# DEPARTMENT OF MECHANICAL ENGINEERING

## M.TECH. (CAD/CAM)


SARDAR VALLABHBHAI NATIONAL INSTITUTE OF TECHNOLOGY
Ichchhanath, Surat-395007, Gujarat, India
**www.svnit.ac.in**

# MISSION & VISION STATEMENT OF INSTITUTE

## Vision statement

To be one of the leading technical institutes disseminating globally acceptable education, effective industrial training and relevant research output.

## Mission statement

To be a globally accepted center of excellence in technical education catalyzing absorption, innovation, diffusion and transfer of high technologies resulting in enhanced quality for all the stakeholders.

# MISSION & VISION STATEMENT OF THE DEPARTMENT

## Vision statement

Department of Mechanical Engineering, Sardar Vallabhbhai National Institute of Technology, Surat perceives to be globally accepted center of quality technical education based on innovation and academic excellence.

## Mission statement

Department of Mechanical Engineering, Sardar Vallabhbhai National Institute of Technology, Surat strives to disseminate technical knowledge to its undergraduate, post graduate and research scholars to meet intellectual, ethical and career challenges for sustainable growth of humanity, nation, and global community.

# PROGRAMME EDUCATIONAL OBJECTIVES (PEO)

The overall educational objective for **Master of Technology in CAD/CAM** is to educate students with excellent technical capabilities in the mechanical engineering discipline with the knowledge of computer aided design and manufacturing, who will be responsible citizens and continue their professional advancement through life-long learning.

As mechanical engineers with expertise in CAD/CAM, postgraduates are prepared with following educational objectives:

| | |
|---|---|
| PEO1 | To impart the knowledge of engineering subject matter incorporating computer as a tool and building a bright career in the area of design, simulation, manufacturing and production. |
| PEO2 | To create technical ability in students by hands-on experience of design software to develop digital parts and CAM software to generate tool path for machining and conducting various experiments using latest infrastructure to enhance research approach. |
| PEO3 | To construct the confidence by employing various learning resources for solving engineering / industrial problems, designing products for social economic issues to explore skill of entrepreneur. |
| PEO4 | To develop professionalism to formulate and solve problems of interest individually and in team with high value of ethics. |
| PEO5 | To apply an environment of communication through oral and written presentation of technical reports derived research reports so as to interact with academicians, researchers, and industrial practices. |

# PROGRAM OUTCOMES (PO)

| | |
|---|---|
| PO1 | An ability to independently carry out research /investigation and development work to solve practical problems. |
| PO2 | An ability to write and present a substantial technical report/document. |
| PO3 | Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program. |
| PSO1 | Design, analyse, formulate and solve engineering problems using computer software, tools and techniques. |
| PSO2 | Adopt and demonstrate multidisciplinary approach to solve design, manufacturing and allied problems. |

# COURSE STRUCTURE FOR M. TECH. (CAD/CAM) AS PER NEP

## SEMESTER –I

| Code № | Subject | L | T | P | Exam Scheme | | | Total | Credits | Notional Hours of Learning (Approx.) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Theory Marks | Tuto. Marks | Pract. Marks | | | |
| MECC101 | **Core 1**<br>Finite Element Methods | 3 | 0 | 2 | 100 | - | 50 | 150 | 4 | 85 |
| MECC103 | **Core 2**<br>Computer Aided Design | 3 | 0 | 2 | 100 | - | 50 | 150 | 4 | 85 |
| MECC105 | **Core 3**<br>Computer Aided Manufacturing | 3 | 0 | 2 | 100 | - | 50 | 150 | 4 | 85 |
| <br>MECC111<br>MECC113<br><br>MECC115<br><br>MECC117<br><br>MECC119 | **Core Elective 1**<br>1. Advanced Mechanics of Solids<br>2. Concurrent Engineering: Tools, Techniques and Applications<br>3. Computer Aided Production Planning<br>4. Condition Monitoring and Fault Diagnosis of Rotating Machinery<br>5. Material Characterization and Testing | 3 | 0 | 0 | 100 | - | - | 100 | 3 | 55 |
| <br>MECC121<br>MECC123<br><br>MECC125<br>MECC127<br>MECC129 | **Core Elective 2**<br>1. Fracture Mechanics<br>2. Product Design and Development<br>3. Industrial Robotics<br>4. Design of Pressure Vessels<br>5. Failure Analysis and NDE | 3 | 0 | 0 | 100 | - | - | 100 | 3 | 55 |
| MECC107 | **Software Practice-I** | 0 | 0 | 4 | | | 100 | 100 | 2 | 70 |
| **Total Credits/ Notional Hours of Learning** | | | | | | | | | **20** | **435** |
| MECC191 | **Vocational Training / Professional Experience (Optional) (Mandatory for Exit)** | 2 | 0 | 0 | * | | 100 | 100 | 5 | 80 |
| MECC193 | | 3 | 0 | 0 | * | | 100 | 100 | | 120 |

***As per requirement of professional courses, in case of industry placed student / vocational training or professional experience (5 credit)**

## SEMESTER –II

| Code № | Subject | L | T | P | Exam Scheme | | | Total | Credits | Notional Hours of Learning (Approx.) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Theory Marks | Tuto. Marks | Pract. Marks | | | |
| **MECC102** | **Core 1**<br>Computer Aided Machine Design | 3 | 0 | 2 | 100 | - | 50 | 150 | 4 | 85 |
| **MECC104** | **Core 2**<br>Rapid prototyping and Tooling | 3 | 0 | 0 | 100 | - | - | 100 | 3 | 55 |
| <br>**MECC112**<br>**MECC114**<br><br>**MECC116**<br><br>**MECC118**<br>**MECC120** | **Core Elective 3**<br>1. Design of Experiments<br>2. Instrumentation and Experimental Methods<br>3. Smart Materials and Manufacturing<br>4. Computer Aided Tool Design<br>5. Quality Engineering and Management | 3 | 0 | 0 | 100 | - | - | 100 | 3 | 55 |
| <br>**MECC122**<br>**MECC124**<br><br>**MECC126**<br>**MECC128**<br><br>**MECC130** | **Core Elective 4**<br>1. Optimization Techniques<br>2. Theory of Elasticity and Plasticity<br>3. Industrial Tribology<br>4. Design and Analysis of Composite Structure<br>5. Surface Engineering | 3 | 0 | 0 | 100 | - | - | 100 | 3 | 55 |
| <br>**MECC172**<br><br>**MECC174** | **Institute Elective**<br>1. Extended Finite Element Methods<br>2. Computational Fluid Dynamics Techniques | 3 | 0 | 0 | 100 | - | - | 100 | 3 | 55 |
| **MECC106** | **Software Practice-II** | 0 | 0 | 4 | | | 100 | 100 | 2 | 70 |
| **MECC108** | **Mini Project** | 0 | 0 | 4 | | | 100 | 100 | 2 | 70 |
| **Total Credits/ Notional Hours of Learning** | | | | | | | | | **20** | **445** |
| **MECC192** | **Vocational Training / Professional Experience (Optional) (Mandatory for Exit Laboratory Practice 2** | 2 | 0 | 0 | * | - | 100 | 100 | 5 | 80 |
| **MECC194** | | 3 | 0 | 0 | * | - | 100 | 100 | | 120 |

***As per requirement of professional courses, in case of industry placed student / vocational training or professional experience (5 credit)**

## SEMESTER –III

| Code No. | Subject | L | T | P | Exam Scheme | | | Total | Credits | Notional Hours of Learning (Approx.) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Theory Marks | Tuto. Marks | Pract. Marks | | | |
| | **MOOC course-I*** | | | | | | | | 3/4 | 70/80 |
| | **MOOC course-II*** | | | | | | | | 3/4 | 70/80 |
| **MECC295** | **Dissertation Preliminaries** | | | | | - | 350 | 350 | 14 | 560 |
| **Total Credits** | | | | | | | | | **20/22** | **700/720** |

- **Student have to choose the subject with recommendation of supervisor.**

## SEMESTER -IV

| Code No. | Subject | L | T | P | Exam Scheme | | | Total | Credits | Notional Hours of Learning (Approx.) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Theory Marks | Tuto. Marks | Pract. Marks | | | |
| **MECC296** | **Dissertation** | | | | - | - | 600 | 600 | 20 | 800 |
| **Total Credits** | | | | | | | | | **20** | **800** |

# CREDIT MATRIX

| **Category** | **Credits to be earned** | | | | |
|---|---|---|---|---|---|
| | **Sem- I** | **Sem - II** | **Sem- III** | **Sem - IV** | **Total** |
| **Core Courses** | 12 | 7 | - | - | 19 |
| **Elective Courses** | 6 | 9 | - | - | 15 |
| **Software/ Laboratory** | 2 | 2 | - | - | 4 |
| **Dissertation** | - | - | 14 | 20 | 34 |
| **Mini Project** | - | 2 | - | - | 2 |
| **Vocational Training / Professional Experience (Optional) (Mandatory for Exit Laboratory Practice 2** | *5* | *5* | - | - | *10* |
| **MOOC course-I** | - | - | 3/4 | - | 3/4 |
| **MOOC course-II** | - | - | 3/4 | - | 3/4 |
| **Total Credits** | 20 | 20 | 20/22 | 20 | 80/82 |

| MECC101 | : | FINITE ELEMENT METHODS | L | T | P | Credits |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 2 | 04 |

## 1. Course Outcomes (COs):

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

| | |
|---|---|
| CO1 | Explain the fundamental concepts of the theory of the finite element method. |
| CO2 | Develop element characteristic equation and generation of global equation. |
| CO3 | Apply suitable boundary conditions to a global equation for bars, trusses and beams. |
| CO4 | Evaluate the governing FE equations for solving 1D and 2D problems. |
| CO5 | Apply the FE analysis for practical applications in static and dynamic condition. |
| CO6 | Apply the FE method for thermal, potential flow and transient problems. |

## 2. Syllabus:

| **Introduction** | **(05 Hours)** |
|---|---|
| Relevance of finite element analysis in design, Modeling and discretization, Interpolation, Elements, Nodes and degrees-of-freedom, Applications of FEA. One-Dimensional Elements and Computational Procedures: Bar elements, Beam elements, Bar and beam elements of arbitrary orientation, Assembly of elements, Properties of stiffness matrices, Boundary conditions, Solution of equations, Mechanical loads and stresses, Thermal loads and stresses. | |
| **Basic Elements Truss and Beam** | **(08 Hours)** |
| Interpolation and shape functions, Element matrices, Linear triangular elements (CST), Quadratic triangular elements, Bilinear rectangular elements, Quadratic rectangular elements, Solid elements, Higher order elements, Development of Truss equations, Development of beam equations, Nodal loads-stress calculations. | |
| **Isoperimetric Elements** | **(07 Hours)** |
| Bilinear quadrilateral elements, Quadratic quadrilaterals, Hexahedral elements, Numerical integration, Quadrature, Static condensation, Load considerations, Stress calculations, Examples of 2D and 3D applications. | |
| **Finite Elements in Structural Dynamics Applications** | **(10 Hours)** |
| Solid and Structural Mechanics Applications: One dimensional problem static analysis of trusses, Analysis of plates, Solid of revolution. Dynamic analysis: Dynamic equations, Mass and damping matrices, Natural frequencies and modes, Damping, Model methods, Ritz vectors, Component mode synthesis, Direct integration techniques, Explicit and implicit methods, Analysis by responses spectra | |
| **Heat Transfer and Fluid Mechanics Applications** | **(08 Hours)** |
| Heat Transfer, Element formulation, Reduction -nonlinear problems, Transient thermal analysis, Acoustic frequencies and modes, fluid structure interaction problems, Plane incompressible and rotational flows. | |

| FEA Applications in Other Fields | (07 Hours) |
|---|---|
| Applications of FEA in torsion, Potential flow seepage, Fluid flow in ducts. | |

**(Total Lecture Hours: 45)**

## List of Practical

1. Analysis of 2-D Truss.
2. Analysis of 2-D Frame.
3. Analysis of L Shaped Bracket.
4. Analysis of Square plate with circular hole.
5. Analysis of Solid.
6. Dynamic and Modal analysis of Cantilever beam.
7. Analysis of 2-D heat flow problem.
8. Analysis of 2-D transient heat flow in plate.
9. Simulation of flow over car body.

