VIT®
Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

SCHOOL OF MECHANICAL ENGINEERING

M.Tech CAD/CAM

Curriculum & Syllabi

(*2023-2024 batch onwards*)

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VISION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

- Transforming life through excellence in education and research.

MISSION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

- **World class Education**: Excellence in education, grounded in ethics and critical thinking, for improvement of life.
- **Cutting edge Research**: An innovation ecosystem to extend knowledge and solve critical problems.
- **Impactful People**: Happy, accountable, caring and effective workforce and students.
- **Rewarding Co-creations**: Active collaboration with national & international industries & universities for productivity and economic development.
- **Service to Society**: Service to the region and world through knowledge and compassion.

VISION STATEMENT OF THE SCHOOL OF MECHANICAL ENGINEERING

- To be a leader in imparting world class education in Mechanical Engineering, with a vision to nurture scientists and technocrats of the highest caliber engaged in global sustainable development.

MISSION STATEMENT OF THE SCHOOL OF MECHANICAL ENGINEERING

- To create and maintain an environment fostering excellence in instruction & learning, Research and Innovation in Mechanical Engineering and Allied Disciplines.
- To equip students with the required knowledge and skills to engage seamlessly in higher educational and employment sectors ensuring that societal demands are met.

M. Tech CAD/CAM

PROGRAMME OUTCOMES (POs)

PO_01: Having an ability to apply mathematics and science in engineering applications.

PO_02: Having an ability to design a component or a product applying all the relevant standards and with realistic constraints, including public health, safety, culture, society and environment.

PO_03: Having an ability to design and conduct experiments, as well as to analyse and interpret data, and synthesis of information.

PO_04: Having an ability to use techniques, skills, resources and modern engineering and IT tools necessary for engineering practice.

PO_05: Having problem solving ability- to assess social issues (societal, health, safety, legal and cultural) and engineering problems.

PO_06: Having adaptive thinking and adaptability in relation to environmental context and sustainable development.

PO_07: Having a clear understanding of professional and ethical responsibility.

PO_08: Having a good cognitive load management skills related to project management and finance.

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M. Tech CAD/CAM

PROGRAMME SPECIFIC OUTCOMES (PSOs)

On completion of M. Tech. (CAD/CAM) programme, graduates will be able to

- **PSO_1:** Analyse, design and develop mechanical systems to solve complex engineering problems by integrating modern mechanical engineering tools, software and equipment's.
- **PSO_2:** Adopt a multidisciplinary approach to solve real-world industrial problems.
- **PSO_3:** Independently carry out research / investigation to solve practical problems and write / present a substantial technical report/document

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M. Tech CAD/CAM

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

1. Graduates will be engineering practitioners and leaders, who would help solve industry's technological problems.

2. Graduates will be engineering professionals, innovators or entrepreneurs engaged in technology development, technology deployment, or engineering system implementation in industry.

3. Graduates will function in their profession with social awareness and responsibility.

4. Graduates will interact with their peers in other disciplines in industry and society and contribute to the economic growth of the country.

5. Graduates will be successful in pursuing higher studies in engineering or management.

6. Graduates will pursue career paths in teaching or research.

Agenda Item 67/12

To consider and approve the revised programme credit structure, curriculum and course contents of Master of Technology in CAD / CAM

ANNEXURE – 16

Master of Technology in CAD/CAM

School of Mechanical Engineering

Programme Credit Structure	**Credits**
Discipline Core Courses	24
Skill Enhancement Courses	05
Discipline Elective Courses	12
Open Elective Courses	03
Project/ Internship	26
Total Graded Credit Requirement	70

Discipline Core Courses **24**

		L	T	P	C
MCDM501L	Advanced Mechanics of Solids	2	1	0	3
MCDM502L	Applied Materials Engineering	3	0	0	3
MCDM503L	Computer Graphics and Geometric Modelling	2	0	0	2
MCDM503P	Computer Graphics and Geometric Modelling Lab	0	0	2	1
MCDM504L	Finite Element Methods	3	0	0	3
MCDM504P	Finite Element Methods Lab	0	0	2	1
MCDM505L	Integrated Manufacturing Systems	3	0	0	3
MCDM505P	Integrated Manufacturing Systems Lab	0	0	2	1
MCDM506L	Advanced Vibration Engineering	3	0	0	3
MMAE503L	Additive Manufacturing Technology	3	0	0	3
MMAE503P	Additive Manufacturing Technology Lab	0	0	2	1

Skill Enhancement Courses **05**

MENG501P	Technical Report Writing	0	0	4	2
MSTS501P	Qualitative Skills Practice	0	0	3	1.5
MSTS502P	Quantitative Skills Practice	0	0	3	1.5

Discipline Elective Courses **12**

MAUE505L	Vehicle Dynamics	3	0	0	3
MAUE505P	Vehicle Dynamics Lab	0	0	2	1
MCDM601L	Advanced Finite Element Methods	3	0	0	3
MCDM602L	Design For Manufacture and Assembly	3	0	0	3
MCDM603L	Product Design and Life Cycle Management	3	0	0	3
MCDM604L	Fracture Mechanics	3	0	0	3
MCDM605L	Manufacturing and Mechanics of Composites Materials	3	0	0	3
MCDM606L	Optimization Methods	3	0	0	3
MCDM607L	Computational and Experimental Vibration Analysis and Control	3	0	0	3
MCDM607P	Computational and Experimental Vibration Analysis and Control Lab	0	0	2	1
MCDM608L	Computational Fluid Dynamics	3	0	0	3
MCDM608P	Computational Fluid Dynamics Lab	0	0	2	1
MCDM609L	Design Thinking and Innovation	3	0	0	3
MCDM610L	Machine Fault Diagnostics	3	0	0	3
MCDM611L	Computer Aided Process Planning	3	0	0	3
MCDM612L	Advanced Manufacturing Technology	3	0	0	3
MCDM613L	Statistics and Quality Management	3	0	0	3
MAUE605L	Vehicle Aerodynamics	3	0	0	3
MMAE608L	Design and Analysis of Experiments	2	1	0	3

Open Elective Courses **03**

Engineering Disciplines | Social Sciences

Project and Internship **26**

MCDM696J	Study Oriented Project	02
MCDM697J	Design Project	02
MCDM698J	Internship I/ Dissertation I	10
MCDM699J	Internship II/ Dissertation II	12

Course Code	Course Title	L	T	P	C
MCDM501L	**Advanced Mechanics of Solids**	**2**	**1**	**0**	**3**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives :

The main objectives of this course are to:

1. Introduce the students the behavior of structural and mechanical systems subjected to various types of loading.
2. Impact skills to evaluate the resulting stresses, strains and deflections as well as failure criteria of these systems.

Course Outcome :

On completion of this course student should be able to:

1. Analyze mechanical and structural systems respond to a wide variety of loading.
2. Analyze and compute the stresses and deflections, and failure criteria of a variety of mechanical and structural systems.
3. Compute the stress function calculation for non-circular shaft.
4. Evaluate the Energy methods and shear center towards designing mechanical and structural systems
5. Demonstrate the stresses and deflections calculation in beams subjected to unsymmetrical loading structures
6. Analyze Radial and tangential stresses and displacements in curved beams like rotating disks.

Module:1	**Stress and strain Relations**	**6 hours**

Stress-strain relations and general equations of elasticity in Cartesian and polar co-ordinates, Transformation of stress and strain in 3D, Principal values and directions – Problems

Module:2	**2D elasticity solutions**	**6 hours**

Plane stress and strain, Airy's function solutions to some 2D elasticity problems in Cartesian and polar coordinates such as beams, pressure vessel and plate with circular hole – Problems

Module:3	**Torsion of non-circular shafts**	**6 hours**

Torsion of rectangular cross sections - St. Venant theory, Prandtl stress function, membrane analogy, torsion of hollow thin-walled tubes- Problems

Module:4	**Energy methods**	**6 hours**

Principle of minimum potential energy, Castigliano's theorems- Problems

Module:5	**Shear centre**	**6 hours**

Bending axis and shear center - shear center for axi-symmetric and unsymmetrical sections-shear flow-problems

Module:6	**Unsymmetrical bending**	**6 hours**

Stresses and deflections in beams subjected to unsymmetrical loading- Problems

Module:7	**Curved beams**	**7 hours**
Radial and circumferential stresses in curved beams, deflection of curved beams, closed ring subjected to concentrated load and uniform load – chain links and crane hooks – Problems Stresses due to rotation: Radial and tangential stresses and displacements in rotating disks of constant and variable thickness- Problems		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	A. P. Boresi and R. J. Schmidt, Advanced Mechanics of Materials, Wiley India, 2009
2.	Schmerr Jr., L. Advanced Mechanics of Solids: Analytical and Numerical Solutions with MATLAB®. Cambridge: Cambridge University Press, 2021.

Reference Books

1.	M. H. Sadd, Elasticity: Theory, Applications and Numerics, Elsevier India, 2012
2.	S. P. Timoshenko, J. N. Goodier, Theory of Elasticity, Tata McGraw-Hill Education, 2010
3.	L. S. Srinath, Advanced Mechanics of Solids, Tata McGraw-Hill Education, 2008
4.	J. P. Den Hartog, Advanced Strength of Materials, Dover, 2012

Tutorial

1.	Module 1	2 hours
2.	Module 2	2 hours
3.	Module 3	2 hours
4.	Module 4	2 hours
5.	Module 5	3 hours
6.	Module 6	2 hours
7.	Module 7	2 hours
	Total tutorial hours	**15 hours**

Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCDM502L	Applied Materials Engineering	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives :

The main objectives of this course are to:

1. Familiarize students with basic concepts of mechanical behavior of materials.
2. Impart knowledge of different classes of materials and their applications.
3. Impart knowledge on various surface modification techniques.
4. Familiarize students with different material working practices

Course Outcome :

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

1. Demonstrate mechanical behavior of materials
2. Apply fatigue fracture and creep mechanism in failure analysis and design.
3. Apply modern materials in different engineering applications.
4. Modify surfaces to improve wear resistance
5. Analyze the metal working practices and suggest best alternatives
6. Analyze defects in forging, extrusion and sheet metal processes.

Module:1	Review of basic concepts	7 hours

Mechanical behavior of Materials, Mechanical properties of materials, stress and strain, Mohr's strain circle, Elasticity, plasticity, Tensile Testing, stress-strain curve for ductile, brittle and polymer materials, Bridgman correction, Other tests of plastic behavior, Strain hardening of metals-mechanism.

Module:2	Fatigue, Fracture and Creep mechanisms	6 hours

S-N curves, effect of mean stress, stress concentration, design estimates, cyclic stress strain behavior, Ductility and Fracture, slip system, Griffiths theory, Orowan theory, theoretical fracture strength, Irwin's fracture analysis, fracture mechanics in design, Creep mechanisms, temperature dependence of creep.

