.	**Content**	
01	Battery case for EV;	
02	Motor compartment / Passenger compartment - improve performance;	
Objective: To Provide design guidance		
Sl. No.	**Content**	
01	Battery case for EV (Metal vs Composite);	
02	Motor compartment / Passenger compartment - improve performance;	

Course Code:19EMEE401 **Course Title: Dynamics & Durability of Vehicles**

L-T-P: 3-0-0 Credits: 3 Contact Hrs: 3 hrs/week

ISA Marks: 80 ESA Marks: 20 Total Marks: 100

Teaching Hrs: 40 Exam Duration: 3 hrs

PART A

(Dynamics of Vehicles)

Sl. No.	Content	Teaching Hours
1	Introduction - Kinematics & Compliance in vehicles;	02
2	Introduction to Roads and Loads;	02
3	Introduction to Durability in industry;	02
4	Data and Assumptions for multi-body systems - quality control;	03
5	Loads mapping for downstream use with examples;	03
6	Example applications using Multi-Body Dynamic Systems;	03
7	Introduction - Flex Body;	02
8	Durability example with and without Flex body;	03
9	Control systems in Multi-Body;	04
	Total-Theory	**24**
	Hands on Session	
01	Build a 2/3 wheeler suspension system to carry out K&C	08
02	Build a 3 wheeler suspension system to carry out loads extraction for durability	08
	Total-Hands-on	**16**
	TOTAL	**40**

PART B

(Durability of Vehicles)

Sl. No.	Content	Teaching Hours
1	Conduction, Convection, Steady state, Transient flows, Turbulence and its significance	02
2	Importance of BTMS, Current state of thermal management in EV	02
3	Types of battery packs for xEV	02
4	Heat load calculation for battery packs	02
5	How to approach design assessment of power pack for thermal management	02
6	Importance of data & assumptions (includes baselining)	02
7	Example case of using AcuSolve to assess a design	03
8	How to improve the thermal performance of a power pack design	02
9	Importance of Drag co-eff for vehicles moving at high speeds	02
10	Fast assessment of A-Surface design for drag using VWT	02
11	Introduction to thermal management in electronic circuits	03
	Total-Theory	**24**
	Hands on Session	
01	Assume 2 different designs and compare the thermal performance	07
02	Prepare 2 vehicle designs (external surface) and compute drag	07
	Total-Hands-on	**16**
	TOTAL	**36**

Text Books/Reference Books:

3. Dr. N.K. Giri, Automotive Mechanics, 8th Edition, 2008, Khanna Publication, New Delhi.
4. Nitin Ghokale, Practical finite element analysis, Finite to infinite, 2008.
5. Practical Aspects of Structural Optimization, Altair University, 3rd Edition.
6. Robin Hardy, Iqbal Husain, "Electric and Hybrid Vehicles". CRC Press, ISBN 0-8493-1466-6.

7. Ron Hodkinson and John Fenton, “Lightweight Electric/ Hybrid Vehicle Design”. SAE International
8. John M. Miller, Propulsion Systems for Hybrid Vehicles" Institute of Electrical Engineers, London, ISBN0 863413366.
9. Automobile Electrical and Electronic systems, Tom Denton, Third Edition, 2004, SAE International, SAE ISBN 0 7680 147 2, Society of Automotive Engineers. Inc 400 common wealth Drive, Warrendale, PA 15096-0001 USA.

PROJECTS:

Part A

Objective: To carry out Dynamic and Durability of different chassis

Sl. No.	Content
01	Compare durability of conventional ICE chassis with Electric version

Part B

Objective: To carry out to analyze the heat produced during EV operation and streamline external airflow

Sl. No.	Content
01	Compute Delta T for a chosen EV battery pack
02	Improve drag performance of a chosen external vehicle element

Course Code: 19EMEE308 **Course Title: Applications of Vibrations and Acoustics**

L-T-P: 3-0-0 Credits: 3 Contact Hrs: 3 hrs/week

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Teaching Hrs: 40 Exam Duration: 3 hrs

Unit I

1. Response of Mechanical Systems to Vibrations and Shocks 5 Hrs

Characteristics of vibration and shock, response of linear mechanical systems to vibrations, response properties of non-linear systems, response of mechanical systems to stationary random vibrations, shock response and shock spectra, vibrations in structures.

2. Vibration Measuring Instrumentation and Techniques 5 Hrs

Introduction, displacement, velocity and acceleration transducers, smart sensors and transducers, electronic data sheets, selection of accelerometer, calibration and system performance checks, practical considerations in mounting accelerometers, sensor design technique (FEA), sensor selection, mounting, cabling practices and signal conditioning, sensor and signal analysis.

3. Fundamentals of Signal Analysis 5 Hrs

Data acquisition and processing, signal operations, frequency domain analysis, sampling of continuous time signals, Fast Fourier transform, FFT analyser setup, leakage and windowing, averaging, real-time analysis of stationary and transient signals.

Unit II

4. Vibration Monitoring and Analysis Techniques 5 Hrs

Transducer considerations, vibration data collection errors, time domain analysis, statistical descriptors of vibration signals, Lissajous pattern, frequency domain analysis, quefrency domain analysis, demodulation technique, advanced fault diagnostic techniques.

5. Modal Analysis 5 Hrs

Experimental aspects of modal testing, FRF data of SDOF and MDOF systems, Classical, OMA, ODS, SRS & FE Correlation, vibration and shock testing, examples of vibration and acoustics – automotive, aerospace and defence, engineering and white goods, research.

6. Vibration Control 5 Hrs

Introduction; Vibration Nomo graph and vibration criteria; Reduction of vibration at the source, Control of vibration; Control of natural frequencies, Introduction of damping, Vibration isolation for different types of foundation, Shock isolation, Active vibration control, Vibration absorbers: Undamped and damped dynamic vibration absorber.

Unit III

7. Fundamentals of Sound 5 Hrs

Sensor selection, measurement techniques, applications-environmental, product noise: sound power and sound pressure, noise source identification: intensity and acoustic holography, building acoustics, sound quality.

8. Standards for Noise and Vibration 5 Hrs

Standards for sensors, frequency analysis, sound level meter, sound power measurement, sound intensity measurement, vibration measurement, measurement of damping.

Text Books:

1. C. Sujatha, Vibration and Acoustics, Tata McGraw-Hill Education, 2010
2. Singiresu S. Rao, Mechanical Vibrations, 6th Edition, Pearson Education, 2018.

Reference Books:

1. M. L. Munjal, Noise and Vibration Control, World Scientific Publishing Co, Pvt. Ltd., 2013
2. Bruel and Kjaer, Mechanical Vibration and Shock Measurements, 2nd Edition, Larsen & son, 1984.

Course Code: 20EMEW401 **Course Title: Senior Design Project**

L-T-P: 0-0-3 Credits: 6 Contact Hrs: 3 hrs/week

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Exam Duration: 3 hrs

About The Course:

Senior Design project course uses User experience design (UX) approach to solve complex engineering problems. In this course students are challenged to solve frontier complex engineering problems in the field of smart manufacturing, green engineering, and Design engineering and advanced materials. The objective of the course is to infuse lifelong qualities in students such as research, design thinking, innovation and entrepreneurial qualities. After this course students are capable to convert customer pain points into business solution.