## 3. Books Recommended:


| | |
|---|---|
| 1 | R. D. Cook. Concepts and applications of finite element analysis. John Wiley & Sons, 2007. |
| 2 | D. L. Logan. A first course in the finite element method. Cengage Learning, 2016. |
| 3 | J. N. Reddy. An introduction to the finite element method, Vol. 1221, New York: McGraw-Hill, 2004. |
| 4 | T. Chandrupatla, A. Belegundu. Introduction to finite elements in engineering. Cambridge University Press, 2021. |
| 5 | O. C. Zienkiewicz, R. L. Taylor, J. Z. Zhu. The finite element method: its basis and fundamentals. Elsevier, 2005. |

| MECC103 | : | COMPUTER AIDED DESIGN | L | T | P | Credits |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 2 | 04 |

## 1. Course Outcome (COs):

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

| | |
|---|---|
| CO1 | Understand the concept of computer graphics, drafting, and modelling using different commands and graphical user interface |
| CO2 | Apply the concept of transformation for generating different positions of given problem with defined geometry |
| CO3 | Create 3D models assemblies and generative drawings of a given engineering part or product |
| CO4 | Apply the knowledge of programming for complex shape required in engineering for drafting or modelling |
| CO5 | Determine the coordinates of space curves and parametric curves required for generating features in CAD models |
| CO6 | Analyze surfaces based on different criteria's and process of creation |

## 2. Syllabus:

| Introduction to Computer Graphics | (04 Hours) |
|---|---|
| Basics of Computer Aided Design, Introduction to Computer graphics, DDA and Bresenham's algorithm for generating various figures, and basics of CAD/CAM hardware. | |
| **Transformation of Geometries** | **(10 Hours)** |
| 2D Transformation of geometries and 3D Transformations for Translation, Rotation, Scaling, Symmetry, Reflection, and Homogeneous Transformations, Orthographic Projections, Axonometric Projections, Oblique Projections, Perspective Transformation. | |
| **Parametric and Non-Parametric Curves** | **(07 Hours)** |
| Representation of curves – Explicit and Implicit Equations Parametric and non-parametric Curves, Splines, Bezier, B-Splines and generation of surfaces and surfaces. | |
| **Computer Aided Drafting and Modeling** | **(12 Hours)** |
| Introduction to Drafting and modelling of solids, Coordinate system, Fundamentals of solid modeling, Customization, 3D sketches, Datum features, Modeling operation Strategy and creating features, Geometric constraints, Modeling aids & tools, Generalized, views, Presentation of dimensioning / tolerances/symbols & annotation, Associatively, Parent child relationship, Parametric design, Programming techniques in drafting/ modeling/analysis, Concept of computer animation, Properties calculation Hidden line and surface removal. | |
| **Design of Surfaces** | **(05 Hours)** |
| Surface design, and Surface analysis. | |

| **Assembly of CAD Parts and Surface** | **(07 Hours)** |
|---|---|
| Top down and Bottom up approaches of creating and assembly. Presentation of assembly. | |

**(Total Lecture Hours: 45)**

## List of Practical

1. Introduction to drafting technologies & drafting practice.
2. Introduction interfacing of drafting package using program techniques.
3. Sketching/Drafting of assigned problem using programming.
4. Practice for 3-D modeling.
5. Modeling of assigned problem.
6. Modeling using parametric relations.
7. Modeling using linkage options.
8. Practice for assembly creation.
9. Practice for view generation.
10. Model/View associatively

## 3. Books Recommended:


| | |
|---|---|
| 1 | D. Hearn. Computer graphics, C version. Pearson Education India, 1997. |
| 2 | D. F. Rogers, J. A. Adams. Mathematical elements for computer graphics. McGraw-Hill, Inc, 1989. |
| 3 | I. Zeid. CAD/CAM theory and practice. McGraw-Hill Higher Education, 1991. |
| 4 | M. Chris. CAD/CAM: Principles, Practice and Manufacturing, Prentice Hall, 1999. |
| 5 | P. N. Rao. CAD/CAM: principles and applications. Tata McGraw-Hill Education, 2004. |

| MECC105 | : | COMPUTER AIDED MANUFACTURING | L | T | P | Credits |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 2 | 04 |

## 1. Course Outcomes (COs):

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

| | |
|---|---|
| CO1 | Explain fundamentals of CAM |
| CO2 | Demonstrate work zero, machine zero, tool zeros, work offset, tool length offset, and cutter radius offset and canned cycles |
| CO3 | Develop a CNC part program using cutter radius offset commands |
| CO4 | Develop a CNC part program by applying various features, such as cutter radius offset, subprogram, mirror, canned cycles, and pocket cycles, of machining centre to reduce programming task. |
| CO5 | Develop a NC/CNC part program manually and using CAD/CAM software for a given part drawing having multiple operations |
| CO6 | Explain the Group Technology, Flexible Manufacturing System and CAPP with advantages and limitations |

## 2. Syllabus:

| | |
|---|---|
| **Introduction to CAD, CAM, CIM, NC/CNC, DNC and Automation** | **(02 Hours)** |
| Definition of CAD, CAM, CIM, NC, CNC, DNC. Understanding differences among these terms. Direct Numerical Control and Distributed Numerical Control. Automated manufacturing systems and basic types, manufacturing support systems. | |
| **NC/CNC Machine Tools** | **(04 Hours)** |
| Components of NC/CNC system, Specification of CNC system, Classification of CNC machines, Constructional details of CNC machines, Axis designation, CNC control loops. | |
| **CNC Part Programming – Milling** | **(25 Hours)** |
| Basic Programming terms, Programming format, Preparatory (G-Codes) and Miscellaneous (m-Codes) functions, Machine zero, work zero and tool zero, Work offsets, Tool length offset and setup methods, cutter radius offset, CNC milling cutter holder, Part programming for milling – linear and circular interpolation, subprogram, fixed cycles, mirrors commands, machining large hole pattern, polar coordinates, round and rectangular pocket machining and cycles. | |
| **Automatically Programmed Tools (APT)** | **(04 Hours)** |
| Introduction to APT, geometry and motion statements, programming for geometry, drill cycles, and hole pattern. | |
| **Introduction to CAM software** | **(03 Hours)** |
| Modeling, toolpath generation, simulation of toolpath, generating CNC program. | |
| **Group Technology (GT), Flexible Manufacturing Systems (FMS) and Compute Aided Process Planning (CAPP)** | **(07 Hours)** |

| |
|---|
| Introduction to GT, implementation considerations, benefits and applications, GT methods - visual search method, production flow analysis, Parts classification and coding.<br>Introduction, General Considerations for FMS, types of FMS, Flexibilities, their measurements, Computer control in FMS, Automated material handling systems, AGVs, Automatic storage and retrieval systems, Manufacturing cells, cellular v/s flexible manufacturing.<br>Manual and computer aided process planning, steps, and types. |

**(Total Lecture Hours: 45)**

## List of Practical

1. Demonstration of CNC Milling machine with user interface and calculating the coordinates of given geometry in absolute end increment mode for cutter path.
2. Introduction of G codes and M codes and write the CNC part programming for a given geometry using linear, Circular interpolation.
3. Write CNC part program using cutter path co-ordinate for a geometry made of lines and arcs.
4. Write the CNC programming for a given geometry using Mirror and Subroutine.
5. Write the CNC programming for a given geometry using Polar Co-ordinate for drilling cycles.
6. Write the CNC programming for a given geometry using Tool Radius Compensation and Repeat loop for Peck drilling cycles.
7. Introduction and programming of canned cycles of milling machine.
8. Demonstration of AS/RS and AVG operation.

## 3. Books Recommended:


| | |
|---|---|
| 1 | S. F. Krar, A. Gill. CNC: Technology and Programming, McGraw-Hill, 1989. |
| 2 | P. Smid. CNC programming handbook: a comprehensive guide to practical CNC programming. Industrial Press Inc, 2003. |
| 3 | S. K. Sinha. CNC Programming (FANUC Control), Galgotia Publications Pvt Ltd., 2011. |
| 4 | S. H. Suh, S. K. Kang, D. H. Chung, I. Stroud. Theory and design of CNC systems. Springer Science & Business Media, 2008. |
| 5 | M. P. Groover. Automation, production systems, and computer-integrated manufacturing. Pearson Education India, 2016. |

| MECC111 | : | ADVANCED MECHANICS OF SOLIDS | L | T | P | Credits |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 03 |

## 1. Course Outcomes (COs):

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

| | |
|---|---|
| CO1 | Illustrate the stress at a point and constitutive relations. |
| CO2 | Analyze the transformation of stress and strain in 3D including the utilization of yield criteria. |
| CO 3 | Design the curved beams for different types of stresses. |
| CO 4 | Analyze the shear stresses in non- circular shafts. |
| CO 5 | Estimate the bending stresses in un-symmetric straight beams. |
| CO 6 | Analyze the strain at a point in rotating disks. |

## 2. Syllabus:

| | |
|---|---|
| **Introduction** | **(09 Hours)** |
| Stress definition and stress-traction relations; Deformation, strain definition, strain-displacement relation; Constitutive equations; Equilibrium and compatibility equations. | |
| **Analysis of Stresses and Strains in rectangular and polar coordinates** | **(12 Hours)** |
| Cauchy's formula, Principal stresses and principal strains, 3D Mohr's Circle, Octahedral Stresses, Hydrostatic and deviatoric stress, Two-dimensional problem solutions, Plane stress and plane strain, compatibility conditions. Advanced two-dimensional problems. | |
| **Introduction to curvilinear coordinates** | **(12 Hours)** |
| Generalized Hooke's law and theories of failure. Energy Methods. Bending of symmetric and unsymmetric straight beams, effect of shear stresses, curved beams, Shear centre. | |
| **Torsion of prismatic solid sections** | **(12 Hours)** |
| Prandtl stress function, thin-walled sections, circular, rectangular and elliptical bars, membrane analogy. Thick and thin-walled cylinders, Composite tubes, Rotating disks and cylinders. | |

**(Total Lecture Hours: 45)**

## 3. Books Recommended:


| | |
|---|---|
| 1 | M. H. Sadd. Elasticity: theory, applications, and numeric, 3rd edition, Academic Press, 2014. |
| 2 | L. S. Srinath. Advanced mechanics of solids, 3rd Edition, McGraw-Hill, 2009. |
| 3 | R. G. Budynas. Advanced Strength and Applied Stress Analysis, 2nd Edition, McGraw Hill, 2017. |
| 4 | P. Boresi, R. J. Schmidt. Advanced Mechanics of Materials, 6th Edition, John Willey and Sons,1985. |
| 5 | F. P. Beer, E. R Johnston. Mechanics of Materials \| 8th Edition (in SI Units), McGraw Hill. |

| MECC113 | : | CONCURRENT ENGINERING: TOOLS, TECHNIQUES AND APPLICATIONS | L | T | P | Credits |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 03 |

## 1. Course Outcomes (COs):

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

| | |
|---|---|
| CO1 | Support the multi-disciplinary integrated product development teams and Plan and implement a new product development program. |
| CO2 | Apply appropriate concurrent engineering tools and techniques to design and develop environment-friendly products by leveraging both manufacturing cost and lifecycle cost. |
| CO3 | Determine the customer needs and ensure that the product design is robust and meets the professional standards with better quality. |
| CO4 | Design and develop the products with high reliability, maintainability, and availability. |
| CO5 | Apply the information technology tools for collaborative product design and development. |
| CO6 | Demonstrate the applications of concurrent design of structures, products and components. |

## 2. Syllabus:

| | |
|---|---|
| **Introduction** | **(07 Hours)** |
| Motivation, definition, and philosophy of Concurrent Engineering (CE); sequential and concurrent processes; Principles of CE; Organizing for CE; CE teams and team dynamics; Role of CAD/CAM/CAE/CIM and automation in CE; Managing product development projects; Decomposition of product development stages; Benefits of CE; Implementation issues of CE. | |
| **Concurrent Engineering Tools and Techniques** | **(10 Hours)** |
| Design for manufacturing (DFM), Design for assembly (DFA); Factors influencing form design; Casting and machining considerations; Design for manufacturing and Assembly (DFMA) guidelines and examples; Lifecycle design of products with circular economy concept; Design for environment (DFE) with examples; Design for (-to-)cost; Design for X (DFX); Value engineering. | |
| Design for quality; Taguchi's methods for designing robust products; Design of Experiments (DOE) with examples; Design optimization; Quality function deployment (QFD) with examples. | **(06 Hours)** |
| Design for reliability, maintainability and availability with examples; Failure modes and effects analysis (FMEA); Fault tree analysis (FTA); Rapid prototyping methods; Design simulation; Virtual and augmented reality environments for CE. | **(08 Hours)** |
| Role of Information Technology In Concurrent Engineering Information technology (IT) components and functions; Artificial Intelligence for IT | **(07 Hours)** |

| | |
|---|---|
| operations used for product design; Collaborative product development; Collaborative product commerce, Cloud IoT for CE. | |
| **Selected Applications of Concurrent Engineering** | **(07 Hours)** |
| Design of aerospace and naval structures made of composite materials; Design of automotive components; Design of medical devices; Design of electronic products; Design of white goods parts. | |