Module:3	Modern materials and alloys	6 hours

Super alloys, Refractory metals, Shape memory alloys, Dual phase steels, Micro alloyed steel High strength low alloy steel, Transformation induced plasticity steel(TRIP steel), Maraging steel, Smart materials, Metallic glass, Quasi crystal, Nano-crystalline materials, metal foams, Compacted graphite cast iron and creep resistant aluminum alloys

Module:4	Surface modifications of materials	6 hours

Mechanical surface treatment and coating, Case hardening and hard facing, Thermal spraying, Vapor deposition and ion implantation, Diffusion coating, electroplating and Electrolysis, Conversion coating, Ceramic coating, Organic coatings, diamond coating, Laser based surface modification

Module:5	Review of Metal Working	6 hours

Mechanisms of metal working, Flow-stress determination, Temperature in metal working, strain-Rate Effects, Friction and Lubrication, Deformation- zone geometry, Hydrostatic Pressure, Workability, Residual stress.

Module:6	Forging	6 hours

Forging equipment, types, forging in plain strain, calculation of forging loads, forging defects, powder metallurgy forging, Residual stresses in forging.
Rolling:

Classification, Rolling of bars and shapes, Forces and geometrical relationship, calculation of rolling loads, variables and defects in rolling, rolling mill control, theories.		
Module:7	**Extrusion and Sheet metal forming**	**6 hours**
Classification, Analysis of extrusion process, Deformation, lubrication and defects. Forming methods, shearing and blanking, bending, stretch forming, deep drawing, Limit criteria, Defects.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	George E. Dieter, Mechanical Metallurgy, McGraw Hill, 2017.
Reference Books	
1.	Norman E. Dowling, Mechanical Behavior of Materials , Prentice Hall, 2012
2.	Kenneth G Budenski and Michael K Budenski Engineering Materials' by Prentice-Hall of India Private Limited, 2009.
3.	William F. Hosford& Ann Arbor Robert M. Caddell, Metal Forming : Mechanics and Metallurgy, Cambridge University Press, 2011
4.	J.E.Dorn, Mechanical behaviour of materials at elevated temperatures, McGraw Hill, 2000.
5.	Henry Ericsson Theis, Handbook of Metal forming Processes, CRC Press, 1999

Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCDM503L	Computer Graphics And Geometric Modelling	2	0	0	2
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

The main objectives of this course are to:

1. Impact skills related to product lifecycle management (PLM), which represents an all-encompassing vision for managing data relating to the design, production, support and ultimate disposal of manufactured goods.
2. Provide hands on training in classical geometric modeling as well as its modern use of computer graphics.

Course Outcome

On completion of this course student should be able to:

1. Apply various procedures of PLM to engineering product ranges.
2. Integrate the role of graphic communication in the engineering design process
3. Generate various curves and surfaces using Computer graphics.
4. Generate technical drawings of parts and assemblies according to engineering design standards.
5. Use different CAD software's to generate computer models and technical drawing complicated assembly.
6. Calculate mass properties and translate product data to suit various processors.

Module	Title	Hours
Module:1	**Overview of CAD/CAM Systems**	**4 hours**
Product life cycle, CAD/CAM systems and applications,3D modeling concepts, PLM and associated databases		
Module:2	**Computer graphics Concepts**	**4 hours**
Transformations – 2D & 3D, Homogenous representation, concatenated transformations, Visualisation – Hidden line, surface and solid algorithms, shading, colors		
Module:3	**Geometric modeling – Curves**	**4 hours**
Curve entities and representation, analytic curves – line, circle, ellipse, parabola, synthetic curves–Hermite cubic spline, Bezier curve, B-spline curve, NURBs, Curve manipulations		
Module:4	**Geometric modeling – Surfaces**	**4 hours**
Surface entities and representation, surface analysis, Analytical surfaces, synthetic surfaces – Hermite bicubic surface, Bezier surface, B-spline surface, Coons surface, surface manipulations		
Module:5	**Geometric modeling – Solids**	**4 hours**
Geometry and topology, solid entities and representation, Boundary representation, Constructive solid geometry, Features		
Module:6	**Assembly Modeling**	**4 hours**
Introduction, assembly tree, assembly planning, mating conditions, assembly approaches, testing mating conditions, managing assemblies, inference of position and orientation, assembly analysis		
Module:7	**Mass properties and Product data exchange**	**4 hours**
Calculation of mass properties, Types of translators, IGES, STEP, ACIS and DXF, processors		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)

1.	Ibrahim Zeid, "Mastering CAD/CAM", McGraw Hill Education (India) P Ltd., SIE, 2013		
Reference Books			
1.	P. N. Rao, "CAD/CAM: Principles and Applications", 2012, McGraw Hill Education (India) P Ltd.		
2,	David F. Rogers and J. Alan Adams, "Mathematical Elements for Computer Graphics" Tata McGraw-Hill Edition authors, book title, year of publication, edition number, press, place		
Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCDM503P	**Computer Graphics and Geometric Modelling Lab**	**0**	**0**	**2**	**1**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives

1. To expose the students to geometric modelling and assembly in a CAD environment using tools used in industry like CATIA / NX / PTC Creo / Solid Works / Inventor etc
2. Able to do industry scale drawings, customization, programming for design automation, Macro writing, etc.

Course Outcome

1. Generate and interpret engineering, technical drawings of parts and assemblies according to engineering design standards.
2. Use CAD software to generate a computer model and technical drawing for a simple, well-defined part or assembly.

Indicative Experiments	
1.	2D view sketches and solid models of shaft support, machine block, sliding block & support, bearing bracket, vice-body, depth stop & flange connector
2.	Design tree, visualisation tools, command and GUI managers, units etc.; Sketcher tools – profiles, dimensional & geometric constraints, transformation tools, coordinate systems etc.
3.	Solid modelling and assembly of Universal coupling – use design tables/macros
4.	Solid modeling –Sketch based features like extrude, revolve, sweep, etc and variational sweep, loft, etc., dress based features like fillet, chamfer, draft, shell etc. Boolean operations etc. design table macros, formulas and other design automation tools, mass property calculations, multibody features, functional modelling etc
5.	Assembly modelling : Assembly planning - Insert, position and orientation, assembly mating and simulation, interference and assembly analysis, assembly properties like CG etc., assembly approaches
6	Solid modelling, assembly and drafting with GD&T of a tool post
7	Drafting – standard views, dimensioning, layouts, GD&T, Bill of materials, exploded views etc
8	Solid modelling, assembly of a windmill and a study of assembly interference
9	Surface modelling of an mobile phone case
10	Surface modelling - wire frame models and manipulations, analytical surfaces, generative shape design - Extrude, Sweep, Trim .etc and Mesh of curves, Free form etc, multi-section & blended surfaces, surface manipulations, automation tools etc Surface reconstruction from cloud point data and from other reverse engineering tools etc
11	Surface modelling of a soap bottle with its plastic tool design and design for sustainability
12	Creation of surfaces from reverse engineered data from a toy car
13	Design a concept of a hair dresser using concept tools
14	Preparation of a CAD model of an aerofoil for FEA/CFD analysis
Total Laboratory Hours	**30 hours**

Text Book(s)			
1.	Ibrahim Zeid, “Mastering CAD/CAM”, McGraw Hill Education (India) P Ltd., SIE, 2013		
Reference Books			
1.	P. N. Rao, “CAD/CAM: Principles and Applications”, 2012, McGraw Hill Education (India) P Ltd.		
2.	David F. Rogers and J. Alan Adams, “Mathematical Elements for Computer Graphics” Tata McGraw-Hill Edition authors, book title, year of publication, edition number, press, place		
Mode of assessment: Continuous assessment / FAT / Oral examination and others			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCDM504L	**Finite Element Methods**	**3**	**0**	**0**	**3**
Pre-requisite	**NIL**	**Syllabus Version**			
		1.0			

Course Objectives :

The main objectives of this course are to:

1. Enable the students understand the mathematical and physical principles underlying the Finite Element Method (FEM) as applied to solid mechanics and thermal analysis
2. Introduce students to the theory of elasticity
3. Teach students the characteristics of various elements in structural and thermal analysis and selection of suitable elements for the problems being solved
4. Introduce students to various field problems and the discretization of the problem
5. Make the students derive finite element equations for simple and complex elements

Course Outcome :

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

1. Apply the knowledge of mathematics and engineering to solve problems in structural and thermal engineering by approximate and numerical methods
2. Employ various formulation methods in FEM.
3. Apply suitable boundary conditions to a global equation for bars, trusses to solve displacements, stress and strains induced.
4. Apply suitable boundary conditions to a global equation for beams and frames to solve displacements, stress and strains induced.
5. Analyze linear 2D and 3D structural problems using CST element and analyze the Axi-symmetric problems with triangular elements. Evaluate heat transfer problems for bar, stepped bar and fin like structures.
6. Analyze the Vector Variable problems using Plane stress, Plane Strain and Axi-symmetric conditions
7. Demonstrate the use of Finite element analysis in Production Processes

Module:1	Fundamental concepts	6 hours

Physical problems, Finite Element Analysis as Integral part of Computer Aided Design;. Stresses and Equilibrium; Boundary Conditions; Strain-Displacement Relations; Stress – strain relations, Linear and nonlinear material laws; Temperature Effects; Definition of Tensors and indicial notations; Deformation gradients; Classification of different types of deformations; Degree of Freedom; Field Problem and their degree of freedom. Solid Mechanics Problems and Fluid Mechanics Problems. Deformations and stresses in bars, thin beams, thick beams, plane strain- plane stress hypothesis, thin plate, thick plate, axisymmetric bodies; Approximate nature of most of these deformation hypotheses; General 3D deformation (linear small deformation), Large deformation (nonlinear).

Module:2	General Techniques and Tools of Displacement Based Finite Element Analysis	6 hours

Mathematical models, Approximate solutions, Minimization procedure, Variational procedure, Interpolation polynomial method, Nodal approximation method and Finite Element Solutions. Strong or classical form of the problem and weak or Variational form of the problem; Galerkin’s and Weighted residual approaches; Shape and interpolation

functions for 1D, 2D & 3D applications; Use of shape (interpolation) functions to represent general displacement functions and in establishment of coordinate and geometrical transformations; Hermite, Lagrange and other interpolation functions.		
Module:3	**One Dimensional Problems: Bars & Trusses**	**6 hours**
Introduction; Local and global coordinate systems; Transformation of vectors in two and three dimensional spaces; Finite Element stiffness matrix and load vector of a basic element in local coordinate system using energy approach; Assembly of Global Stiffness Matrix and Load vector; Treatment of boundary conditions; Solution algorithms of linear system matrices; Example problems in trusses; Formulation of dynamics analysis, global mass matrix; Extraction of modal frequencies and mode shape.		
Module:4	**One Dimensional Problems – Beams and Frames**	**7 hours**
Finite Element Modeling of a basic beam element in local coordinate system using energy approach; Formulation of element matrices; Assembly of the Global Stiffness Matrix, Mass matrix and Load vector; Treatment of boundary Conditions; Euler Bernoulli (thin) beam element and Timoshenko (thick) beam element; Beam element arbitrarily oriented in plane (2D) as Plane frames and in space as space frame analysis (3D); Solution algorithms of linear systems.; extraction of modal frequencies and mode shape.		
Module:5	**Two Dimensional Analysis – Scalar Variable Problems**	**6 hours**
Formulation of 2D problems using Partial Differential Equations; Solution algorithm using Energy principle; Constant Strain Triangles (CST); Bilinear Quadrilateral Q4; Formulating the element matrices; Modelling boundary conditions; Solving the field problems such as heat transfer in automotive cooling fin, engine cover; Torsion of a non-circular shaft etc.		
Module:6	**Vector Variable problems - Plane stress, Plane Strain and Axi-symmetric Analysis**	**6 hours**
Equilibrium equation formulation – Energy principle and formulating the element matrices - Plane stress, plane strain and axi-symmetric elements; Orthotropic materials; Isoparametric Elements; Natural co-ordinate system; Higher Order Elements; Four-node Quadrilateral for Axisymmetric Problems; Hexahedral and tetrahedral solid elements; Linear, Quadratic and cubic elements in 1D, 2D and 3D; Numerical integration of functions; Gauss and other integration schemes. C0 and C1 continuity elements.		
Module:7	**Analysis of Production Processes**	**6 hours**
FE Analysis of metal casting – Special considerations, latent heat incorporation, gap element – time stepping procedures – Crank – Nicholson algorithm – Prediction of grain structure - Basic concepts of plasticity – Solid and flow formulation – small incremental deformation formulation – FE Analysis of metal cutting, chip separation criteria, incorporation of strain rate dependency.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**
Text Book(s)		
1.	Seshu.P, Finite Element Analysis, Prentice Hall of India, 2013	
2.	Saeed Moaveni, Finite Element Analysis, Theory and Application with ANSYS, Pearson Fifth Edition, 2021	
Reference Books		
1	Robert D. Cook, David S. Malkus, Michael E. Plesha, Robert J. Witt,Concepts and	