**(Total Lecture Hours: 45)**

## 3. Books Recommended:



| | |
|---|---|
| 1 | B. Prasad. Concurrent Engineering Fundamentals I & II, Prentice Hall, New Jersey, 1996. |
| 2 | I. Moustapha. Concurrent Engineering in Product Design and Development, New Age International, New Delhi, 2006. |
| 3 | G. Boothroyd, P. Dewhurst, W. Knight. Product Design for Manufacture and Assembly, 3rd Edition, Routledge, Boca Raton, 2010. |
| 4 | J. R. Hartley. Concurrent Engineering: Shortening Lead Times, Raising Quality, and Lowering Costs, 4th Edition, Routledge, Boca Raton, 2017. |
| 5 | K. T. Ulrich, S. D. Eppinger, M. C. Yang. Product Design and Development, 7th Edition, McGraw Hill Education (India), Noida, 2020. |

| MECC115 | : | COMPUTER AIDED PRODUCTION PLANNING | L | T | P | Credits |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 03 |

## 1. Course Outcomes (COs):

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

| | |
|---|---|
| CO1 | Explain different methods of computer aided process planning (CAPP) and distinguish between process planning and production planning. |
| CO2 | Determine the forecast of a product for the given historical data using forecasting models. |
| CO3 | Solve the facility layout problems using different algorithms and create part families and machine cells in a manufacturing facility using group technology approach. |
| CO4 | Evaluate material requirement plan for a product and explain enterprise resource planning (ERP). |
| CO5 | Create schedules for multiple machines/workstations and describe the capacity planning. |
| CO6 | Explain different computer aided measurement and inspection techniques. |

## 2. Syllabus:

| | |
|---|---|
| **Introduction** | **(05 Hours)** |
| Production systems and their types -mass production, batch production and job shop production systems. Introduction to process planning in manufacturing, Role of process planning. Computer aided process planning (CAPP) - variant and generative type process planning. | |
| **Computer Aided Forecasting** | **(06 Hours)** |
| Introduction to forecasting, sources of data, demand patterns, forecasting errors, forecasting models – Quantitative: moving average, linear regression and exponential smoothing methods; Qualitative - Delphi method. | |
| **Facility Layout Planning** | **(10 Hours)** |
| Introduction to facility layout, objectives, types of facility layout- line layout, process layout, cellular layout and fixed position layout, advantages and disadvantages. Assembly line balancing, line balancing algorithms- largest candidate rule, Kilbridge and Wester method, and ranked positional weights method. Heuristics of process layout problems - computerized relative allocation of facility technique, automated layout design program and computerized relationship layout planning. Multi objective approach for facility layout planning. | |
| **Group Technology** | **(06 Hours)** |
| Introduction, benefits of group technology, part families, part classification and coding, applications of GT. Algorithms and models for Group Technology - Rank order clustering algorithm and Bond energy algorithm. | |
| **Material Requirement Planning** | **(06 Hours)** |

| | |
|---|---|
| Introduction, Objective of the MRP system, inputs to the MRP System – product structure or bill of materials (BOM), master production schedule (MPS) and inventory status file. MRP calculations. Manufacturing resources planning (MRP-II). Enterprise resource planning (ERP). | |
| **Scheduling and Capacity Planning** | **(07 Hours)** |
| Introduction, Single machine scheduling –shortest processing time rule, weighted mean flow time rule, earliest due date rule, model to minimize total tardiness, branch and bound algorithm. Introduction to parallel processors under single machine scheduling. Flow shop scheduling – Johnson's algorithm. Job shop scheduling. Capacity planning – measure of capacity, capacity strategies, tools for capacity planning. | |
| **Computer Aided Measurement and Inspection** | **(05 Hours)** |
| Computer Aided Testing, Contact and Non-contact type inspection, Co-ordinate measuring machines (CMM), types of CMM, Applications of CMM and its Benefits, Laser viewers for production profile checks, Machine vision technology, Microprocessors in metrology. | |

**(Total Lecture Hours: 45)**

## 3. Books Recommended:


| | |
|---|---|
| 1 | R. Panneerselvam. Production and Operations Management, 3rd Edition, PHI Learning Pvt Ltd, 2015. |
| 2 | M. P. Groover. Automation production systems and computer integrated manufacturing, 5th edition, Pearson Edu Ltd, 2019. |
| 3 | E. E. Adam, R. J. Ebert. Production and Operations Management, 5th Edition, Prentice Hall of India, 2015. |
| 4 | J. Heizer, B. Render, C. Munson. Operations Management, Pearson Edu Ltd, 12th Edition, 2017. |
| 5 | S. N. Chary. Production and operations management, McGraw Hill Education (India) Pvt. Ltd, 6th Edition, 2019. |

| MECC117 | : | CONDITION MONITORING AND FAULT DIAGNOSIS OF ROTATING MACHINERY | L | T | P | Credits |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 03 |

## 1. Course Outcomes (COs):

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

| | |
|---|---|
| CO1 | Describe basic terminologies used in condition monitoring of rotating machinery. |
| CO2 | Examine vibration analysis problems of complex rotating systems. |
| CO3 | Understand and analyze rotor systems with non-linear effects included. |
| CO4 | Identify and analyze rotating machinery faults using different methods. |
| CO5 | Illustrate the utility of instrumentation and terminology used in signal analysis for fault detection in rotating machinery. |
| CO6 | Analyse various plots used in condition monitoring of rotors to predict rotor faults. |

## 2. Syllabus:

| **Introduction To Condition Monitoring** | **(09 Hours)** |
|---|---|
| Introduction to condition monitoring, Maintenance approach, Basics of machinery vibration, Conventions and characteristics - amplitude, frequency and phase. | |
| **Vibration Analysis Of Complex Rotating Systems** | **(12 Hours)** |
| Asymmetric rotors, Axial vibrations, Torsional vibration - Holzer`s method, Transfer Matrix method, Geared and Branched systems, Effect of isotropic and anisotropic supports, Alford force, Whirling of rotor, Campbell diagram, Overhung rotors, Morton effect, Temperature effect on vibration. | |
| **Rotating Machinery Faults And Detection** | **(14 Hours)** |
| Rotating machinery faults and its detection - Unbalance, Misalignment, Bent rotors, Bearing defects,Oil Whirl, Oil whip, Looseness, Electric motor defect, Rotor stator rub etc., frequency range of faults, Non-destructive testing, Acoustic emission technique and applications, Introduction to Active magnetic bearing. | |
| **Instrumentation And Signal Analysis** | **(10 Hours)** |
| Instrumentation and Fault Detection Transducers - Displacement, Velocity and Acceleration, Computer aided data acquisition, Oscilloscope, Vibration Exciter systems, Signal Analysis,Basics of FFT, Trend plot, Time domain plot, Frequency domain plot, Spectrum plot, Waterfall plot, RMS, Peak and Peak-peak value, Case studies - Spectrum interpretation charts. | |

**(Total Lecture Hours: 45)**

## 3. Books Recommended:

| | |
|---|---|
| 1 | Michael I. Friswell, John E. T. Penny, Seamus D. Garvey, Arthur W. Lees. Dynamics of Rotating Machines, Cambridge University Press, 2010. |
| 2 | A. Davies. Handbook of Condition Monitoring: Techniques and Methodology, Springer Science & Business Media. |
| 3 | R. Isermann. Fault diagnosis applications, Springer – Verlag, Berlin. |
| 4 | W. T. Thomson. Theory of Vibration with Applications, CBS Publishers and Distributors, New Delhi. |
| 5 | J. S. Rao. Rotor Dynamics, New Age International Ltd. |

| MECC119 | : | MATERIAL CHARACTERIZATION AND TESTING | L | T | P | Credits |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 03 |

## 1. Course Outcomes (COs):

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

| | |
|---|---|
| CO1 | Understand importance of Materials characterization techniques. |
| CO2 | Describe principles of operation and uses of Thermal analysis equipment. |
| CO3 | Explain the production of X-rays, electrons and the electron-specimen interaction mechanisms. |
| CO4 | Describe fundamental principles of operation of four materials characterization techniques, namely optical microscopy, scanning electron microscopy, transmission electron microscopy and scanning probe microscopy. |
| CO5 | Analyze the micro and nano-images obtained with the different materials characterization techniques to the behavior of materials and their mechanical properties. |
| CO6 | Understand importance of various non-destructive evaluation for material Characterization. |

## 2. Syllabus:

| | |
|---|---|
| **Importance of Material Characterisation** | **(02 Hours)** |
| Classification of techniques for characterization, macro and micro characterization structure of solids, Basic principles & concepts. | |
| **Thermal analysis Technique and Metallographic techniques** | **(05 Hours)** |
| Introduction, Instrumentation, experimental parameters, Different types used for analysis, Thermo gravimetry, Differential thermal analysis, Differential Scanning Calorimetry, Basic principles, Instrumentation, working principles, Applications, Limitations. | |
| **Diffraction Method** | **(05 Hours)** |
| Braggs Law, X ray Diffraction methods, Determination of crystal structure, Lattice Parameter, Residual Stress, crystallite size, Applications, Limitations. | |
| **Microscopy** | **(06 Hours)** |
| Optical Microscopy **-** Introduction, Optical principles, Instrumentation, Specimen preparation, quantitative metallography Interaction of electron beam with materials; scanning electron microscopy– construction and working of SEM, various imaging techniques, applications; FESEM transmission electron microscopy - specimen preparation for TEM; applications of TEM; various imaging techniques, applications, Applications, Limitations. | |
| **Spectroscopy Techniques for Chemical Analysis** | **(06 Hours)** |
| Atomic absorption spectroscopy, X-ray spectrometry, infrared spectroscopy, XRF, UV-Visual (UV-VIS), IR, and Raman spectroscopy. Mass spectroscopy: Principles and brief account, EDS, WDS, EPMA Instrumentation, Working procedure, Applications, Limitations. | |

| Surface Characterisation | (07 Hours) |
|---|---|
| XPS(ESCA), UPS, Auger Electron Spectroscopy, Electron Probe Microanalysis (EPMA), Working procedure, Applications, Limitations. | |
| **Nano-mechanical characterization** | **(07 Hours)** |
| AFM, STM and Nano indentation studies, Introduction, Basic principles - applications and limitations. | |
| **Non-Destructive testing** | **(07 Hours)** |
| Introduction, Liquid penetrant inspection, Magnetic particle inspection, Ultrasonic inspection, Eddy current inspection, X-ray radiography. | |

**(Total Lecture Hours: 45)**

## 3. Books Recommended:


| | |
|---|---|
| 1 | S. Zhang, Lin Li, A. Kumar. Materials Characterisation Techniques, CRC press, 2008. |
| 2 | Y. Leng. Materials Characterisation: Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons (Asia), 2013. |
| 3 | D. A. Skoog, F. J. Holler, S. R. Crouch. Instrumental analysis (Vol. 47). Belmont: Brooks/Cole, Cengage Learning, 2017. |
| 4 | W. Kemp. Organic Spectroscopy, 3rd ed., Palgrave Macmillan, 2019. |
| 5 | C. R. Brundle, C. A. Evans, S. Wilson. Encyclopedia of Materials Characterisation, Butterworth-Heineman, 1992. |

| MECC121 | : | FRACTURE MECHANICS | L | T | P | Credits |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 03 |

## 1. Course Outcomes (COs):

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

| | |
|---|---|
| CO1 | Explain the basic, principals of fracture mechanics. |
| CO2 | Explain the theory of elasticity and plasticity. |
| CO3 | Evaluate the stress intensity factor by various methods. |
| CO4 | Solve the problems on J-integral and crack arrest |
| CO5 | Analyse the different modes of fracture. |
| CO6 | Apply the fracture analysis on practical applications. |

## 2. Syllabus:

| Overview of Fracture Mechanics | (10 Hours) |
|---|---|
| Introduction and history, kinds of failure, brittle and ductile fracture, modes of fracture, Defects and cause of defects in the materials, Different types of loadings, Fracture Mechanics and the Energy Balance Approach, Micro and macro crack. Stress concentration due to hole. Case study of failure of structures due to fracture. | |
| **The Energy Release Rate** | **(08 Hours)** |
| Griffith analysis, Criteria for crack growth, The crack resistance (R curve), Compliance, Stability, Fracture beyond general yield. The Crack-tip opening displacement. The Use of CTOD criteria. Experimental determination of CTOD, energy release rate. | |
| **Stress Intensity Factor** | **(09 Hours)** |
| Linear Elastic Fracture Mechanics, Crack in plate with finite dimension, edge crack, embedded crack, First mode, second mode and mixed mode stress intensity factor, relation between stress intensity factor (SIF) and energy release rate (G) and critical stress intensity factor, Westergaard's approach, Numerical examples on the evaluation of different SIF. | |
| **J Integral, Dynamics and Crack Arrest** | **(09 Hours)** |
| Concept of J integral. Limitation of J integral. Experimental determination of J integral and the parameters affecting J integral. Crack speed and kinetic energy. Dynamic stress intensity and elastic energy release rate. Crack branching. Principles of crack arrest. Crack arrest in practice. Dynamic fracture toughness. | |
| **Crack Propagation and Applications of Fracture Mechanics** | **(09 Hours)** |
| Crack growth and the stress intensity factor. Factors affecting crack propagation, Paris law, Required information for fracture mechanics approach and engineering applications of fracture mechanics. | |

**(Total Lecture Hours: 45)**

## 3. Books Recommended:

| | |
|---|---|
| 1 | P. Kumar. Elements of fracture mechanics, Tata McGraw Hill, New Delhi, 2017.Mc Graw Hill Education, 2009. |
| 2 | T. L. Anderson. Fracture Mechanics-Fundamental and Application, CRC Press, Fourth Edition, 2017. |
| 3 | D. Broek. Elementary Engineering Fracture Mechanics, Kluwer Academic Publications, Fourth Edition, 2011 |
| 4 | K. Hellan. Introduction to fracture mechanics, McGraw Hill, 2nd Edition, 2016. |
| 5 | S. K. Maiti. Fracture mechanics: Fundamentals and Applications, Cambridge University Press, First edition, 2015 |

| MECC123 | : | PRODUCT DESIGN AND DEVELOPMENT | L | T | P | Credits |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 2 | 04 |

## 1. Course Outcomes (COs):

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

| | |
|---|---|
| CO1 | Illustrate the importance of conceptual design to the product development. |
| CO2 | Apply the market research analysis to identify customer needs. |
| CO3 | Apply the creative thinking tools for the development of new design concepts. |
| CO4 | Analyse the optimal design concept using decision making methodology. |
| CO5 | Illustrate the embodiment design and robust design concepts. |
| CO6 | Analyse the various factors like human and cost in relation to industrial design. |

## 2. Syllabus:

| **Need for Developing Products** | **(15 Hours)** |
|---|---|
| The importance of engineering design, types of design, the design process, relevance of product lifecycle issues in design, designing to codes and standards, societal considerations in engineering design, generic product development process, various phases of product development, planning for products, establishing markets, market segments, relevance of market research<br>**Identifying Customer Needs**<br>Voice of customer, customer populations, hierarchy of human needs, need gathering methods, affinity diagrams, needs importance, establishing engineering characteristics competitive benchmarking, quality function deployment, house of quality, product design specification, case studies. | |
| **Creative Thinking** | **(15 Hours)** |
| Creativity and problem solving, creative thinking methods, generating design concepts, systematic methods for designing, functional decomposition, physical decomposition, functional representation, morphological methods, TRIZ axiomatic design.<br>**Decision Making**<br>Decision theory, utility theory, decision trees, concept evaluation methods, Pugh concept selection method, weighted decision matrix, analytic hierarchy process, introduction to embodiment design, product architecture, types of modular architecture, steps in developing product architecture. | |
| **Industrial Design** | **(15 Hours)** |
| Human factors design, user friendly design, design for serviceability, design for environment, prototyping and testing, cost evaluation, categories of cost, overhead costs, activity based costing, methods of developing cost estimates, manufacturing cost, value analysis in costing. | |

**(Total Lecture Hours: 45)**

## 3. Books recommended:


| | |
|---|---|
| 1 | K. T. Ulrich and S. D. Eppinger. Product Design and Development, McGraw-Hill Education, 2016 |
| 2 | C. L. Dym, P. Little and E. Orwin. Engineering Design: A Project-Based Introduction, 4th Edition, John Wiley & Sons Inc., 2013. |
| 3 | G. E. Dieter and L. C. Schmidt. Engineering Design, McGraw-Hill International Edition, 2013. |
| 4 | A. Jamnia. Introduction to Product Design and Development for Engineers, CRC Press, 2018. |
| 5 | K. Prashant. Product Design: Creativity, Concepts and Usability, PHI Learning Private Limited, 2012. |

| MECC125 | : | INDUSTRIAL ROBOTICS | L | T | P | Credits |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 03 |

## 1. Course Outcomes (COs):

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

| | |
|---|---|
| CO1 | Explain the basics of robotic systems. |
| CO2 | Apply the concept of robot arm kinematics. |
| CO3 | Analyze statics and dynamics of robots. |
| CO4 | Analyze manipulator trajectories. |
| CO5 | Analyze control of robot manipulators. |
| CO6 | Illustrate robot programming, sensing and vision. |

## 2. Syllabus:

| **Introduction** | **(04 Hours)** |
|---|---|
| Introduction to robots, Robot manipulators, Robot anatomy, Coordinate systems, Work envelope, Types and classification, Specifications, Actuators and drives. | |
| **Mathematical Representation of Robots** | **(05 Hours)** |
| Rotations and translation of vectors, Transformations and Euler angle representations, Homogenous transformations, Representation of position and orientation of a rigid body, Homogeneous transformations, Denavit-Hartenberg (D-H) notations and parameters, Representation of joints, link representation using D-H parameters. | |
| **Forward and Inverse Kinematics** | **(10 Hours)** |
| Introduction, Forward and inverse kinematics problems, Velocity and Statics analysis, Linear and angular velocity of links, Velocity propagation, Jacobians for robotic manipulators, Statics and force transformation of robotic manipulators, Singularity analysis. | |
| **Robot Dynamic analysis** | **(05 Hours)** |
| Introduction, Forward and inverse dynamics, Mass and inertia of links, Lagrangian formulation for equations of motion for robotic manipulators, Newton-Euler formulation method. | |
| **Trajectory Planning and Control** | **(11 Hours)** |
| Joint and Cartesian space trajectory planning and generation, Classical control concepts using the example of control of a single link, Independent joint PID control, Control of a multi-link manipulator, Nonlinear model based control schemes. | |
| **Force Control of manipulators** | **(03 Hours)** |
| Hybrid position/force control. | |
| **Robot Programming, Sensing and Vision** | **(07 Hours)** |
| Robot Programming, Introduction to sensing and vision in robotics. | |

**(Total Lecture Hours: 45)**

## 3. Books Recommended:


| | |
|---|---|
| 1 | A. Ghosal. Robotics: Fundamental Concepts and Analysis, Oxford University Press, 2006. |
| 2 | J. J. Craig. Introduction to Robotics: Mechanics and Control, 4th edition, Pearson, 2018. |
| 3 | R. J. Schilling. Fundamentals of Robotics Analysis and Control, Pearson Education India, 2015. |
| 4 | K. S. Fu, R. C. Gonzalez, C. S. G. Lee. Robotics: Control, Sensing, Vision, and Intelligence, McGraw Hill, 1987. |
| 5 | S. K. Saha. Introduction to Robotics, McGraw Hill Education India, 2014. |

| MECC127 | : | DESIGN OF PRESSURE VESSELS | L | T | P | Credits |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 03 |

## 1. Course Outcomes (COs):

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

| | |
|---|---|
| CO1 | Describe the factors influencing the design of pressure vessels. |
| CO2 | Calculate the different stresses and strains in a pressure vessel. |
| CO3 | Design the head and shell for the pressure vessel |
| CO4 | Estimate the stresses in the nozzle and its reinforcement |
| CO5 | Analyze the critical part of pressure vessels. |
| CO6 | Evaluate the buckling pressure and type of failure |

## 2. Syllabus:

| | |
|---|---|
| **Introduction:** | **(04 Hours)** |
| Factors influencing the design of vessels, Classification of pressure vessels, Material selection, Loads and types of failures. | |
| **Stresses in pressure vessels:** | **(13 Hours)** |
| Stresses in circular ring, Cylinder and sphere, Membrane stresses in vessels under internal pressure, Thick cylinders, Shrink-fit stresses, Autofrettage of thick cylinders, Thermal stresses. | |
| **Design Of Heads** | **(05 Hours)** |
| Introduction, Design for hemispherical head, Ellipsoidal head, Torispherical head, Conical and toriconical head, Flat heads and covers. | |
| **Design of Nozzles and Openings** | **(05 Hours)** |
| Introduction, Stress concentration about a circular hole, Cylindrical and spherical shell with circular hole under internal pressure, Nozzles in pressure vessels. | |
| **Discontinuity Stresses in Pressure Vessel** | **(11 Hours)** |
| Introduction, Beam on elastic foundation, infinitely long beam, Semi-Infinite beam, Cylindrical vessel under axially symmetrical loading, Extent and significance of load deformations on pressure vessels, Stresses built in a bimetallic joint, Deformation and stresses in flanges | |
| **Buckling of Vessels** | **(07 Hours)** |
| Buckling phenomenon, Elastic Buckling of circular ring and cylinders under external pressure, Collapse of thick walled cylinders or tubes under external pressure, Effect of supports on Elastic buckling of cylinders, Buckling under combined External pressure and axial loading | |

**(Total Lecture Hours: 45)**

## 3. Books Recommended:


| | |
|---|---|
| 1 | J. F. Harvey. Theory and Design of Pressure Vessels, Springer US, 2007. |
| 2 | S. Chattopadhyay. Pressure Vessels: Design and Practice, CRC Press, 2004. |
| 3 | Lloyd E. Brownell, Edwin H. Young, Process Equipment Design, Wiley Interscience, 1966 |
| 4 | A. S. Tooth. Pressure Vessel Design: Concepts and Principles, 1st Edition, CRC Press, 2012. |
| 5 | D. R. Moss, M. M. Basic. Pressure Vessel Design Manual, 4th Edition, Elsevier Science, 2012. |

| MECC129 | : | FAILURE ANALYSIS AND NDE | L | T | P | Credits |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 03 |

## 1. Course Outcomes (COs):

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

| | |
|---|---|
| CO1 | Develop knowledge about the basic concept of material selection |
| CO2 | Define tools and techniques of failure analysis, procedural steps for investigation of failure and failure data retrieval. |
| CO3 | Identify the different fracture modes and their characteristics. |
| CO4 | Understand and be able to identify the common modes of failure of engineering components |
| CO5 | Apply understanding to relevant case studies and identify failure mechanisms. |
| CO6 | Understand concept of Non Destructive evaluation and its applications for Failure analysis |

## 2. Syllabus:

| **Introduction** | **(06 Hours)** |
|---|---|
| Philosophy of material selection, motivation for selection, relationship to available resources, concept of resource base, Criteria for selection of engineering materials. Case studies in material selection like materials for bearings, gears, automobile structures, aircraft components, ship structures. | |
| **General Procedures for Failure Analysis** | **(06 Hours)** |
| Sources of Failures, Steps in Failure Analysis, collection of data and samples; preliminary examination; non-destructive inspection; mechanical testing; selection and preservation of fracture surfaces; macroscopic and microscopic examination; selection; preparation and examination of metallographic sections; fracture classification; report writing. | |
| **Failure of brittle and ductile material** | **(07 Hours)** |
| Details of fractographic, Crack initiation and propagation in ductile and brittle material, Griffith theory, Irwin's modification, surface and embedded cracks, Surface treatments to minimize the surface cracks, Crack growth mechanism for plane stress and plain strain, Notch sensitivity, stress tri-axiality, Failure due to tension and torsion, Modulus of rupture, stress intensity factor. | |
| **Fatigue Failures** | **(05 Hours)** |
| factors affecting fatigue life; stages of fatigue fracture; fatigue cracking; effects of variables; mean stress; stress concentration; metal characteristics; manufacturing process; elevated temperature fatigue; contact fatigue. | |
| **Types of corrosion** | **(06 Hours)** |

| | |
|---|---|
| Stress Corrosion, corrosion cracking, Analysis of corrosion failure, Procedure for analysis of stress corrosion cracking. Effect of Environment. Analysis of corrosion characteristics of metals and alloys in different environment. Types of wear, Role of friction, Interaction of corrosion and wear. Analysis of wear failure. | |
| **Elevated-Temperature Failures** | **(05 Hours)** |
| creep; stress rupture; thermal fatigue; effect of atmospheric environment; failures in industrial application; testing techniques. | |
| **Case studies in failure analysis** | **(05 Hours)** |
| Case histories of component failures. Typical case studies of failure of important components such as gears, shafts, pressure vessels etc. Prevention of failures. | |
| **Non-destructive testing (NDT)** | **(05 Hours)** |
| Principle and methodology of different NDT methods, Liquid Penetration Testing, Ultrasonic Testing, Radiographic Testing, Magnetic Particle Testing. | |