	Applications of Finite Element Analysis, John Wiley & Sons, Incl.2002.
2	S.S.Rao, Finite element method in Engineering, 2011, Butterworth Heinemann
3	J.N Reddy, An introduction to the Finite Element Method, 2017, Mcgraw Hill
4	Tirupathi R. Chandrapatla, Ashok D. Belegundu, Introduction to Finite Element in Engineering Pearson 4th Edition, 2011

Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	**Course Title**	**L**	**T**	**P**	**C**
MCDM504P	**Finite Element Methods Lab**	**0**	**0**	**2**	**1**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives

1. To enable the student's skills in FEM software that can be used and implemented for various engineering applications.
2. To develop proficiency in the application of the finite element method (modeling, analysis, and interpretation of results) to realistic engineering problems

Course Outcome

1. Demonstrate the ability to create and analyze the FE models for trusses, frames, plate structures, machine parts, and engineering components using general-purpose FE softwares like Ansys, Matlab etc
2. Demonstrate the ability to evaluate and interpret FEA analysis results for design and evaluation purposes

Indicative Experiments

1.	Stress analysis of a bar without considering self-weight	4 hours
2.	Effect of self-weight on stress of a vertical hanging bar	4 hours
3.	Stress analysis of the tapered rod	4 hours
4.	Two dimensional truss problem	4 hours
5.	Bending moment and shear force diagram of various beams	4 hours
6.	Plane stress and plane strain analysis	4 hours
7.	Modal, harmonic and transient analysis on bar, beam and plates	3 hours
8.	Axi-symmetric analysis	3 hours
	Total Laboratory Hours	**30 hours**

Mode of assessment: Continuous assessment / FAT / Oral examination and others

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCDM505L	**Integrated Manufacturing Systems**	**3**	**0**	**0**	**3**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives :

The main objectives of this course are to

1. Acquaint the students with the need of integration of manufacturing system.
2. Make the students understand the design principles and automation of mechanical assemblies.
3. Introduce the students the importance of Group technology, Robotics and Flexible automation.
4. Familiar with virtual manufacturing and lean production.

Course Outcome :

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

1. Demonstrate the importance of Automation of machine components.
2. Apply the principles of control system advanced automation to various mechanical engineering systems.
3. Design the applications of robotics and group technology in industries.
4. Analyze the applications of automated assembly.
5. Analyze cellular manufacturing using group technology.
6. Identify the optimal manufacturing support system for lean production.

Module:1	**Introduction**	**5 hours**

Production Systems, Automation in Production System, Manual Labor in Production Systems, Automation Principles and Strategies.
Manufacturing Industries and Products, Manufacturing Operations, Production Facilities, Product/Production Relationship

Module:2	**Introduction to automation**	**5 hours**

Basic Elements of an Automated System, Advanced Automation Functions, Levels of Automation, Industrial control systems

Module:3	**Control system components**	**5 hours**

Sensors, Actuators, Analog-to-Digital Conversion, Digital-to-Analog Conversion, Input/output Devices for Discrete Data
Fundamentals of Numerical Control - Computer Numerical Control, Applications, Part programming

Module:4	**Industrial robotics**	**8 hours**

Robot anatomy, Control systems, Applications, and Robot programming, Discrete Control using Programmable Logic Controllers (PLC)
Manufacturing Systems - Components, Classifications, Overview, single station manufacturing cells, Flexible manufacturing systems, components, applications, Planning and implementation and analysis

Module:5	**Group technology and Cellular manufacturing**	**7 hours**

Part families, Parts Classification and Coding, Production Flow Analysis, Cellular

Manufacturing, Application Considerations in Group Technology, Quantitative Analysis in Cellular Manufacturing		
Module:6	**Assembly systems**	**7 hours**
Manual assembly lines, Automated manufacturing systems and Automated assembly systems. Quality control systems – Quality assurance, Statistical Process Control (SPC), Inspection principles and practises, inspection technologies		
Module:7	**Manufacturing support systems**	**6 hours**
Product design and CAD/CAM in the production system, Process planning and concurrent engineering, production planning and control systems - Just In Time (JIT) and Lean production		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	M.P. Groover, Automation Production systems and Computer Integrated manufacturing, Pearson Education, 2015.
2	Jayaprakash, G.., Groover, Mikell P.. Automation, Production Systems, and Computer-integrated Manufacturing. United Kingdom: Pearson Education

Reference Books

1.	XunXu, Integrating advanced Computer Aided Design, Manufacturing and Numerical Control, IGI Global, 2009
2.	J.A. Rehg& H. W. Kraebber, Computer Integrated Manufacturing, Pearson Education 2005
3.	T.C. Chang, R. Wysk and H.P. Wang, Computer aided Manufacturing, Pearson Education, 2009
4	Scheer, August-Wilhelm. CIM Computer Integrated Manufacturing: Towards the Factory of the Future. Springer Science & Business Media, 2012.
5	Alavudeen, A., and N. Venkateshwaran. Computer integrated manufacturing. PHI Learning Pvt. Ltd., 2008.

Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCDM505P	**Integrated Manufacturing Systems Lab**	**0**	**0**	**2**	**1**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives :

The main objectives of this course are to

1. Acquaint the students with the need of integration of manufacturing system.
2. Make the students understand the design principles and automation of mechanical assemblies.
3. Introduce the students the importance of Group technology, Robotics and Flexible automation.
4. Familiar with virtual manufacturing and lean production.

Course Outcome :

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

1. Demonstrate the importance of Automation of machine components.
2. Apply the principles of control system advanced automation to various mechanical engineering systems.
3. Design the applications of robotics and group technology in industries.
4. Analyze the applications of automated assembly.
5. Analyze cellular manufacturing using group technology.
6. Identify the optimal manufacturing support system for lean production.

Indicative Experiments

1	3D solid modelling and assembly using a CAD/CAM system for a plastic injection moulding die
2	Write required CNC program for turning/ milling operations.
3	Generate CNC program using any CAD Software for turning/ milling operations.
4	Generation of CNC program by optimising tool path movement using CAM software for lathe and mill.
5	Inspection planning for automated inspection for an automotive component
6	Industrial Robot Programming for spot welding and paint shop application
7	Generate suitable Computer aided Process plan
8	Virtual commissioning of pick and place robot by integrating PLC hardware using a suitable simulation software
	Total Laboratory Hours **30 hours**

Text Book(s)

1.	M.P. Groover, Automation Production systems and Computer Integrated manufacturing, Pearson Education, 2015.
2	Jayaprakash, G.., Groover, Mikell P.. Automation, Production Systems, and Computer-integrated Manufacturing. United Kingdom: Pearson Education

Reference Books

1.	XunXu, Integrating advanced Computer Aided Design, Manufacturing and Numerical Control, IGI Global, 2009
2.	J.A. Rehg& H. W. Kraebber, Computer Integrated Manufacturing, Pearson Education, 2005

3.	T.C. Chang, R. Wysk and H.P. Wang, Computer aided Manufacturing, Pearson Education, 2009		
Mode of assessment: Continuous assessment / FAT			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCDM506L	**Advanced Vibration Engineering**	**3**	**0**	**0**	**3**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives :

The main objectives of this course are to:

1. Introduce classical Vibration theories, relating to discrete and continuous systems with applications
2. Teach various numerical techniques including FE for analysis of complex structures and modal testing for natural frequencies and mode shapes.
3. Introduce non-linearity and random phenomena in vibrating systems including their stability.

Course Outcome :

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

1. Apply concepts of Mechanical vibrations single, two and multi degree freedom systems and in continuous, Non-linear and Random Vibration concepts.
2. Demonstrate the classical vibration theories, relating to discrete and continuous systems with applications.
3. Use and apply various numerical techniques for analysis of complex structures Perform various experimental techniques such as modal testing to identify natural frequencies and mode shapes.
4. Analyze various measurements of vibration techniques in structures and employ suitable control techniques
5. Interpret and demonstrate non-linearity and random phenomena in vibrating systems including their stability.

Module:1	**Introduction to Vibrations**	**6 hours**

Free and Forced Vibration analysis of single degree of freedom- Undamped and viscously damped vibrations-Measurement of damping-Response to Periodic, Harmonic and Non-periodic Excitations.

Module:2	**Two degree of freedom system**	**6 hours**

Free and Forced vibration analysis-Coordinate transformation and linear superposition-Vibration Absorption and Vibration Isolation

Module:3	**Multi degree of freedom system**	**6 hours**

Stiffness and Flexibility matrix- Eigen Value formulation- Lagrange's method-Principle of Orthogonality- Modal matrix and modal analysis of multi DOF

Module:4	**Approximate numerical methods**	**6 hours**

Rayleigh's Method, Matrix inversion method, Stodola's method, Holzer's method, Transfer Matrix method.

Module:5	**Vibrations of Continuous systems**	**6 hours**

Vibration analysis of strings- Vibration of bar- Vibration of beams by Euler's equation-Effect of rotary inertia and shear deformation effects-Effect of axial force

Module:6	**Experimental methods**	**6 hours**

Vibration exciters and measuring instruments- Free and forced vibration tests- Signal analysis-Industrial case studies		
Module:7	**Introduction to Random Vibration**	**4 hours**
Probability density function- Stationary and ergodic process- Auto-correlation function-Power spectral density-Narrow band and wideband random processes-Response of single and Multi-DOF systems.		
Module:8	**Introduction to non-linear vibration**	**3 hours**
Fundamental conceptsin stability and equilibrium points-Perturbation technique- Duffing equation, Phenomena of Jump, vibration analysis of a simple pendulum with non-linear behavior Contemporary Discussion		
Module:9	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	S. S. Rao, “Mechanical Vibrations”Pearson India, 6th Edition 2016.
2.	Kelly SG “Mechanical Vibrations” CL Engineering 1st Edition,2011

Reference Book

1.	Dukkipati RV, “Advanced Mechanical Vibrations”, Narosa Publications, 2008.
2.	Benson H. Tongue, “Principles of Vibrations”, Oxford University Press, Delhi, 2012.
3.	W.T. Thomson, M.D. Dahleh, “Theory of Vibrations with applications”, Pearson New International 5th Edition, 2013.
4.	Meirovitch L, “Fundamental of Vibration”, Waveland, Pr.Inc., 2010
5.	William J Boltega, “Engineering Vibrations”, CRC Press, 2nd Edition, 2014.
6.	Paolo L. Gatti, “Applied Structural and Mechanical Vibrations: Theory and Methods”, Second Edition, CRC Press, 2017.

Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMAE503L	Additive Manufacturing Technologies	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To acquaint students with the concept of Additive Manufacturing (AM), various AM technologies, selection of materials for AM, modeling of AM processes, and their applications in various fields.
2. Able to design and print 3D components using various printing tools.
3. Apply digital manufacturing technologies to various facets of human endeavor.

Course Outcome

Upon successful completion of the course, the students will be able to

1. Understanding the concepts, capabilities and limitations of additive technologies and their varied applications.
2. Identifying the suitable file format and data processing technique for AM systems using software.
3. Proposing suitable material and AM systems for specific requirement.
4. Applying design for additive manufacturing guidelines in designing mass customized products.
5. Suggesting the appropriate post processing technique to improve the quality of printed part.
6. Designing appropriate rapid tools for any given medical and automobile applications.

Module:1	Introduction	4 hours

Introduction to AM, AM evolution, Distinction between AM & CNC machining, Steps in AM, Classification of AM processes, Advantages of AM and Types of materials for AM, Design Freedom in AM, Rapid Tooling and Reverse Engineering

Module:2	Process Planning for Additive Manufacturing	7 hours

3D model data creation, Concept of reverse engineering, Data collection, Modeling for printing, file formats: STL, OBJ, AMF, 3MF, CLI, STL file errors, Correction and printability analysis, Optimization of part orientation and support structure generation, Types of supports, Slicing parameters, Tool path generation.

Module:3	Additive Manufacturing Processes	8 hours

Basic principles of the Additive Manufacturing process, Generation of layer information, Physical principles for layer generation. Elements for generating the physical Layer, Classification of Additive Manufacturing processes, Overview of polymerization: Stereo-lithography (SL)-Photopolymerisation, Selective Laser Sintering/Melting in the Powder Bed, Layer Laminate Manufacturing (LLM), Three-Dimensional Printing (3DP), Wire and powder based Direct Energy Deposition technologies, Material Jetting, Binder Jetting, and Hybrid AM Processes.

Module:4	Materials for AM	6 hours

Multifunctional and graded materials in AM, Atomic structure and bonding, Nature of polymers, Thermoplastics and thermosetting polymers, Types of polymerizations, Properties of polymers, Degradation of polymers, Metal and Ceramic Powders, Composites, Role of solidification rate, Evolution of non-equilibrium structure, microstructural studies, Structure property relationship, and Case studies.

Module:5	Design for Additive Manufacturing	6 hours

Introduction to geometric modelling, Modelling of synthetic curves like Hermite, Bezier and B-spline, Parametric representation of freeform surfaces, Design freedom with AM, Need for design for Additive Manufacturing (DfAM), CAD tools vs. DfAM tools, Requirements of DfAM methods, General guidelines for DfAM, The economics of Additive Manufacturing,

Design to minimize print time, Design to minimize post-processing.		
Module:6	**Post-Processing for Additive Manufacturing**	**6 hours**
Support structure removal, Surface texture improvement, Surface treatments of Polymer & metal, Heat treatment, HIP & residual stress relieving, UV curing, Cleaning & de-powdering, Machining, Surface coating and Infiltration.		
Module:7	**Rapid Tooling & Reverse Engineering**	**6 hours**
Conventional tooling, Rapid tooling, Differences between conventional and rapid tooling, Classification of rapid tooling: Direct and indirect tooling methods, Soft, Bridge (firm) and Hard tooling methods, Rapid tooling for investment casting, Re-Engineering–Hardware and software: Contact methods, Noncontact methods, Destructive method, Point capture devices, Tracking systems, Internal measurement systems, X-ray Tomography, & Destructive systems		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**
Text Book(s)		
1.	C P Paul , A N Jinoop, Additive Manufacturing – Pricniples, technologies and Applications, Mc Graw Hill Publication, 2021.	
Reference Books		
1.	Additive Manufacturing, Second Edition, Amit Bandyopadhyay Susmita Bose, CRC Press Taylor & Francis Group, 2020.	
2.	Olaf Diegel, Axel Nordin, Damien Motte, A Practical Guide to Design for Additive Manufacturing, Springer Nature Singapore Pte Ltd., 2020.	
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Lab / Seminar		
Recommended by Board of Studies	27-07-2022	
Approved by Academic Council	No. 67	Date 08-08-2022

Course Code	Course Title	L	T	P	C
MMAE503P	**Additive Manufacturing Technology Lab**	**0**	**0**	**2**	**1**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives

1. To acquaint students with the concept of Additive Manufacturing (AM), various AM technologies, selection of materials for AM, modeling of AM processes, and their applications in various fields.
2. Able to design and print 3D components using various printing tools.
3. Apply digital manufacturing technologies to various facets of human endeavor.

Course Outcome

Upon successful completion of the course, the students will be able to
1. Understanding the concepts, capabilities and limitations of additive technologies and their varied applications.
2. Identifying the suitable file format and data processing technique for AM systems using software.
3. Proposing suitable material and AM systems for specific requirement.
4. Applying design for additive manufacturing guidelines in designing mass customized products.
5. Suggesting the appropriate post processing technique to improve the quality of printed part.
6. Designing appropriate rapid tools for any given medical and automobile applications.

Indicative Experiments

1.	Generating a 3D CAD model by Reverse Engineering (UV-Scanner)
2.	Generating a complicated 3D model with freeform surface (Rhinoceros 7)
3.	Generating a model and storing it in .STL format. Calculating the number of triangles required to store the model in .STL format. (Rhinoceros 7)
4.	Performing the slicing operation on the .STL file generated in Problem -3. Proposing the suitable part orientation and support structure design with software (Repeiter/Cura/Pursa).
5.	Calculating the build time required to print complicated 3D model by keeping layer thickness and infill density 0.2mm and 10% respectively. (Repeiter/Cura/Pursa).
6.	Evaluating the dimensional accuracy of the part printed by FDM
7.	Evaluating the dimensional accuracy of the part printed by SLA
8.	Evaluating the dimensional accuracy of the part printed by SLS
9.	Designing a split pattern for sand casting and printing it with FDM, Producing a metal casting in foundry lab., using this 3D printed pattern.
10	Preparing the build set-up for metal 3D printer
11.	Working on process parameter (Laser power, scan speed, hatch width, hatch space, etc.)
12.	Fabrication and post processing of metal part (Support removal, surface treatment, etc.)
Total Laboratory Hours	**30 hours**

Text Book(s)

1.	C P Paul , A N Jinoop, Additive Manufacturing – Pricniples, technologies and Applications, Mc Graw Hill Publication, 2021.

<table>
<tr><td colspan="5">Reference Books</td></tr>
<tr><td>1.</td><td colspan="4">Additive Manufacturing, Second Edition, Amit Bandyopadhyay Susmita Bose, CRC Press Taylor & Francis Group, 2020.</td></tr>
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<tr><td colspan="5">Mode of assessment: Continuous assessment / FAT / Oral examination and others</td></tr>
<tr><td colspan="2">Recommended by Board of Studies</td><td colspan="3">27-07-2022</td></tr>
<tr><td colspan="2">Approved by Academic Council</td><td>No. 67</td><td>Date</td><td>08-08-2022</td></tr>
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Course Code	Course Title	L	T	P	C
MAUE505L	**Vehicle Dynamics**	**3**	**0**	**0**	**3**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives:

1. To enable students to understand the role of tire characteristics and its mechanics for vehicle dynamics
2. To enable the students to understand vehicle performance, handling and ride aspects and the issues involved in it such as braking, traction, road holding, vehicle control and stability
3. To prepare the students to understand significance of steering and suspension mechanisms for vehicle dynamics.
4. To demonstrate how to apply fundamentals of vibrations and acoustics for vehicle NVH perspective along with importance of modal analysis and transfer path analysis

Expected Course Outcome:

On completion of this course, the student will be able to

1. Predict the necessary forces and moments during tire/road interaction through various tire models for vehicle dynamic simulations.
2. Compute maximum traction, optimum braking distribution and stability of the vehicle of two and three axle vehicles
3. Demonstrate the application of fundamental governing equations for longitudinal, lateral and vertical dynamics and able to use state space approach.
4. Compute steady state and transient response of vehicle during cornering.
5. Outline the role of suspension in roll over stability.
6. Evaluate the role of suspension for vibration isolation, rattle space and road holding using appropriate mathematical models.
7. Identify the current literature and the necessity of modern tools for vehicle development

Module:1	Tyre Mechanics	9 hours

Introduction to Vehicle Dynamics- Vehicle and Tyre co-ordinate systems, Tyre types and construction-Tyre forces and moments-Tyre-slip & skid phenomenon grip and rolling resistance-Cornering properties of tyres- Tyre models- Julien’s tyre model for combined tractive and braking effort, Temple & Von Schippe approach of tyre string model for cornering force, Friction Ellipse concept, Magic Formula tyre model for steady state motion. Tyre performance on wet surfaces-Ride properties of tyres.

Module:2	Longitudinal Dynamics	6 hours

Performance characteristics-Maximum tractive effort-Power plant and Transmission characteristics. Braking performance-Study of tractor-semitrailer-Anti lock brake system-Traction control system

Module:3	Lateral Dynamics	6 hours

General frame work and governing equations for vehicle in space-Necessary assumption for deducing governing equations for ground vehicles. Bicycle Model-Low speed turning-High speed cornering-State space approach-Steaty state handling characteristics of two axle vehicle- neutral steer-understeer-oversteer. Steady state gains from Bicycle Model duirng pure cornering. Vehicle handling tests.

Module:4	**Vehicle stability**	**4 hours**
Yaw plane stability and steering conditions-Understeer gradient – Handling response of a vehicle- Lateral transient response-Mimuro plot-Roll over stability analysis.		
Module:5	**Steering and Suspension Mechanisms**	**6 hours**
Steering geometry and mechanism, steering mechanism optimization- Four wheel steering-Solid Axle suspension-Independent suspension-Roll center and Roll axis-Roll mement distribution-Car tyre relative angles-Caster theory- Role of suspension and nonlinearity of tyres on vehicle roll and its effect on Understeer co-efficient		
Module:6	**Vertical Dynamics**	**6 hours**
Vehicle ride characteristics-Human response to vibration-Vehicle ride models-Quarter car model- pitch and bounce model- Suspension performance for ride-vibration isolation,suspension travel, Road holding. Active and Semi-active suspensions. Introduction to random vibration. ISO road roughness and road profiles-RMS acceleration of sprung mass of vehicle for random road excitation.		
Module:7	**Introduction to Noise, Vibration and Harshness**	**6 hours**
Fundamentals of Acoustics, Noise and Vibrations. Frequency response functions-Modal analysis- Transfer path analysis- Single reference- Multi reference analysis.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours	**45 hours**

Text Book(s)

1.	J. Y. Wong (2008), "Theory of Ground Vehicles", 4th Edition, John Wiley and Sons Inc., New York, 2008
2.	Thomas D Gillespie, Fundamentals of Vehicle Dynamics, 2nd Revised Edition, SAE International, Warrendale, 2021

Reference Books

1.	Reza N Jazar "Vehicle Dynamics: Theory and Application", 3rd Edition, Springer International Publishing AG, Switzerland, 2017
2	Katsuhiko Ogata, "Modern Control Engineering",5th Edition, Prentice Hall,Pearson,2010.
3.	C. Sujatha, "Vibration and Acoustics: Measurements and Signal Analysis", McGraw Hill Education (India) Private limited, 2010.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAUE505P	**Vehicle Dynamics Lab**	**0**	**0**	**2**	**1**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives

To prepare students to carry out real-time and virtual experimental measurements for vehicular system and its subsystems.

Course Outcome

Upon Successful Completion of this Lab course, Students will be able to

1. Understand and use the measurement systems such as data acquisition system, various types of exciters, accelerometers, microphones in real time experiments.
2. Carry out virtual testing using CARSIM software to quantify its performance, handling and ride quality.

Indicative Challenging Experiments

1.	Preparation of test set up for spectral testing	3 hours
2.	Experimental Modal Analysis a wheel rim.	3 hours
3.	Quantification of structural transfer function for NVH study of a passenger car	3 hours
4.	Quantification of Vibro-acoustic transfer function for NVH study of a passenger car	3 hours
5.	Preparation of test set up for signature testing	3 hours
6.	Interior noise measurement in a passenger car during different operating condition	3 hours
7.	Whole body vibration measurement of an occupant in a passenger car	3 hours
8.	Mathematical modelling of ride models for suspension performance using Matlab/Simulink	3 hours
9.	Virtual vehicle testing & stability analysis using CARSIM	3 hours
10.	Vibro-acoustic analysis of a component using Simcenter 3D	3 hours
	Total Laboratory Hours	30 hours

Mode of assessment: Continuous assessment / FAT / Oral examination and others

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAUE605L	**Vehicle Aerodynamics**	**3**	**0**	**0**	**3**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives

1. To impart basic knowledge of aerodynamics and fluid-vehicle interaction to the student.
2. To enable the student to design, model and test low drag, fuel efficient, and acoustic, luxury sedans, commercial trucks, motorcycles and high performance vehicles.
3. To empower the students to design vehicles to be stable and crashworthy.
4. To enable the students to integrate autonomous and EV technologies into ecofriendly vehicle designs.

Course Outcome

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

1. Comprehend and apply the basic principles of aerodynamics to the design of road vehicles.
2. Render vehicles more stable by reducing the aerodynamic drag, lift and side wind forces and moments.
3. Design fuel efficient and low noise luxury sedans, SUVs, race cars, motorcycles, trucks and buses.
4. Assess and evaluate autonomous and EV technologies and applicability to road vehicles.
5. Simulate advanced computational and simulation tools to model, simulate and analyze the performance of road vehicles.

Module:1	Introduction to Road Vehicle Aerodynamics	5 hours

Basic principles of road vehicle aerodynamics, Evolution of road vehicles, borrowed shapes, Streamlining era, Parametric studies, One-volume bodies, Bathtub bodies, Commercial vehicles, Motorcycles, Shape and detail optimization, Concept vehicles, Autonomous and electric vehicles - chassis and air flow, Performance analysis of cars and light trucks.

Module:2	Vehicle motion and aerodynamics	7 hours

Vehicle equation of motion, Types and origins of aerodynamic drag, Drag reduction systems - Ultra-low drag designs, Tire rolling resistance, Climbing resistance, Effective mass, Traction diagram, Acceleration capability and vehicle elasticity, Fuel consumption and economy - Gear-ratio re-matching - EPA driving cycles – Urban – Highway – Combined, Low fuel consumption strategies.

Module:3	Stability, aesthetics and comfort	7 hours

Flow field around a vehicle - Interior and exterior flows - Attached, separated and oscillating flows, Aerodynamic forces and moments, Cornering and side wind behaviors, Stability index, Passing maneuvers, Undertrays, Diffusers and Spoilers, Center of gravity and center of pressure, Active aerodynamic controls, Safety and aesthetics, Soiling - Visibility impairment; ventilation, Air flow and odor removal, Advanced radiator and HVAC systems.

Module:4	High performance and commercial vehicles	6 hours

Low C.G chassis, Open wheel F1 and closed top NASCAR designs, Wings - Air dams - Barge boards - Side skirts – Undertrays – Diffusers - Strakes and wickers, Over steer,

under steer, Drafting. Commercial vehicle aerodynamics - Truck aerodynamics - Improvements in design - Different styles of trailers. - Effect of gap between truck and trailer - Fairings.		
Module:5	**Measurement and testing techniques**	**6 hours**
Wind tunnel and on-road testing techniques - Classification and design of wind tunnels - Instrumentation and data acquisition - Wind tunnel components and corrections, Road testing methods - Cross-wind and engine cooling tests - Soiling, water and dirt accumulation, visibility measurements on road, 1-D sound wave equation - Sound wave expansion - Sound reflection - Transmission and absorption - Vortex sound – Buffeting - Sound and flow control - Active and passive methods - Simplified acoustic models.		
Module:6	**Computational Fluid Dynamics and Applications**	**7 hours**
Introduction to CFD analysis - CFD vs. experimentation, Fundamentals of fluid mechanics – Continuity - Navier-stokes and energy equations, Modeling and Discretization techniques - Basic steps in CFD computation - 3-D structured and unstructured grid generation - Mesh smoothing and sensitivity checks - Turbulence models - Eddy viscosity and non-eddy viscosity models - RANS and ARSM models - LES and DNS methods.		
Module:7	**Vehicle Aerodynamic Simulation**	**5 hours**
Ahmed and Windsor body simulations, Grid-free simulation methods - Solid and surface model simulations - Climatic wind tunnel simulations, Commercial software packages - SIMSCALE – ANSYS – FLUENT- FIDAP - N3S – FLOW 3D simulations, HVAC simulation - Cross-wind sensitivity simulations.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	"Automotive Aerodynamics", Joseph Katz, Wiley, July 2016, ISBN: 978-1-119-18572-7, 680 pages
2.	"Modifying the Aerodynamics of Your Road Car", Julian Edgar, Veloce Publishing Ltd., January 2022, ISBN-13 : 978-1787112834
Reference Books	
1.	Aerodynamics of Road Vehicles, W.H. Hucho, SAE, US 4th edn., Feb. 1998, ISBN-13 : 978-0768000290.

Mode of Evaluation **:** Continuous Assessment Tests, Quizzes, Assignment, Final Assessment Test			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMAE608L	**Design and Analysis of Experiments**	**2**	**1**	**0**	**3**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives:

The objectives of this course are to:

1. Introduce the student to the principles and methods of statistical analysis of experimental designs.
2. Provide knowledge on process/product optimization through statistical concepts.

Course Outcome :

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

1. Identify the Principles and Guidelines of Design of Experiments
2. Analyze the Randomized Block Designs
3. Analyze the Factorial Designs
4. Explain the comparison of classical and Taguchi's approach in Design of Experiments
5. Solve the problems by Regression Analysis.
6. Analyze the importance of response Surface Methodology in Design of Experiments

Module	Title	Hours
Module:1	**Experiments with a Single Factor**	**7 hours**
Basic Principles and Guidelines of Design of Experiments - Single Factor Experiments – ANOVA - Model Adequacy Checking - Determining Sample Size - Comparing Pairs of Treatment Means - Introduction to DOAE software		
Module:2	**Randomized Block Designs**	**5 hours**
Randomized complete block design - Latin square designs - Graeco-Latin square design - Balanced incomplete block designs		
Module:3	**Factorial Designs**	**7 hours**
Two levels - 2k factorial designs - Confounding and Blocking in factorial designs		
Module:4	**Fractional Factorial Designs**	**7 hours**
The One-Half and One-Quarter Fraction of the 2k Design - General 2k–p Fractional Factorial Design – Resolution		
Module:5	**Robust Design**	**5 hours**
Comparison of classical and Taguchi's approach - orthogonal designs - S/N ratio - application to Process and Parameter design.		
Module:6	**Regression Analysis**	**6 hours**
Introduction - Simple Linear Regression Analysis - Multiple Linear Regression Model - Model Adequacy Checking		
Module:7	**Response Surface Methodology**	**6 hours**
Response surface methodology, parameter – optimization - robust parameter design and its application to control of processes with high variability		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)				
1.	Douglas C. Montgomery, (2017), Design and Analysis of Experiments, John Wiley & Sons, Inc., 9th edition			
Reference Books				
1.	Philip J. Ross, (2000), Taguchi Techniques for quality Engineering, Prentice Hall			
2.	Angela Dean, Max Morris, John Stufken, Delrek Bingham (2015), Handbook of Design and Analysis of Experiments, Chapman & Hall/CRC Publishers.			
3.	K. Krishnaiah, P. Shahabuddeen (2012) Applied Design of Experiments and Taguchi Methods, PHI Publications.			
Tutorial				
1.	Module 1			2 hours
2.	Module 2			2 hours
3.	Module 3			2 hours
4.	Module 4			2 hours
5.	Module 5			2 hours
6.	Module 6			2 hours
7.	Module 7			3 hours
	Total tutorial hours			**15 hours**
Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT				
Recommended by Board of Studies	27-07-2022			
Approved by Academic Council	No. 67	Date	08-08-2022	

Course Code	Course Title	L	T	P	C
MCDM601L	**Advanced Finite Element Methods**	**3**	**0**	**0**	**3**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives :

The objective of this course is to

1. Enable students to earn advanced topics in FEM so that this tool can be used for analysis, design, and optimization of engineering systems.
2. Make students to focus on nonlinear structural analysis. Various nonlinearities in structural problems will be demonstrated using the mathematical and numerical aspects.
3. Student will also be exposed in computer programming and use of commercial FE programs

Course Outcome :

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

1. Analyse linear, nonlinear and simple time-dependent problems in structural discipline using finite element methods
2. Use the particular continuum and structural (beam, plate and shell) elements for formulating, integrating and for solving elastic problems.
3. Estimate the errors in Finite Element Analysis
4. Evaluate special element technology, performance and validation procedures
5. Solve special problems related geometric and material nonlinearities
6. Carryout projects on large deformation and transient nature

Module:1	**Finite Element Methods-A review**	**6 hours**

Governing differential equations of one- and two dimensional problems, Library of one dimensional and two dimensional elements; Gauss Quadrature and isoparametric elements-Stress Calculation and Gauss points-Convergence requirements and Patch test

Module:2	**Bending of Plates and Shells**	**6 hours**

Bending of Plates and Shells – Finite Element Formulation of Plate and Shell Elements – Thin and Thick Plates-Confirming and non-Confirming Elements – C0 and C1 Continuity Elements – Shell elements as degenerate 3D stress elements-Applications.