**(Total Lecture Hours: 45)**

## 3. <u>Books Recommended:</u>


| | |
|---|---|
| 1 | R. B. Charlie, A. Choudhury. Failure Analysis of Engineering Materials, McGraw Hill Education, 2002. |
| 2 | R. W. Hertzberg, R. P. Vinci, J. L. Hertzberg. Deformation and fracture mechanics of engineering materials. John Wiley & Sons, 2020. |
| 3 | V. Ramachandran. Failure analysis of engineering structures: methodology and case histories. ASM International, 2005. |
| 4 | ASM Handbook, Failure Analysis and Prevention, Volume 11, 2002, .ASM International. |
| 5 | L. D. C. F. Canale, G. E. Totten, R. A. Mesquita. Failure analysis of heat treated steel components. ASM international, 2008. |

| | | | | | | |
|---|---|---|---|---|---|---|
| **MECC107** | **:** | **SOFTWARE PRACTICE -I** | **L** | **T** | **P** | **Credits** |
| | | | **0** | **0** | **4** | **02** |

## 1. <u>Course Outcomes (COs):</u>

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

| | |
|---|---|
| CO1 | Understand the GUI and tool related to sketch and 3D Modelling. |
| CO2 | Develop sketch by using space curve and different commands. |
| CO3 | Create 3D model using suitable features. |
| CO4 | Develop assembly of a given part. |
| CO5 | Create drawing of given component and assembly. |
| CO6 | Create animations of a given product. |

## <u>Exercises</u>:

1. Drafting/Modelling of given 2D/3D model.
2. Develop assembly of a given product.
3. Motion Simulation of a given product.
4. To create production drawing of a given object or product.
5. To create drawing of exploded assembly views.
6. To create bill of materials and balloons of a product drawing.

| MECC102 | : | COMPUTER AIDED MACHINE DESIGN | L | T | P | Credits |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 2 | 04 |

## 1. Course Outcomes (COs):

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

| | |
|---|---|
| CO1 | Understand the engineering design process and its role in machine elements. |
| CO2 | Analyze and interpret the design of shafts and its applications. |
| CO3 | Understand various gear and gear boxes problem. |
| CO4 | Explain design requirements of mechanical brake and clutch. |
| CO5 | Explain the design requirements of sliding and rolling contact bearings and their applications. |
| CO6 | Create a technical drawing & model for given part or assembly using given CAD software. |

## 2. Syllabus:

| **Introduction** | **(10 Hours)** |
|---|---|
| Phases of design, Standardization and interchangeability of machine elements, Tolerances from process and function, Individual and group tolerances, Selection of fits for different design situations, Design for assembly and modular constructions, Concepts of integration. | |
| **Shafting** | **(10 Hours)** |
| Analysis and Design of shafts for different applications, detailed design, Preparation of production drawings, integrated design of shaft, Bearing and casing, Design for rigidity. | |
| **Gears and Gear Boxes** | **(12 Hours)** |
| Principles of gear tooth action, Gear correction, Gear tooth failure modes, Stresses and loads, Component design of spur, helical, Bevel and worm gears, Deign for sub assembly, Integrated design of speed reducers and multi-speed gear boxes, application of software packages. | |
| **Clutches and Brakes** | **(13 Hours)** |
| Integrated design of automobile clutches and over running clutches. Dynamics and thermal aspects of vehicle braking – Integrated design of brakes for machine tools, automobiles and mechanical handling equipment. | |

**(Total Lecture Hours: 45)**

## List of practical :

1. Practice/Study of Programming Language C, C++, VB, Python, etc.
2. Computer Aided Design of Shafts under Different Loading Conditions.
3. Computer Aided Design of Spur Gear.
4. Computer Aided Design of Helical Gear.
5. Computer Aided Design of Worm Gear.
6. Computer Aided Design of Bevel Gear.
7. Optimum Design of kinematics layout of Gear boxes.
8. Computer Aided Design of Brakes.
9. Computer Aided Design of Clutches
10. Computer Aided Design of Material Handling Equipment

## 3. Books Recommended:


| | |
|---|---|
| 1 | W. C. Orthwein. Clutches and Brakes: Design and Selection, 2nd Edition, Taylor & Francis, 2004. |
| 2 | R. C. Juvinall and K. M. Marshek. Fundamentals of Machine Component Design, Wiley India, 2020. |
| 3 | G. M. Maitra. Handbook of Gear Design, 2nd Edition, Tata McGraw Hill, 1994. |
| 4 | R. G. Budynas and J. K. Nisbett. Shigley's Mechanical Engineering Design, McGraw Hill Publications, 2016. |
| 5 | Design Data: Data Book of Engineers, P. S. G. College of Technology, Revised Edition, Coimbatore, 2016. |

| MECC104 | : | RAPID PROTOTYPING AND TOOLING | L | T | P | Credits |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 03 |

## 1. Course Outcomes (COs):

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

| | |
|---|---|
| CO1 | Analyze the role of rapid prototyping in product development cycle and Recommend scope of improvements in product development. |
| CO2 | Integrate design concepts with CAD or reverse engineering for geometry preparation for Rapid prototyping of part. |
| CO3 | Identify defects in the data for rapid prototyping and propose necessary improvements. |
| CO4 | Analyze the working of different rapid prototyping systems and recommend suitable process for a given material and application. |
| CO5 | Explain the concept of rapid tooling. |
| CO6 | Analyze the process chain of different rapid prototyping systems and Create a pathway for rapid manufacturing. |

## 2. Syllabus:

| **Introduction** | **(02 Hours)** |
|---|---|
| CAD-CAM and its integration, Development of CAD CAM, The importance of being Rapid, Rapid Prototyping (RP) Defined, Time compression Technologies, Product development and its relationship with rapid prototyping, Process chain for rapid prototyping. | |
| **Reverse Engineering** | **(04 Hours)** |
| Reverse Engineering and CAD model, Digitizing Techniques: Mechanical Contact Digitizing, Optical Non-contact Measurement, CT Scanning Method, Data Processing for Surface Reconstruction, Software for Reverse Engineering, Case studies. | |
| **Data Preparation For Rapid Prototyping** | **(10 Hours)** |
| STL interface Specification, STL data generation, STL data Manipulation, Advantages and limitations of STL file format, Open files, Repair of STL files, Alternative RP interfaces, Part orientation and support generation, Factors affecting part orientation, Various models for part orientation determination, The function of part supports, Support structure design, Automatic support structure generation. Model Slicing and Contour Data organization, Direct and adaptive slicing: Identification of peak features, Adaptive layer thickness determination, Tool path generation. | |
| **Liquid Based Rapid Prototyping Processes** | **(06 Hours)** |
| Photo polymerization, principle and working of stereo lithography apparatus, scanning techniques, curing processes, Mask Projection based RP systems, Two Photon Vat Photo polymerization, Typical materials and applications. | |

| Powder Based Rapid Prototyping Processes | (10 Hours) |
|---|---|
| Powder fusion mechanism, powder handling and recycling, Principle and working of Selective Laser Sintering, Laser Engineering Net Shaping process, Electron Beam Melting, Binder Jet 3D Printing, process parameters, Typical materials and applications. | |
| **Solid Based Rapid Prototyping Processes** | **(07 Hours)** |
| Basic principle and working of fused deposition modelling process, liquification, solidification and bonding, bio extrusion, Laminated Object Manufacturing process, Wire and Arc based RP system, Typical materials and applications. | |
| **Rapid Tooling** | **(06 Hours)** |
| Classification of Rapid Tooling (RT) Routes, RP of Patterns, Indirect RT: Indirect method for Soft and Bridge Tooling, Indirect method for Production Tooling, Direct RT: Direct RT method for Soft and Bridge Tooling, Direct method for Production Tooling, Other RT Approaches. Rapid Manufacturing: Methods, limitations. | |

**(Total Lecture Hours: 45)**

## 3. Books Recommended:


| | |
|---|---|
| 1 | D. Gibson, Rosen, B. Stucker. Additive Manufacturing Technologies, Springer Publisher,2010. |
| 2 | C. K. Chua, K. F. Leong, C. S. Lim. Rapid Prototyping – Principles and Applications, World Scientific, 3rd Edition, 2010. |
| 3 | K. V. Patri and M. Weiyin. Rapid Prototyping: Laser-based and Other Technologies, Springer Publisher, 2004. |
| 4 | R. Noorani. 3D Printing Technology, Applications and Selection, CRC Press, 2017. |
| 5 | M. W. M. Cunico. 3D Printers and Additive Manufacturing: The Rise of The Industry 4.0, Concept 3D, 2019. |

| MECC112 | : | DESIGN OF EXPERIMENTS | L | T | P | Credits |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 03 |

## 1. Course Outcomes (COs):

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

| | |
|---|---|
| CO1 | Explain the fundamentals of Design of Experiments (DoEs). |
| CO2 | Design and conduct experiments for developing linear model and analyse the resulting data to obtain valid conclusions and optimize the system. |
| CO3 | Identify optimal or good designs for developing nonlinear model efficiently and effectively, and analyse the resulting data to obtain valid conclusions and optimize the system. |
| CO4 | Explain and construct design matrix for conducting experiments for linear and nonlinear model. |
| CO5 | Explain and apply Taguchi´s robust design methodology for mechanical engineering problems. |
| CO6 | Create standard design and custom design as per situations, and analyse the data for valid conclusions using software |

## 2. Syllabus:

| | |
|---|---|
| **Introduction to Design and analysis of experiments** | **(04 Hours)** |
| Basic Principles of Design and Analysis of Experiments, Guidelines for Designing Experiments, model of a system, types of experimental design (first-order and second-order model), basic statistical concepts, single factor experiments. | |
| **Linear experimental designs and optimization** | **(16 Hours)** |
| Basic definition and principles, $2^k$ full factorial design, a geometrical representation, standard order form, first order response surface model, estimation of main and interaction effects, statistical analysis, estimation of parameters and model adequacy test, $2^{k-p}$ fractional factorial design, steps to construct fractional factorial design, first order response surface model, estimation of main and interaction effects, statistical analysis, estimation of parameters and model adequacy test, screening designs. | |
| **Non-linear experimental designs and optimization** | **(12 Hours)** |
| Basic definition and principles, $3^k$ full factorial design, central composite designs, Box-Behnken design, estimation of linear and nonlinear effects, a second order response surface model, sequential approach. | |
| **Taguchi Design** | **(05 Hours)** |
| Introduction to Taguchi design, orthogonal arrays (OA), properties of OA, design of OA, Concept of S/N ratio. | |
| **Software Practice** | **(08 Hours)** |

| |
|---|
| Introduction to software used for design and analysis of experiments, systematic analysis and steps involved in software for the analysis of factorial design, fractional factorials method, Taguchi method and response surface methodology, case studies and examples. |

**(Total Lecture Hours: 45)**

## 3. Books Recommended:

| | |
|---|---|
| 1 | D. C. Montgomery. Design and analysis of experiments, John wiley & sons. |
| 2 | R. K. Roy. Design of experiments using the Taguchi approach: 16 steps to product and process improvement, John Wiley & Sons, 2001. |
| 3 | K. Hinkelmann, O. Kempthorne. Design and analysis of experiments, volume 1: Introduction to experimental design, Vol. 1, John Wiley & Sons. |
| 4 | A. Dean, D. Voss. Design and analysis of experiments, Springer. |
| 5 | J. Antony. Design of Experiments for Engineers and Scientists, 2nd Edition, Elsevier Inc., 2014. |

| MECC114 | : | INSTRUMENTATION AND EXPERIMENTAL METHODS | L | T | P | Credits |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 03 |

## 1. Course Outcomes (COs):

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

| | |
|---|---|
| CO1 | Understand of experimental analysis and Instrumentation related to measurement systems. |
| CO2 | Analyse and fit the experimental data. Different kind of errors coming in data will also be analysed. |
| CO3 | Explain error and uncertainty in physical measurements. |
| CO4 | Determine the mathematical model of measurement systems and response characteristics. |
| CO5 | Discuss the concepts of Data acquisition signal process analysis. |
| CO6 | Explain principles, theory and applications of various sensors and transducers of flow and temperature measurements. |