Module:3	**Three dimensional solids**	**6 hours**

Introduction - Tetrahedra element - Hexahedron element-Linear and higher order elements - Elements with curved surfaces

Module:4	**Special Purpose elements**	**6 hours**

Crack tip elements – Transition elements - Finite strip elements-Strip element methods-Method of infinite domain – nodeless elements

Module:5	**Nonlinear Analysis**	**6 hours**

Introduction to nonlinear analysis- Material Nonlinearity-Plasticity-Creep-Visoplasticity-Non-linear constitutive problem in solid mechanics- Various yield considerations-solution procedures-direct iteration method, Newton Raphson method and Modified newton raphson

method- Application in Any One manufacturing process		
Module:6	**Nonlinear Analysis -Geometrical nonlinearity**	**6 hours**
Large deflection and instability-Iteration solution of nonlinear equations; General incremental nonlinear equation-Lagrange description of motion-Deformation gradient tensor-Velocity gradient tensor-Strain tensor-Stress tensor-Basic expression of the total and updated Lagrangian formulations-Total and updated Lagrangian formulations – Application in Any One manufacturing process		
Module:7	**Dynamic Analysis**	**7 hours**
Lumped and consistent mass matrices - Damping matrix – Free, Transient and Forced response – Solutions of Eigen-systems - Implicit methods for transient dynamics - Mode superposition – Sub space Iterative Technique – Houbolt, Wilson, Newmark – Methods – Examples		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1	Robert D. Cook, David S. Malkus, Michael E. Plesha, Robert J. Witt,Concepts and Applications of Finite Element Analysis,John Wiley & Sons, Incl.,2002
2	O.C. Zienkiewicz, R.L. Taylor, J.Z. Zhu, Finite element method: Its Basic and fundamentals- Butterworth Heinemann, 2015.
3	Saeed Moaveni, Finite Element Analysis, Theory and Application with ANSYS, Pearson Fifth Edition, 2021.
Reference Books	
1	Bathe K.J. Finite Element Procedures. Prentice Hall, 2006.
2	S.S.Rao, Finite element method in Engineering, Butterworth Heinemann,2011
3	J.N.Reddy, An introduction to nonlinear finite element analysis, Oxford University Press,2013

Mode of Evaluation **:** Continuous Assessment Tests, Quizzes, Assignment, Final Assessment Test			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCDM602L	Design for Manufacture And Assembly	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

The objective of this course is to

1. Make students to redesign the components to achieve cost effectiveness, optimum shape, easy manufacturability, easy assembly and serviceability.
2. Enable students to integrate compatibility between material and manufacturing process, material and shape to ensure an optimum combination of function and manufacturability.
3. Teach students to make the design that is easy to manufacture by applying DFMA principles.

Course Outcome

Upon completion of this course, the student shall be able to:

1. Design components by applying DFMA guidelines for the ease of manufacture and assembly.
2. Apply GD&T guidelines in manufacturing processes.
3. Select suitable materials and manufacturing processes.
4. Evaluate the modifications in a design that can be facilitated during casting, forging, extrusion and machining.
5. Incorporate the design modifications in the various assembly techniques such as temporary fastening, welding, soldering, brazing and riveting processes.
6. Redesign of assembly by applying suitable DFMA software.

Module:1	Introduction	7 hours
Objectives and Principles of DFMA, Geometric Tolerancing and Dimensioning**:** Process capability studies, Feature tolerances, Geometric tolerances and Dimensioning - Assembly limits - Datum features- Tolerance stacks.		

Module:2	Selection of Materials and Manufacturing process	6 hours
Selection of Materials and Manufacturing process, Design requirements, Materials choice for metal forming and machining processes		

Module:3	Design for Casting	5 hours
Design of castings based on parting line considerations, minimizing core requirements, Metal injection moulded parts: Process, suitable materials, Design recommendations for metal injection moulded parts.		

Module:4	Design for Metal Forming	5 hours
Design recommendation for metal extrusion, stamping, fine blanked parts, Rolled formed section. Design for Forging: Forging processes, Suitable materials for forging, Design recommendations.		

Module:5	Design for Machining	6 hours
Economics of machining, Features to facilitate machining – surface finish, review of relationship between attainable tolerance grades and different machining processes, Design guidelines for turning, drilling and milling.		

Module:6	**Design for Assembly**	**6 hours**
Design for Assembly principles and process, Design for Welding, Brazing and Soldering and Design for Joining of Plastics		
Module:7	**Redesign for Manufacture**	**8 hours**
Design for economy, Identification of uneconomical design – Modifying the design – Computer Applications for DFMA – Case Studies.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Geoffrey Boothroyd, Peter Dewhurst, Winston A. Knight, Product Design for Manufacture and Assembly, 2010, 3rd Edition, CRC Press, Taylor & Francis Group.

Reference Books

1.	A K Chitale, and R C Gupta, Product design and Manufacturing, 2011, 6th edition, Prentice Hall India Learning Private Limited.
2.	Karl T. Ulrich, Steven D. Eppinger, Maria C. Yang, Product Design and Development, 2020, 7th edition, Tata McGraw-Hill.
3.	Michael Ashby, Materials Selection in Mechanical Design, 2019, 5th edition, Elsevier Publications.
4.	O. Molloy, S. Tilley and E. A. Warman, Design for Manufacturing and Assembly: Concepts, Architectures and Implementation, 1998, Springer.
5.	Harry Peck, Designing for Manufacture, 1973, Pitman Publishing.
6.	Robert Matousek, Engineering Design – A systematic Approach, Translated by A.H. Burton and edited by D.C. Johnson, 1963, Springer.

Mode of Evaluation: CAT / Written assignment / Quiz / FAT

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCDM603L	Product Design and Life Cycle Management	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

The objectives of this course are to

1. Introduce the new product management process
2. Expose students to product life cycle management stages
3. Teach students the DFX concepts from the concept to recovery or disposal
4. Enable students to apply analytic methods during all stages of product planning, development, launch, and control.

Course Outcomes

Upon completion the course, student will be able to

1. Demonstrate the product design and development practices
2. Evaluate the product planning and product life cycle
3. Identify the customer needs in product development
4. Design and analyze the concept and Product Architecture
5. Apply DFX concepts from the conception to recovery or disposal
6. Apply innovation in stages of product planning, development, analysis and control

Module:1	Introduction to design- product design	5 hours

Product design practiced in industry. Product development – Characteristics of successful product development- duration and cost- challenges. Product development process and organizations - generic development- concept development-process flows- organizations.

Module:2	Product Planning	6 hours

Identifying opportunities- evaluation- resources- pre project planning. Case Studies on Business development and New product development. Time compression technologies- Collaborative product development – concurrent engineering – Product life cycle strategies. Design to cost – Design to Life cycle cost – Design for warranties. Case Studies on Product life cycle.

Module:3	Identifying Customer Needs	6 hours

Raw data collection-Interpret raw data-Organize the need- Relative importance. Product Specifications- Establishing target Specifications- Prepare list of metrices- competitive benchmarking- setting the final specifications.

Module:4	Concept Generations	6 hours

Clarify the problem- Search externally- search internally- Systematic exploration. Concept Selection- Concept Screening- Concept Scoring. Concept Testing- Purpose-Survey population-Survey format-Communicate-Response.

Module:5	Product Architecture	6 hours

Types of Modularity- Product change- product variety- component standardization- product performance- management. Industrial Design- Need- Impact- Industrial design process-

managing- Quality. Design for people – Ergonomics.		
Module:6	**Design for X**	**8 hours**
Manufacturing cost-Reduction in cost of components- reduction in cost of assembly-reduction in cost of supporting production- DFM decision on other factors. Design for Environment. Prototyping- Principles of prototyping- prototyping technologies- planning for prototypes. Case studies on design for manufacturing. Quality assurance – Failure Mode and Effect Analysis, Design for Quality, Design for Reliability, Approach to Robust Design, Design for Optimization, Design for test and inspection.		
Module:7	**Patents and Intellectual Property**	**6 hours**
Patent- trademark- trade secret- copyright- preparing a disclosure. Product development economics- Elements of economic analysis- economic analysis process. Managing projects- project planning-accelerating projects-project execution.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Karl T. Ulrich, Steven D. Eppinger (2015), Product Design and Development, McGraw-Hill.
Reference Books	
1.	Robert G. Cooper (2017), Winning at New Products: Creating Value Through Innovation, Hachette Book Group, New York.
2.	John Stark (2015), Product Lifecycle Management (Decision Engineering), Springer Publications.

Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCDM604L	Fracture Mechanics	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives :

The objective of this course is to:

1. Introduce the physical and mathematical principles of fracture mechanics and their applications in a wide range of engineering design.
2. Expand the knowledge on experimental methods to determine the fracture toughness and develop the students understanding on the design principle of materials and structures using fracture mechanics approaches

Course Outcome :

Student shall be able to

1. Identify the design parameters against fracture
2. Ascertain whether the design is safe against fracture
3. Identify the methods to prevent fracture
4. Compute the crack tip opening displacement
5. Demonstrate the experimental and numerical approaches to prevent fracture
6. Evaluate the fatigue life cycles and assess the life enhancement methods under fatigue load

Module:1	Introduction	6 hours

Review of a) Ductile and brittle fractures b) Conventional design practices, Need for fracture mechanics in design, Micromechanics of various types of fracture, Mode I, II and III cracks, Crack detection methods.

Module:2	Energy Release Rate and Resistance of Crack	6 hours

Stress concentration concepts, Griffith's theory and Irwin's modification, Energy release rate, Change in compliance and strain energy approaches, Crack resistance curves, Plane stress and plane strain cases, Crack stability and instability conditions.

Module:3	Linear Elastic Fracture Mechanics	7 hours

Linear Elastic Fracture Mechanics (LEFM), Conditions for validity of LEFM, Stress field around crack tip in Mode I, II and III cracks, Stress intensity parameter, Formulations under complex loads, Relation between stress intensity parameter and energy release rate, Crack tip plastic zone, Analysis of plastic zone size by conventional yield theories, Irwin's correction.

Module:4	Elastic Plastic Fracture Mechanics	6 hours

Relevant and scope, J-Integral, Path independence, Stress-Strain relation, Engineer Approach.

Module:5	Crack Tip Opening Displacement	6 hours

Introduction, Relationship between CTOD, KI, GI for small scale yielding, Equivalence between CTOD and J

Module:6	**Experimental and Numerical Approaches**	**6 hours**
Test methods to measure material fracture toughness and critical J integral value, Correlations between impact energy and fracture toughness. Finite element modelling of crack and evaluation of J integral and stress intensity parameter-Direct and indirect methods.		
Module:7	**Fatigue Failure**	**6 hours**
S-N curve, crack initiation, crack propagation, effect of overload, variable amplitude fatigue load		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	T.L. Anderson, Fracture mechanics: Fundamentals and Applications, 4th Edition. CRC Press, Taylors & Francis, 2017.
Reference Books	
1.	Broek David, Elementary Engineering Fracture Mechanics, Springer Science & Business Media, 2012.
2.	Campbell Flake C, Fatigue and Fracture: Understanding the Basic, ASM International, Materials Park, Ohio, 2012.
3.	Steven R. Lampman,ASM Handbook, Vol. 19, Fatigue and Fracture, etc., ASM International, 2002.
4.	Chin-Teh Sun, Z.H. Jin, Fracture Mechanics, Academic Press, Elsevier, 1st Edition, 2012.
5.	K. Ramesh,E-Book: Engineering Fracture Mechanics (With Trouble shooting and searching, multimedia facilities) by, IIT, Chennai.

Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCDM605L	**Manufacturing and Mechanics of Composites Materials**	**3**	**0**	**0**	**3**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives :

The objective of this course is to:

1. Present an introduction to composite materials.
2. Make students to understand the properties of fiber and matrix materials used in commercial composites.
3. Provide a basic understanding of linear elasticity with emphasis on the difference between isotropic and anisotropic material behavior.
4. Enable students to analyze a laminated plate in bending, including evaluation of laminate properties from lamina properties and find residual stresses from curing and moisture.
5. Make student to predict the failure strength of a laminated composite plate.
6. Help students to acquire skills required in processing different composite materials.

Course Outcome :

Upon completion of the course, the students will

1. Apply advanced techniques of composite materials and manufacturing processes.
2. Analyses the reinforced composite design and design for different combinations and orientations of reinforcements.
3. Use the micro, meso and macro mechanics and implement of Classical Laminate Theory (CLT) to study and analyze the laminated composites.
4. Demonstrate the Hygro-Thermo-Mechanical behavior of composite materials, failure analysis and conduct application oriented case studies.
5. Analyse a laminated plate in bending, including evaluation of laminate properties from lamina properties and find residual stresses from curing and moisture.
6. Provide a knowledge base of issues related to fracture of composites and environmental degradation of composites

Module:1	**Manufacturing of Composites**	**6 hours**

Raw Materials: Introduction, Reinforcements manufacturing, Matrix materials manufacturing, Fabric constructions, 3D Braided performs,Pepregs, Moulding compounds-Materials selections, guidelines.

Module:2	**Manufacturing composite laminates**	**7 hours**

Manufacture of PMC's, VARTEM and SCRIMP, Manufacture of MMC's C/C and CMC's - processing- Forming structural shapes- Different casting methods, Sol-gel method, Non-autoclave curing- Manufacturing defects.

Module:3	**Micro and Macro mechanical analysis of composite materials**	**6 hours**

Introduction to composite materials- Classification-Micromechanical Analysis of a Lamina-Volume and Mass Fractions, Density, and Void Content- Prediction of engineering properties using micromechanics-Material properties of the fiber and matrix.

Macro mechanical analysis of a lamina -linear elastic stress-strain characteristics of Fiber-Reinforced material: Stress and deformations in Fiber-Reinforced materials-Maxwell-Betti reciprocal theorem- Stress-strain relations- Effects of free thermal strains and moisture strains.

Module:4	**Stress and Strain**	**6 hours**

Stress-strain relations for plane stress- Effects of free thermal and free moisture strains- Plane stress & strain relations in a global coordinate system- Transformation relations- Transformed reduced compliances & stiffness- Effects of free thermal and free moisture strains		
Module:5	**Classical Lamination Theory**	**6 hours**
Kirchhoff Hypothesis- Laminate Nomenclature-Laminate strains and displacements - Implications of the Kirchhoff Hypothesis- Laminate stresses & strains -Stress distributions through the thickness- Force and moment resultants-Laminate stiffness matrix: ABD Matrix-Classification of laminates and their effect on the ABD Matrix-Elastic couplings.		
Module:6	**Theories of Failures of Laminates**	**6 hours**
Symmetric laminates- Cross-ply laminates- Angle ply laminates- Antisymmetric laminates-Balanced laminate- Quasi-isotropic laminates. Failure theories for fiber-reinforced materials: Maximum stress criterion- Tsai-Wu criterion- Environmental effects- Effect of laminate classification on the unit thermal force and moment resultants.		
Module:7	**Design and Analysis**	**6 hours**
Through-thickness laminate strains- Thickness change of a laminate- Thickness change of a laminate due to free thermal strain effects-Through-thickness laminate coefficient of thermal expansion.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Michael W. Hyer and Scott R White, Stress Analysis of Fiber-Reinforced Composite Materials, DEStech Publications, Inc, 2009.
Reference Books	
1.	Autar K. Kaw,Mechanics of Composite Materials , Taylor & Francis, 2006.
2.	Robert Millard Jones,Mechanics of composite materials, Taylor & Francis, 1999.
3.	Jack R. Vinson, R. L. Sierakowski,The behavior of structures composed of composite materials by, Kluwer Academic Publishers, 2002.

Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCDM606L	Optimization Methods	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives :

The objective of this course is to

1. Expose students to the role of optimization in engineering design and its importance.
2. Introduce the different optimization algorithms in linear as well as non-linear programming problems
3. Introduce the non-traditional optimization algorithms in solving non-linear optimization problems.

Course Outcome :

Upon completion of the course work, the students will be able to:

1. Apply advanced concepts of mathematics to formulate design optimization problems as well as apply necessary and sufficient conditions based on differential calculus, in finding maxima/minima of single and multi-variables functions.
2. Demonstrate the concept of unimodal function and apply region elimination methods for one dimensional non-linear optimization problems covering various applications.
3. Analyse the potential advantage of search methods and gradient based methods and apply for unconstrained non-linear optimization problems covering wide range of applications.
4. Enumerate the differences between direct and indirect optimization methodsand apply for solving constrained non-linear optimization problems covering wide range of applications.
5. Understand and apply quadratic programming approach to solve quadratic functions with equality constraints covering wide range of applications.
6. Interpret the nature of posynomial function and apply geometric programming approach in solving engineering design problems.
7. Implement basic optimization algorithms in a computational setting and apply existing optimization software packages to solve engineering problems.
8. Demonstrate the scope of optimization in design of machine elements and apply appropriate optimization techniques for robust design.

Module:1	Classical Optimization Techniques	6 hours

Introduction, methods, engineering applications of optimization-Statement of an optimization problem-classification of optimization problems-Single variable optimization-Multivariable optimization with no constraints-Multi variable optimization with equality and in equality constraints: Lagrange multipliers method, Kuhn-Tucker conditions.

Module:2	One-Dimensional Nonlinear Optimization	6 hours

Unimodal function – Region elimination methods: Unrestricted search, Dichotomous Search, Fibonacci method, Golden Section method.

Module:3	Unconstrained Nonlinear Optimization	6 hours

Direct Search methods: Univariate method, Pattern directions, Hook and Jeeves' method, Powell's method-Indirect search methods: Gradient of a function, Cauchy method, Fletcher-Reeves method.

Module:4	**Constrained Non-linear Optimization**	**6 hours**
Characteristics of a constrained optimization problem - Direct methods: Cutting plane method, methods of feasible directions – Indirect methods: Interior and exterior penalty function methods.		
Module:5	**Quadratic programming**	**5 hours**
Introduction-applications-necessary conditions-solution to quadratic programming problem using Wolfe’s method.		
Module:6	**Geometric programming**	**5 hours**
Introduction to Geometric programming – Solution from differential calculus point of view – Solution from arithmetic-geometric inequality point of view.		
Module:7	**Advanced Non-linear Optimization**	**5 hours**
Genetic Algorithms -Working principle-Genetic operators-Numerical problem-Simulated Annealing – Numerical problem - Neural network based optimization-Optimization of fuzzy systems-fuzzy set theory-computational procedure.		
Module:8	**Design Optimization of Machine Elements**	**4 hours**
Functional requirements- desirable and undesirable effects –material and geometrical parameters – adequate designs, Optimum design – primary design equation, subsidiary design equations, limit equations – basic procedural steps for methods of optimum design – constrained parameters and free variables – normal, redundant and incompatible specifications general planning.		
Module:9	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Singiresu S. Rao, Engineering Optimization - Theory and Practice, John Wiley & Sons, Inc., 2019
2.	Kalyanmoy Deb, Optimization for Engineering Design: Algorithms and Examples, PHI Learning Pvt. Ltd., 2012.

Reference Books

1.	Wilhelm Forst, Dieter Hoffmann, Optimization - Theory and Practice, Springer, 2010.
2.	A. Ravindran, G. V. Reklaitis, K. M. Ragsdell, Engineering Optimization: Methods and Applications, John Wiley & Sons, 2006.

Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCDM607L	**Computational and Experimental Vibration Analysis and Control**	**3**	**0**	**0**	**3**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives:

1. Acquire comprehensive knowledge in the fundamental mathematical and physical basis of finite element methods.
2. Build FEM models of physical problems exposed to vibration and apply appropriate constraints and boundary conditions.
3. Develop and exercise critical thinking in interpreting results from FEM analysis such as the ability to identify the mode shapes, stress contours, eigen frequency as well as response characteristics.
4. Enable students to connect the disciplines of vibration and control on a firm mathematical basis, and study vibration control problems using numerical software.

Course Outcome:

1. Demonstrate the development of equations of motion and boundary conditions
2. Apply Finite element displacement method for vibration problems
3. Compute the In-plane and flexural vibration of plates
4. Compute the Vibration of Stiffened and Folded Plates
5. Analyze the free and forced vibration concepts
6. Evaluate the control system and State space form representation

Module:1	**Development of finite element energy functions**	**6 hours**
Axial and torque elements, beam and plate bending elements, membrane element-three dimensional solids-axisymmetric solid- Development of equations of motion and boundary conditions		
Module:2	**Finite element displacement method**	**6 hours**
Rayleigh-Ritz method-Axial vibration of bars- Torsional vibration of shafts- Bending vibration of beams- Vibration of trusses and frames -Inclusion of shear deformation and rotary inertia effects.		
Module:3	**In-plane and flexural vibration of plates**	**6 hours**
In-plane vibration of plates: Linear triangular element-Linear rectangular element- Linear quadrilateral element- Area coordinates for triangles- Linear triangle in area coordinates. Rectangular and triangular elements- conforming and non-conforming elements.		
Module:4	**Vibration of Stiffened and Folded Plates**	**6 hours**
Stiffened Plates- Effect of membrane displacements-Folded Plates		
Module:5	**Analysis of free and forced vibration**	**6 hours**
Modal analysis- representation of damping: structural and viscous damping- steady state response to harmonic and periodic excitation- transient response- response to random excitation: response of single degree-freedom, direct and modal response of multi-degree of freedom system-simulation using FEA software’s		

Module:6	**Control of flexible structures**	**6 hours**
Control systems- stability theory-stability of multi-degrees of freedom systems-analysis of second order system- transfer function analysis.		
Module:7	**State space form representation**	**7 hours**
Control law design for state space system-linear quadratic regulator-modal control for second order systems-dynamic observer control calculations using coding tools Experimental methods: Vibration exciters and measuring instruments- Free and forced vibration tests- Measurement of Damping- Industrial case studies and Contemporary Discussion		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Maurice Petyt, “Introduction to finite element vibration analysis”, Cambridge University Press, 2nd Edition, 2015.
2	K. Ogata, “Modern control engineering”, 5th Edition Pearson Education India, 2015.

Reference Books

1.	S. S. Rao, “The finite element method in engineering”, 6th Edition, ELSEVIER INDIA, 2019.
2.	J.N. Reddy, “An introduction to finite element method”, McGraw Hill Professional, 2018
3.	S. Graham Kelly, “Theory and problems of mechanical vibrations”, McGraw Hill, 1996.
4.	Richard C. Dorf and Robert H. Bishop, “Modern control system”, 14th Edition, Pearson Education Inc, 2022.
5.	C. Sujatha, “Vibration and Acoustics: Measurement and Signal Analysis”, McGraw Hill, 2017.