## 2. Syllabus:

| **Significance of Measurement and Instrumentations** | **(05 Hours)** |
|---|---|
| Introduction, generalized configuration and functional stages of measuring systems, the transducer and its environment, an overview, sensing process and physical laws, Types of measurement problems. Transducer classification and their modelling, characteristics of instruments, design and selection of components of a measuring system. | |
| **Dynamic Response of Instruments** | **(05 Hours)** |
| Mathematical model of a measuring system, response of general form of instruments to various test inputs; time domain and frequency domain analysis Elementary transfer functions, Bode plots of general transfer functions. | |
| **Errors in Measurement and Uncertainty in measurements** | **(06 Hours)** |
| Errors in instruments, Causes and types of experimental errors, Analysis of experimental data and determination of overall uncertainties in experimental investigation, Uncertainties in measurement of measurable parameters like pressure, temperature, flow etc. under various conditions, Estimation for design and selection for alternative test methods. | |
| **Transducers** | **(08 Hours)** |
| Developments in sensors, detectors and transducer technology, displacement transducers; force, torque and motion sensors, piezoelectric transducers, capacity type transducers, Strain gauge transducers, Accelerometers, pressure transducers based on elastic effect of volume and connecting tubing. Transducers for Position, speed, vibration, sound, humidity, and moisture measurement, Hall effect Transducer. | |

| Data Acquisition and Signal Processing | (05 Hours) |
|---|---|
| Systems for data acquisition and processing modules and computerized data system digitization rate, time and frequency domain representation of signals, and Nyquist criterion a brief description of elements of mechatronics modular approach to mechatronics and engineering design. | |
| **Advanced Flow Measurements**<br>Basic flow meters, magnetic, ultrasonic flow meters, Flow visualization, shadowgraph, Schlieren and interferometric techniques, Pitot static tubes; hot wire anemometers, flow measuring problems, Laser Doppler velocity meter, flow measurements using coriolis effect. | **(08 Hours)** |
| Systems for data acquisition and processing modules and computerized data system digitization rate, time and frequency domain representation of signals, and Nyquist criterion a brief description of elements of mechatronics modular approach to mechatronics and engineering design. | |
| **Temperature Measurements** | **(08 Hours)** |
| Modes of heat transfer, laws of conduction, convection and radiation, Temperature scales, classification of Temperature Sensors, Overview of Temperature Sensor Material, Expansion thermometers, filled system thermometers Thermoelectric sensors, electric resistance sensors; thermistors, Electrical temperature instruments, thermocouples, RTD, and thermistors, Pyrometers, IR temperature detectors, radiations pyrometers, Temperature measuring problems in flowing fluids, dynamic compensation. | |

**(Total Lecture Hours: 45)**

## 3. Books Recommended:


| | |
|---|---|
| 1. | E. O. Doeblin. Measurements System Application and Design, 5th Edition, McGraw Hill, 2004. |
| 2. | J. P. Holman. Experimental Methods for Engineers, 8th Edition. New York: McGraw-Hill, 2012. |
| 3. | T. G. Beckwith, R. D. Marangoni, J. H. Lienhard. Mechanical Measurements, 6th Edition, Prentice Hall of India, 2006. |
| 4. | A. K. Gosh. Introduction to Measurements and Instrumentation, 4th Edition, PHL Learning Private limited, 2012. |
| 5. | P. E. Donald. Industrial Instrumentation, CBS publishers, 2004. |

| MECC116 | : | SMART MATERIALS AND MANUFACTURING | L | T | P | Credits |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 03 |

## 1. Course Outcomes (COs):

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

| | |
|---|---|
| CO1 | Understand the ideas about intelligent and smart materials. |
| CO2 | Study the applications of electro-rheological fluids and Piezoelectric materials. |
| CO3 | Apply the concept and use of shape memory materials and fibre optics in the modern applications. |
| CO4 | Design the vibration absorption systems. |
| CO5 | Evaluate the modelling of shells, beams and plates. |
| CO6 | Elaborate the outcomes related to the smart structure for a specific application. |

## 2. Syllabus:

| | |
|---|---|
| **Smart Materials and Structural Systems** | **(06 Hours)** |
| Introduction to Smart Materials and Structures, Actuator materials, sensing technologies, micro-sensors, intelligent systems, hybrid smart materials, passive sensory smart structures, reactive actuator-based smart structures, active sensing and reactive smart structures, smart skins. | |
| **Intelligent Materials** | **(05 Hours)** |
| Primitive functions of intelligent materials, intelligence inherent in materials, materials intelligently harmonizing with humanity, intelligent biological materials. | |
| **Electro–Rheological Fluids** | **(05 Hours)** |
| Suspensions and electro, rheological fluids; the electro-rheological phenomenon, charge migration mechanism for the dispersed phase, electro rheological fluid actuators | |
| **Piezoelectric Materials** | **(04 Hours)** |
| Background, Piezoelectricity, industrial piezoelectric materials, smart materials featuring piezoelectric elements | |
| **Shape Memory Materials** | **(04 Hours)** |
| Background on shape memory alloys, applications of shape memory alloys, Continuum applications: structures and machine systems, Discrete applications, impediments to applications of shape memory alloys, shape memory plastics. | |
| **Fiber Optics** | **(05 Hours)** |
| Overview, light propagation in an optical fiber, embedding optical fibers in fibrous polymeric thermo-sets, fiber optic strain sensors. | |
| **The Piezoelectric Vibrations Absorber Systems** | **(08 Hours)** |

| | |
|---|---|
| Introduction, single mode absorber, theory, design solution, extension including viscous modal damping, the electromechanical coupling coefficient, inductance, experimental results, multimode absorber, derivation of transfer function, design solution, self-tuning absorber, performance function, control scheme. | |
| **Modelling of Shells, Plates and Beams** | **(08 Hours)** |
| Derivation of the basic shell equations, equation of motion, equations for specific geometries and cylindrical shell, Plate equations and beam equations. | |

**(Total Lecture Hours: 45)**

## 3. Books Recommended:



| | |
|---|---|
| 1 | M. V. Gandhi, B. D. Thompson, B. S. Thompson. Smart Materials and Structures, Springer Netherlands, 1992. |
| 2 | A. V. Srinivasan, D. Michael McFarland, Smart Structures: Analysis and Design, Cambridge, University Press, 2009. |
| 3 | P. L. Reece. Smart Materials and Structures: New Research, Nova Science Publishers, 2007. |
| 4 | A. Preumont. Vibration Control of Active Structures: An Introduction, Springer, 2011. |
| 5 | F. Y. Cheng, H. Jiang, K. Lou. Smart Structures: Innovative Systems for Seismic Response Control, CRC Press, 2008. |

| MECC118 | : | COMPUTER AIDED TOOL DESIGN | L | T | P | Credits |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 03 |

## 1. Course Outcomes (COs):

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

| | |
|---|---|
| CO1 | Define properties of tool material and nomenclatures related to press tools and classifying different cutting tools |
| CO2 | Explain different types of locaters, clams, bushes, gauges and moulds for designing jigs fixtures for and inspection aids for engineering components |
| CO3 | Design jig, fixtures, and moulding dies of a given engineering component and use of computer for creating model |
| CO4 | Evaluate the dimension of press tool components for a given configuration /types of shearing die |
| CO5 | Apply thumb rules and empirical formulas to solve problem related to shearing operation dies and punches and other cutting tools |
| CO6 | Analyse a different scheme of strip layouts for maximizing stock utilisation and use of computer design for a given case for examining feasibility of design |

## 2. Syllabus:

| Tool Design Methods | (07 Hours) |
|---|---|
| Introduction, Design procedure, Statement of the problem, Needs Analysis – Tentative design solutions, finished design, Drafting and design techniques in tooling drawings, Punch and die Manufacturing Techniques. | |
| **Tooling Materials** | **(07 Hours)** |
| Introduction, Properties of tool materials, Metal cutting tools, Single-point cutting tools, milling cutters, Drills and Drilling, Reamer classification, Taps, tap classification, The selection of carbide cutting tools, Determining the insert thickness for carbide tools, Various heat treatments. | |
| **Gages and Gage Design** | **(05 Hours)** |
| Introduction, Fixed Gages, Gage Tolerances, the selection of material for Gages, Indicating Gages, and Automatic gages. | |
| **Design of Drill Jigs** | **(10 Hours)** |
| Principles of location, locating methods and devices, Principles of clamping, Drill jigs, Chip formation in drilling, General considerations in the design of drill jigs, Drill bushings, Methods of construction, Drill jigs and modern manufacturing, Computer aided Jig design. **Design of Fixtures** | |

| | |
|---|---|
| Introduction, Fixtures and economics, Types of Fixtures, Vice Fixtures, Milling Fixtures, Boring Fixtures, Broaching Fixtures, Lathe Fixtures, Grinding Fixtures, Types of Die construction, Computer aided Fixture Design, | |
| **Design of Press Tools** | **(08 Hours)** |
| Die-design fundamentals, Blanking and Piercing die construction, Pilots, Strippers and pressure pads, Presswork materials, Strip layout, Short -run tooling for Piercing, Bending dies, Forming dies, Drawing operations. | |
| **Design of Moulding Dies** | **(08 Hours)** |
| Introduction to Injection moulding process, Parting line selection, Requirement of Air vents, Ejection system, Computer aided die design for injection moulding, Compression molding. | |

**(Total Lecture Hours: 45)**

## 3. Books Recommended:


| | |
|---|---|
| 1 | C. Donaldson, H. L. George, V. C. Goold. Tool Design, Tata McGraw Hill Publishing Company Ltd., 36th Reprint 2006. |
| 2 | P. H. Joshi. Tooling Data, Wheeler Publishing, 2000. |
| 3 | P. C. Sharma. Machine Tool and Tool Design, S Chand Company. 2004. |
| 4 | J.Y.H. Fuh. Computer aided Injection mold design and manufacture, CRC Press 2018. |
| 5 | J. R. Paquin, R. E. Crowley. Die design fundamentals, Ind. Press Inc., New York, 1987. |

| MECC120 | : | QUALITY ENGINEERIN AND MANAGEMENT | L | T | P | Credits |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 03 |

## 1. Course Outcomes (COs):

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

| | |
|---|---|
| CO1 | Explain the different concepts of quality, system reliability & maintenance and its application to the design and manufacturing activities. |
| CO2 | Understand and Apply statistical concepts and techniques for designing of products and process controls. |
| CO3 | Describe and apply reliability analysis concepts to selected applications. |
| CO4 | Describe and Apply the two level factor factorial design, general factorial design and surface response method for experimental design. |
| CO5 | Formulate, analyze, design and synthesize open-ended quality engineering problems using the various statistical process control tools and quality management tool. |
| CO6 | Select and apply newer concepts and initiatives for quality improvement. |

## 2. Syllabus:

| **Introduction** | **(02 Hours)** |
|---|---|
| Introduction to quality control and the quality system, some philosophies and their impact on quality, Cost of quality, Quality audit. | |
| **Statistical Quality Control** | **(14 Hours)** |
| Statistical Concepts and Data analysis: Fundamentals of statistical concepts and techniques in quality control and improvement, Data analysis and sampling; Control Charts: Statistical Process Control using control charts, Control charts for attributes and variables. Process capability analysis: Concepts and procedures of Process capability. Acceptance Sampling: Acceptance sampling for attributes and variables. | |
| **Reliability Analysis** | **(03 Hours)** |
| Reliability: Failure rate analysis, mean failure rate, mean time to failure, mean time between failure, Graphical representation of Fd, Z and R. Generalization in graphical form, integral form, Hazard models, systems reliability, availability, maintenance, overall equipment effectiveness, Total Productive Maintenance (TPM), Failure Mode and Effect Analysis (FMEA). | |
| **Experimental Design** | **(08 Hours)** |
| Experimental Design: Fundamentals of experimental Design, Single, Multi factor and 2k factor experiments, Two level fractional factorial design, Response surface method. Quality loss function.<br>Taguchi method: Taguchi method, Design of experiments using orthogonal array, Data analysis from Taguchi and Multi level factor design. | |
| **New Quality Concepts and Initiatives** | **(12 Hours)** |

| | |
|---|---|
| New Quality Concepts and initiatives: Total Quality Management (TQM) and its techniques, New Seven Management Tools, and Industrial Case studies on Costs of Quality, Five S, kaizen, Quality Circles, Quality Function Deployment (QFD), Poka Yoke, Total Productive Maintenance (TPM), Lean Manufacturing, Six Sigma, Lean Six Sigma, etc. Quality Management through Software. | |
| **Quality Standards** | **(03 Hours)** |
| Quality Standards and Business Excellence Models: Quality System Standards, ISO 9000, ISO 14000, various Quality Awards and case studies. | |
| **World Class Manufacturing** | **(03 Hours)** |
| Manufacturing Excellence World Class Manufacturing (WCM) – Model and elements of WCM. | |

**(Total Lecture Hours: 45)**

## 3. Books Recommended:


| | |
|---|---|
| 1 | A. Mitra. Fundamentals of Quality Control and Improvement, 2nd Ed., Prentice Hall of India, 2011 |
| 2 | K. Krishnaiah, P. Shahabudeen. Applied Design of Experiments and Taguchi Methods, Prentice Hall of India, 2012. |
| 3 | Dale H. Besterfield, Carol Besterfield-Michna, Mary Besterfield-Sacre, Glen H. Besterfield, Hemant Urdhwareshe, Rashmi Urdhwareshe, Total Quality Management, , Pearson Education, 2012. |
| 4 | G. W. Cobb. Introduction to Design and Analysis of Experiments, John Wiley & Sons, 2015. |
| 5 | D. C. Montogomery. Introduction to Statistical Quality Control, John Wiley & Sons, 8th Edition, 2013. |

| MECC122 | : | OPTIMIZATION TECHNIQUES | L | T | P | Credits |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 03 |

## 1. Course Outcomes (COs):

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

| | |
|---|---|
| CO1 | Understand the concept of optimization, related terms and formulate mathematical models for practical problems based on the information provided. |
| CO2 | Use linear programming to solve real life linear programming problems |
| CO3 | Solve transportation and transhipment problems, travelling salesman problem and integer programming |
| CO4 | Determine solutions that will be deployed in real world situations after conducting sensitivity and post optimality analysis |
| CO5 | Apply classical methods to solve nonlinear programming problems |
| CO6 | Apply evolutionary algorithms to solve complex engineering problems where classical methods are not suitable. |

## 2. Syllabus:

| **Introduction** | **(05 Hours)** |
|---|---|
| Introduction to optimization, linear programming, formulation, graphical method, simplex method and special cases. | |
| **Sensitivity and post optimality analysis** | **(08 Hours)** |
| Sensitivity analysis and post optimality analysis, changes in resources and objective function, changes affect feasibility and optimality, duality, dual simplex algorithm, generalize simplex algorithm. | |
| **Special types of linear programming problems** | **(06 Hours)** |
| Transportation problems, Transshipment problems, Travelling salesman problems, Integer programming. | |
| **Introduction to MATLAB and solving linear and nonlinear problems using MATLAB** | **(07 Hours)** |
| Introduction to MALAB, creating and manipulating vectors and matrix, user defined function, special built-in function to create special vectors and matrices, symbolic math, built-in function to solve linear programming problems. | |
| **Nonlinear programming problems** | **(05 Hours)** |
| Nonlinear Programming problems: Graphical method, convex function and convex region, necessary and sufficient conditions, Lagrangian method, Karush-Kuhn-Tucker (KKT) conditions, solving nonlinear problems using MATLAB. | |
| **Evolutionary Algorithm** | **(14 Hours)** |

| |
|---|
| Introduction to evolutionary algorithm, introduction to multi-objective optimization, genetic algorithms, differential evolution algorithm, Particle swarm optimization, tabu search, simulated Annealing technique, solving real life engineering problems using given programming software. |

**(Total Lecture Hours: 45)**

## 3. Books Recommended:



| | |
|---|---|
| 1 | F. S. Hillier, G. J. Lieberman, B. Nag, P. Basu. Introduction to operations research, Tata McGraw-Hill Education, 2017. |
| 2 | H. A. Taha. Operations research: an introduction, Pearson Education India, 2017. |
| 3 | S. S. Rao. Engineering optimization: theory and practice, John Wiley & Sons, 2019. |
| 4 | A. Vasuki. Nature-Inspired Optimization Algorithms, CRC Press, 2020. |
| 5 | D. E. Goldberg. Genetic algorithms: in search, optimization and machine learning, Pearson Education India, 2006. |

| MECC124 | : | THEORY OF ELASTICITY AND PLASTICITY | L | T | P | Credits |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 03 |

## 1. Course Outcomes (COs):

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

| | |
|---|---|
| CO1 | Explain the concept of equilibrium, torsion and bending of bars using theory of elasticity. |
| CO2 | Apply plastic flow theory to predict the material deformation or fracture of selected mechanical component |
| CO3 | Compute the numerical problems using flow rule, plastic work increment, work hardening and tensile instability |
| CO4 | Develop analytical modelling and skills of engineering application related to plastic deformation |
| CO5 | Explain the theory of local necking under uniaxial and biaxial tension in sheet metal forming applications |
| CO6 | Apply plasticity concepts to analyse the stamping, bending and deep drawing process in metal strips |

## 2. Syllabus:

| **Theory of Elasticity** | **(10 Hours)** |
|---|---|
| Plane stress and plane strain, Stress and strain at a point. Equilibrium and compatibility equations. Two dimensional problems in rectangular and polar co –ordinates, Mohr's Circle of Stress in Two dimensions, three dimensional problems, Mohr's Circle of Stress in Three dimensions, Torsion and bending of bars. | |
| **Principles of Plastic Flow Theory** | **(12 Hours)** |
| Stress tensor, Hydrostatic and Deviator component of Stress, Plastic Stress & Strain relationship & Condition of initiation of plastic deformation, Failure Criterion, Plastic work increment, Plastic Anisotropy, Two-dimensional plastic flow theory- Slip line field theory, Introduction of large strains, Strain or work hardening, Experimental strain analysis. | |
| **Tensile Instability** | **(11 Hours)** |
| Introduction, Uniaxial tension of a perfect & an imperfect strip, Uniaxial tension of a rate dependent material, necking in continuous bar, sheets, necking in biaxial tension, Effect of strain hardening, Effect of rate sensitivity, Ductile fracture & reduction of area, Determination of Forming Limit Strains for an Anisotropic material by Neck of growth. Methods for testing material properties. | |
| **Stamping, Bending and Deep Drawing Analysis** | **(12 Hours)** |
| Two-dimensional stamping model, Stretch and draw ratio in stamping, three-dimensional stamping model, bending without tension, bending in Vee-die, Spring back, bending of small | |

| |
|---|
| radius, Deep drawing of a sheet, Cup height, drawing with flange, wall ironing of deep drawn cup. |

**(Total Lecture Hours: 45)**

## 3. Books Recommended:

| | |
|---|---|
| 1 | E. G. Thomsen, C. T. Yang, S. Kobayashi. Mechanics of Plastic Deformation in Metal Processing, The MacMilan Co, 1965. |
| 2 | E. M. Mielnik. Metal Working Science & Engineering, 1st Edition, McGraw - Hill, Inc., New York, 1991. |
| 3 | Z. Marciniak, J. L. Dancan, S. J. Hu. The Mechanics of Sheet Metal Forming, Butterworth-Heinemann, 2002. |
| 4 | S. P. Timoshenko, J. Goodier. Theory of Elasticity, McGraw Hill, 1975. |
| 5 | V. Molotnikov, A. Molotnikov. Theory of Elasticity and Plasticity: A Textbook of Solid Body Mechanics, Springer, 2021 |

| MECC126 | : | INDUSTRIAL TRIBOLOGY | L | T | P | Credits |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 03 |

## 1. Course Outcomes (COs):

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

| | |
|---|---|
| CO1 | Understand and explain different laws of friction and topology of surfaces. |
| CO2 | Differentiate between the types of lubricants, properties and its respective application area. |
| CO3 | Appreciate the various modes of wear and the wear-mechanism maps. |
| CO4 | Understand behaviour of bearing in different lubrication regimes and able to develop mathematical model. |
| CO5 | Select the type of bearing for any given required engineering use and determine the load carrying capacity and other related parameters. |
| CO6 | Decide on the tribological measurement techniques based on performance of machine components. |

## 2. Syllabus:

| | |
|---|---|
| **Introduction to the Concept of Tribo-Design** | **(04 Hours)** |
| Specific principles of tribo-design, tribological problems in machine elements. | |
| **Basic Principles of Tribology** | **(08 Hours)** |
| Sliding friction, relative motion in bodies, friction due to adhesion, deformation, energy dissipation during friction, types of wear and their mechanisms, wear in lubricated contacts and film lubrication. | |
| **Friction, Lubrication and Wear in Lower Kinematic Pairs** | **(10 Hours)** |
| Concept of friction angle, friction in screws with a square and triangular threads, plate, cone and centrifugal clutches, drives utilizing friction force, frictional aspects of brake design and tribo-design aspects of mechanical seals. | |
| **Friction, Lubrication and Wear in Higher Kinematic Pairs** | **(05 Hours)** |
| Loads acting on contact area, traction in contact zone, rolling friction and cam-follower systems. | |
| **Sliding-Element Bearings** | **(05 Hours)** |
| Derivation of Reynolds equation, hydrostatic and thrust bearings, journal bearings, gas bearings, steady-state analysis of fluid-film bearings, modern developments in journal bearing design, selection and design of thrust bearings. | |
| **Rolling-Contact Bearings** | **(06 Hours)** |

| | |
|---|---|
| Analysis of friction in rolling contact bearings, deformations and kinematics of rolling element bearings, lubrication analysis of rolling contact bearings. | |
| **Lubrication and Efficiency of Involute Gears** | **(07 Hours)** |
| Generalities of gear design, lubrication regimes, gear failure due to scuffing, gear pitting, design aspects of gear lubrication and efficiency of gears. | |

**(Total Lecture Hours: 45)**

## 3. Books Recommended:


| | |
|---|---|
| 1 | D. Dowson, C.M. Taylor, M. Godet, D. Berthe. Tribological Design of Machine Elements, 1st Edition, Elsevier Science, 1989. |
| 2 | G. Stachowiak, A. Batchelor. Engineering Tribology, 3rd Edition, Elsevier Science, 2014. |
| 3 | A. Harnoy. Bearing Design in Machinery: Engineering Tribology and Lubrication, CRC Press, 2002. |
| 4 | S. Wen, P. Huang. Principles of Tribology, 2nd Edition, Wiley Publication, (ISBN: 978-1-119-21490-8), 2017. |
| 5 | R. Gohar, H. Rahnejat. Fundamentals of Tribology, 3rd Edition, World Scientific Publishing Company, 2018. |

| MECC128 | : | DESIGN AND ANALYSIS OF COMPOSITE STRUCTURES | L | T | P | Credits |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 03 |

## 1. Course Outcomes (COs):

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

| | |
|---|---|
| CO1 | Understand the different types of composite materials. |
| CO2 | Analyse the macro mechanical behaviour of lamina. |
| CO3 | Analyse the micro mechanical behaviour of lamina. |
| CO4 | Analyze the macro mechanical behaviour of laminate. |
| CO5 | Evaluate the bending, buckling and vibration of laminated plate. |
| CO6 | Understand the design requirement of composite materials. |

## 2. Syllabus:

| | |
|---|---|
| **Introduction** | **(06 Hours)** |
| Classification and characteristics of composite materials, Mechanical behaviour of composite materials, Terminology of laminated composite materials, Manufacture of laminated composite materials, Applications of composite materials. | |
| **Macro-Mechanical Behaviour of a Lamina** | **(08 Hours)** |
| Stress-strain relationship for anisotropic materials, Stiffness, compliances and engineering constants for orthotropic materials, Relationship on engineering constants, Stress-strain relationship for plane stress in an orthotropic material, Strength of an orthotropic lamina | |
| **Micro-Mechanical Behaviour of a Lamina** | **(06 Hours)** |
| Mechanics of materials approach to stiffness, Elasticity approach to stiffness, Mechanics of materials approaches to strength. | |
| **Macro-Mechanics Behaviour of a Laminate** | **(07 Hours)** |
| Classical laminate theory, Special cases of laminate stiffness,Theoretical versus measured laminate stiffness, Strength of laminates, Interlaminar stresses. | |
| **Bending, Buckling and Vibration of Laminated Plates** | **(10 Hours)** |
| Governing equations for bending, buckling and vibration of laminated plate, Deflection of simply supported laminated plates under distributed transverse load, Buckling of laminated plate, Vibration of laminated plate. | |
| **Introduction to Design of Composite Structures** | **(08 Hours)** |
| Introduction, Introduction to structural design, Material Selection, Configuration Selection, Laminate joints, Design requirements and design failure criterion. | |

**(Total Lecture Hours: 45)**

## 3. Books Recommended:


| | |
|---|---|
| 1 | K.K. Autar. Mechanics of composite materials, 2nd Edition, CRC Press, 2006. |
| 2 | R.M. Jones. Mechanics of composite materials, 2nd Edition, Taylor and Fransis, 2018. |
| 3 | M.M. Kaminski. Computational mechanics of composite materials, Springer, 2005. |
| 4 | B.D. Agarwal. Analysis and Performance of Fiber Composites, 3rd Edition, John Wiley & Sons, 2006. |
| 5 | R.F. Gibson, Principles of Composite Material Mechanics, 4th Edition, CRC Press, 2016 |

| MECC130 | : | SURFACE ENGINEERING | L | T | P | Credits |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 03 |

## 1. Course Outcomes (COs):

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

| | |
|---|---|
| CO1 | Decide the surface preparation methods suitable for different substrate materials. |
| CO2 | Demonstrate the ability to use the core concepts of engineering application in material degradation by corrosion, wear and its prevention. |
| CO3 | Elaborate role of surface modifications to achieve several technological properties. |
| CO4 | Explain importance of specific coating technique ,characterization & its applications on specific engineering components. |
| CO5 | Select surface engineering technique for specific wear mechanisms and corrosion control. |
| CO6 | Propose suitable surface engineering technique to control material degradation. |

## 2. Syllabus:

| **Introduction** | **(04 Hours)** |
|---|---|
| Surface engineering: Introduction to surface engineering, Scope of surface engineering for different engineering materials, Surface Preparation methods such as Chemical, Electrochemical, Mechanical: Sand Blasting, Shot peening, Shot blasting, Hydro-blasting, Vapor Phase Degreasing etc., Coatings: Classification, Properties and applications of Various Coating. | |
| **Wear** | **(06 Hours)** |
| Adhesive wear, Abrasive and erosive wear, Wear induced by mechanical fatigue of the worn surface, melting wear, fretting wear and diffusive wear, Analytical models of wear, Wear resistant materials, Fatigue, fracture and creep. | |
| **Corrosion** | **(06 Hours)** |
| Corrosion of metals in aqueous media: Electrochemistry and aqueous corrosion, Electrochemical corrosion of machinery and structures, Corrosion inhibitors, Materials factors in aqueous corrosion. Oxidative reactions of metals with oxygen, sulphur and other halogens. | |
| **Discrete Coatings** | **(06 Hours)** |
| Introduction, Coatings of organic compounds, Electrochemical coatings, Plasma and thermal spraying, plasma-transferred arc the D gun, Vacuum-based coating methods, Friction surfacing, weld overlays and explosive bonding, Advanced coating techniques. | |
| **Integral Coatings and Modified Surface Layers** | **(08 Hours)** |
| Introduction, Thermally or mechanically modified surface layers: Induction hardening, Laser and electron beam surface hardening, Shot-peening, Thermochemical methods of coating: Galvanization and hot-dipping, Carburizing, carbonitriding, nitriding, nitrocarburizing & boronizing, Advanced surface modification technologies: Plasma nitriding and plasma carburization, Surface alloying by laser and electron beam, Ion implantation. | |

| Characterization of Surface Coatings | (07 Hours) |
|---|---|
| Introduction, Measurement of surface roughness and coating thickness, Hardness and microhardness analysis, Adhesivity testing, Microstructural evaluation, Chemical analysis, Residual stress analysis, Corrosion testing. | |
| **Control of Materials Degradation** | **(08 Hours)** |
| Introduction, Methodology of analysing materials degradation, Selection of optimal surface engineering technology, Control of wear by surface engineering, Principles of coating selection for wear resistance, Selection of specific surface engineering techniques for specific wear mechanisms, Control of corrosion by surface engineering, Control of fatigue and fracture by surface engineering | |

**(Total Lecture Hours: 45)**

## 3. Books Recommended:


| | |
|---|---|
| 1 | T. Burakowski, T. Wierzchon. Surface engineering of metals, CRC Press, 2020. |
| 2 | A. W. Batchelor, L. N. Lam, M. Chandrasekaran. Materials degradation and its control by surface engineering, 3rd Edition, Imperial college press, 2011. |
| 3 | L. I. Tushinsky, I. Kovensky, A. Plokhov, V. Sindeyev, P. Reshedko. Coated Metal: Structure and Properties of Metal-Coating Compositions, Springer, Germany, 2002. |
| 4 | M. Ohring. Materials Science of Thin Films, 2nd Edition, Academic Press, 2002. |
| 5 | L. I. Tushinsky, I. Kovensky, A. Plokhov, V. Sindeyev, P. Reshedko. Materials Degradation and Its Control by Surface Engineering, 3Ed Hardcover – Illustrated, February 2011. |

| MECC172 | : | EXTENDED FINITE ELEMENT METHODS | L | T | P | Credits |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 03 |

## 1. Course Outcomes (COs):

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

| | |
|---|---|
| CO1 | Explain the principals of XFEM. |
| CO2 | Analyze different modes of fracture. |
| CO3 | Utilize enrichment functions to solve simple fracture problems by XFEM. |
| CO4 | Evaluate stress intensity factor for isotropic and orthotropic materials by XFEM. |
| CO5 | Evaluate the problems on Cohesive Cracks. |
| CO6 | Solve XFEM based static and dynamic fracture problems. |

## 2. Syllabus:

| | |
|---|---|
| **Introduction** | **(08 Hours)** |
| Structures, discontinuities in the materials, fracture mechanics, comparison between FEM and XFEM, general aspects of XFEM, Partition of unity, enrichment functions, local and non-local models, discrete cracked element, singular elements, enriched elements, Basics of elasticity, LEFEM, strong and weak discontinuities, cracks modeling, XFEM application. | |
| **XFEM for Isotropic Problems** | **(08 Hours)** |
| Basics of FEM, basics of fracture mechanics, partition of unity, enrichment, isotropic XFEM, modeling of strong and weak discontinuities, XFEM approximation, signed distance function, modeling of strong and weak discontinuous fields, modeling of crack, XFEM discretization and integration, tracking moving boundaries, level set method, numerical simulations: A tensile plate with a central crack, single and double edge cracks, edge and center crack in finite and infinite plate. | |
| **XFEM for Orthotropic Problems** | **(09 Hours)** |
| Anisotropic elasticity, elasticity solution, anisotropic stress functions, orthotropic mixed mode problems, energy release rate and stress intensity factor for anisotropic materials, analytical solutions for near crack tip, near crack tip displacement field, XFEM discritization and SIF calculations, numerical simulations: Plate with a crack parallel to material axis of orthotropy, orthotropic and isotropic materials with crack subjected to tensile tractions. | |
| **XFEM for Cohesive Cracks** | **(10 Hours)** |
| Cohesive cracks, Numerical models for cohesive cracks, Crack propagation criteria, Griffith criterion for cohesive crack, Cohesive crack model, XFEM for cohesive cracks (enrichment functions, governing equation and XFEM discritization), numerical simulations: mixed mode bending beam, four point bending beam and double cantilever beam. | |
| **Static and Dynamic Fracture Analysis** | **(10 Hours)** |

| |
|---|
| Analytical Solutions for Near Crack Tip, Mixed Mode Fracture, SIF Calculation by Interaction Integral, Anisotropic XFEM, Analytical Solutions for Near crack tips in dynamic states, analytical solution for near crack tip of a Propagating crack Material, dynamic stress intensity factor, numerical simulations: plate with stationary centre crack, mode I plate with edge crack, mixed mode edge crack in composite plate, composite plate with crack under impulsive loading. |

**(Total Lecture Hours: 45)**

**3. Books Recommended:**

| | |
|---|---|
| 1 | S. Mohammadi. Extended finite element method, 1st edition, Blackwell, 2007. |
| 2 | XFEM fracture mechanics of composites, 1st edition, A John Wiley & Sons, Ltd., Publication 2012. |
| 3 | P Kumar. Elements of fracture mechanics, Tata McGraw Hill, New Delhi, 2017. |
| 4 | Anderson. Fracture Mechanics-Fundamental and Application, T. L. CRC press1998. |
| 5 | R. B. Charlie, A. Chaudhary. Failure Analysis of Engineering Materials, McGraw Hill, New York, 2001. |

| | | | | | | |
|---|---|---|---|---|---|---|
| **MECC174** | **:** | **COMPUTATIONAL FLUID DYNAMICS TECHNIQUE** | **L** | **T** | **P** | **Credits** |
| | | | **3** | **0** | **0** | **03** |

## 1. Course Outcomes (COs):

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

| | |
|---|---|
| CO1 | Develop mathematical model for fluid flow through turbomachine passage. |
| CO2 | Discretize the fundamental equations of flow and other transport processes. |
| CO3 | Apply finite volume method for numerical modeling of flow. |
| CO4 | Solve flow problems using semi-explicit and semi-implicit algorithms. |
| CO5 | Generate mesh for flow domain in complex turbomachinery geometry. |
| CO6 | Solve Navier-Stokes equations for flow through complex turbomachine passages. |

## 2. Syllabus:

| | |
|---|---|
| **Review of Governing Equations Fluid Flo w and Heat Transfer** | **(07 Hours)** |
| Conservation of Mass, Newton's Second Law of Motion, Expanded Forms of Navier stokes equations, Conservation of Energy Principle, Special Forms of the Navier Stokes Equations, Classification of Second order Partial Differential Equation s, Initial and Boundary Conditions, Governing Equations in Generalized Coordinates. | |
| **Finite Difference, Discretization, Consistency, Stability and Fundamental of Fluid Flow Modeling** | **(09 Hours)** |
| Elementary Finite Difference Quotients, Basic Aspects of Finite Difference Equations, Errors and Stability Analysis, Some Nontrivial Problems with Discretized Equations, Applications to Heat Conduction and Convection. | |
| **Solution of Viscous Incompressible Flows by Stream Function -Vorticity Formulation** | **(09 Hours)** |
| Two-Dimensional Incompressible Viscous Flow, Incorporation of Upwind Scheme, Estimation of Discretization Error, Application to Curvilinear Geometries, Derivation of Surface Pressure and Drag. | |
| **Solution of Navier-Stokes Equations for Incompressible Flows Using MAC and SIMPLE Algorithms** | **(10 Hours)** |
| Staggered Grid, Solution of the Unsteady Navier -Stokes Equations, Solutions of Energy Equation, Formulation of the Flow Problems, SIMPLE Algorithm. | |
| **Introduction to FVM**: | **(10 Hours)** |
| Integral Approach, discretization & Higher order scheme, Finite Volume Solution of Unsteady Advection, Diffusion Problems with Source Term. | |

**(Total Lecture Hours: 45)**

## 3. Books Recommended:


| | |
|---|---|
| 1 | D. A. Anderson, J. C. Tannehill, R. H. Pletcher. Computational Fluid Mechanics and Heat Transfer, Hemisphere Publishing Corporation, New York, U.S.A, 1984. |
| 2 | K. Murlidhar, T. Sunderarajan. Computational Fluid Flow and Heat Transfer, Narosa Publishing House, New Delhi, 2003. |
| 3 | J. D. Anderson Jr. Computational Fluid Dynamics, McGraw Hill, Inc. New York, 1996. |
| 4 | S. V. Ankar. Numerical Heat Transfer and Flow, Hemisphere Publ., Corporation, 1985. |
| 5 | H. K. Versteag, W. Malalsekara. An Introduction to Computational Fluid Dynamics, Pearson, 2008 |

| MECC106 | : | SOFTWARE PRACTICE - II | L | T | P | Credits |
|---|---|---|---|---|---|---|
| | | | 0 | 0 | 4 | 02 |

## 1. Course Outcomes (COs):

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

| | |
|---|---|
| CO1 | Develop program using various commands. |
| CO2 | Develop program with instructive computation. |
| CO3 | Apply programming language to solve engineering problems. |
| CO4 | Generate code for solving engineering problems using differential equations. |
| CO5 | Formulate FEA codes for 1D and 2D problems. |
| CO6 | Formulate FEA codes for thermal problems. |

**Exercises**:

1. Exploring programming languages such as MATLAB / Python / Scilab, etc.
2. Write code for 2$^{nd}$ order differential equation for given problems.
3. Write FEA code for solving a given problem of 1D spring and linear bar element.
4. Write FEA code for solving a given problem of 2D truss structure.
5. Write FEA code for solving a given problem of Plane stress and Plane strain
6. Write FEA code for solving a given problem of thermal analysis.