Mode of Evaluation: CAT, Written assignment , Quiz , FAT, Seminar, group discussion, field work

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCDM607P	**Computational and Experimental Vibration Analysis and Control Lab**	**0**	**0**	**2**	**1**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives

1. Develop and exercise critical thinking in interpreting results from FEM analysis such as the ability to identify the mode shapes, stress contours, eigen frequency as well as response characteristics.
2. Enable students to connect the disciplines of vibration and control on a firm mathematical basis, and study vibration control problems using numerical software.

Course Outcome

1. Apply Finite element displacement method for vibration problems
2. Analyze the free and forced vibration concepts

Indicative Experiments

1.	Computation of natural frequencies and numerical simulation of time and frequency responses of uniform rod using a programming tool and compare with experimental tests.
2.	Computation of natural frequencies and numerical simulation of time and frequency responses of uniform beam using a programming tool and compare with experimental tests.
3.	Computation of natural frequencies and numerical simulation of time and frequency responses of various uniform rectangular plate using a programming tool and compare with experimental tests
4.	Computation of natural frequencies and numerical simulation of time and frequency responses of various uniform triangular plates using a programming tool and compare with experimental tests
5.	Computation of natural frequencies and numerical simulation of time and frequency responses of uniform circular plate using a programming tool and compare with experimental tests
6.	Computation of natural frequencies and numerical simulation of time and frequency responses of tapered rod using a programming tool and compare with experimental tests
7.	Computation of natural frequencies and numerical simulation of time and frequency responses of tapered beam using a programming tool and compare with experimental tests
8.	Computation of natural frequencies and numerical simulation of time and frequency responses of tapered plate using a programming tool and compare with experimental tests
9.	Development of dynamic model, the governing equation of motion and adaptive vibration control of the cantilever beams using piezoelectric actuator (PZT). Compare the responses using various control systems
	Total Laboratory Hours **30 hours**

Text Book(s)

1.	Maurice Petyt, “Introduction to finite element vibration analysis”, Cambridge University Press, 2nd Edition, 2015

Reference Books

1.	C. Sujatha, “Vibration and Acoustics: Measurement and Signal Analysis”, McGraw Hill, 2010.
2.	Richard C. Dorf and Robert H. Bishop, “Modern control system”, 13th Edition, Pearson Education, 2016.

Mode of assessment: Continuous assessment, FAT, Oral examination and others

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCDM608L	**Computational Fluid Dynamics**	**3**	**0**	**0**	**3**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives :

The objective of this course is to

1. Provide the students with sufficient background to understand the mathematical representation of the governing equations of fluid flow and heat transfer.
2. Enable the students to understand the fundamental concepts of FDM, FVM and different discretization techniques.
3. Enable students to apply the grid generation techniques.
4. Expose students to the computational complicities on various turbulence models.

Course Outcome :

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

1. Analyze the governing equations of fluid flow and heat transfer
2. Explain the physical behavior of Finite difference discretization
3. Solve fluid flow fields using FVM for diffusion problems
4. Solve fluid flow fields using FVM for diffusion-convection and unsteady flow cases
5. Interpret the Solution Algorithm for Pressure-velocity Coupling in Steady Flows
6. Analyze the model turbulence fluid flow modeling for different fluid flow cases

Module:1	**Governing Equations of Fluid flow and Heat Transfer**	**6 hours**

Modeling of flow, control volume concept, substantial derivative, physical meaning of the divergence of velocity. Continuity equation, momentum equation, energy equation and its conservation form. Equations for viscous flow (Navier Stokes equations), Equations for inviscid flow (Euler equation). Reynolds Transport Theorem, Exact Solution of Simplified Navier Stokes Equation – Parallel Flow, Blassius Solution for determining boundary layer over a flat plate

Module:2	**Classification of Physical behavior and FDM**	**6 hours**

Elliptical, parabolic and hyperbolic equations.
Finite difference discretization (FDM), Forward, backward and central difference, Order of accuracy, different types of errors and boundary conditions.

Module:3	**Finite Volume Method(FVM) for Diffusion Problems**	**6 hours**

FVM for 1D and 2D steady state diffusion, Solution of discretized equations- TDMA scheme for 2D flow.

Module:4	**FVM for Convection-Diffusion Problems**	**6 hours**

FVM for 1D steady state convection-diffusion, Central differencing scheme, Conservativeness, Boundedness, Transportiveness, Upward differencing scheme, Hybrid differencing scheme for 2D convection-diffusion, Power-law scheme, QUICK scheme.

Module:5	**FVM for Unsteady Flows**	**6 hours**

1D unsteady heat conduction (Explicit, Crank-Nicolson, fully implicit schemes), Implicit methods for 2D problems, Discretization of transient convection diffusion problems.		
Module:6	**Solution Algorithm for Pressure-velocity Coupling in Steady Flows**	**6 hours**
Concept of staggered grid, SIMPLE, SIMPLER, SIMPLEC, PISO algorithm.		
Module:7	**Turbulence Modeling**	**7 hours**
Basic equations of Turbulence: Derivation of turbulence using non-dimensional analysis, Reynolds averaging, Reynolds averaged N-S equations, Eddy viscosity hypothesis, Reynolds Stress Transport Equations. First order closures: k-ε two equation models, SST k-ω model. Large Eddy Simulations.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	H.K Versteeg and W Malalasekera (2010), An Introduction to Computational Fluid Dynamics, Prentice Hall,

Reference Books

1.	S.V. Patankar Hemisphere (2004), Numerical Fluid Flow & Heat transfer, CRC press.
2.	D.A.Anderson, J.C.Tannehill and R.H.Fletcher (2007), Computational Fluid Flow and Heat Transfer, Butterworth-Heincmann, New York.
3.	Muralidhar, K., and Sundararajan, T. (2014), “Computational Fluid Flow and Heat Transfer”, Narosa Publishing House, New Delhi.

Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCDM608P	**Computational Fluid Dynamics Lab**	**0**	**0**	**2**	**1**
Pre-requisite	**NIL**	**Syllabus Version**			
		1.0			

Course Objectives

1. To impart skills required for the grid generation techniques
2. To teach different methods of simulation setup for fluid flow problems
3. To enable the students to apply CFD techniques for the design and analysis of aerospace, automotive and turbo machinery systems

Course Outcome

Upon successful completion of the course, students will be able to

1. Perform geometry modeling and grid generation for complex fluid flow domains
2. Perform computational analysis on internal and external flows
3. Analyze the interaction between fluid and structure
4. Setup computational framework for the analysis of reacting flows

Indicative Experiments

1.	Analysis of supersonic flow over a ramp
2.	Analysis of multiphase flow in a pipe
3.	Analysis of heat transfer in a space heater
4.	Analysis of combustion in a swirl stabilized combustor
5.	Analysis of cooling of electronic components
6.	Analysis of flow in an Engine manifold
7.	Analysis of flow in a gear/vane pump

Total Laboratory Hours | **30 hours**

Text Book(s)

1.	Tu, Jiyuan, Guan Heng Yeoh, and Chaoqun Liu. Computational fluid dynamics: a practical approach. Butterworth-Heinemann, 2018.

Reference Books

1.	Blazek, Jiri. Computational fluid dynamics: principles and applications. Butterworth-Heinemann, 2015.
2.	John Matsson, An Introduction to ANSYS Fluent 2020, SDC Publications, 2020

Mode of assessment: Continuous assessment / FAT / Oral examination and others

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCDM609L	Design Thinking and Innovation	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. Exposing student to various creative thinking tools and methods to apply for engineering scenarios
2. Imparting methods to adopt innovation in present and future product/process developments

Course Outcome

1. Evaluate the design thinking and Problem awareness
2. Discuss about the empathic search of problem and observation
3. Define problem concept mapping for given engineering scenarios
4. Identify Ideate and concept generation
5. Demonstrate the testing and validation
6. Explain the embodiment and detail design

Module:1	What is design thinking? - Understanding and awareness	6 hours

History of design thinking – evolution – why design thinking – exponents – practitioners – areas of application - case studies –human centric nature - References – literature – Steps in design thinking – conventional 5 stage IDEO process – extended 8 stage process for engineering product development - Understanding context- Goals .

Problem awareness - what is a problem from Design thinking POV –solution mission – Problem space vs solution space – problem sensitivity- need finding - need to demand progress – wicked problems-problem scoping

Module:2	Observe and learn	6 hours

Empathy- empathic search of problem and observation – ethnography- observation methods – interviewing- questionnaire- analysis of observation results – quantitative-qualitative – visual presentation – emotional understanding – customer journey mapping – experience mapping –empathy map-lead user interaction – customer pains- need classification – explicit, extractable and latent need -user development- behaviour and latent needs – psychology of needs -story boarding results –customer “wants to do identification” - Field trip, group thinking and activity

Module:3	Develop Point of view and problem definition	4 hours

Develop and define problem – Point of view – framing and reframing problem- develop multiple perspective - define stakeholders – define problem and solution boundaries-constraint mapping -assumption bursting- define goal- Integration of desirability , viability and feasibility- develop personas

Concept mapping-knowledge funnel-innovation canvas-discovery funnel- Job to do model – Kano model – reframing – problem solution fix- story boarding

Module:4	Ideate and concept generation	9 hours

Brain storming , nominal group technique, lateral thinking, synectics, Innovation- creativity model(Dr.Teenaseelig), mind map, TRIZ, flow state , morphological analysis, SCAMPER ,design thinking team – Creativity culture – design thinking space – enhancing curiosity, questioning mind-set, mental block , story boarding, idea visualisation, T personality, team structure – team behaviour

Concept generation – concept selection- combining solution

Module:5	**Prototype and learn by doing**	**6 hours**
Build to learn – learn to build – low fidelity prototype – frugal p proto- rapid proto- fail forward – fail fast – learn from failures – iteration to go forward – Case studies - IDEO shopping cart – product specification – benchmark		
Module:6	**Test and Validate**	**6 hours**
Customer centric testing- lead users -user experience mapping – feedback- iteration- retesting – learnings – iteration		
Module:7	**Embodiment and detail design**	**6 hours**
Product design spec – architecture – system modelling and simulation – digital model based design - design for function -form to follow function- mechanical and software design- design for UX – design for quality and reliability - design for cost – design for manufacture and assembly- design for environment – design for six sigma- QFD- FMEA - design to standard – IPR and patents		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Idris Mootee, Design thinking for Strategic Innovation, John Wiley and sons, 2013
Reference Books	
1.	Tim Brown, Change by Design, HarperCollins Publishers, New York, 2019
2.	Jeanne Liedtka and Tim Ogilvie, Design for growth, Columbia Business school, 2011
3.	Karl T. Ulrich, Steven D. Eppinger and Maria C. Yang, Product Design and Development, 7th Edition, McGraw Hill, 2020
4.	Jeanne Liedtka, Andrew King and Kevin Bennett, Solving problems with design thinking, Columbia Business School, 2013.
5.	Tom Kelley and David Kelley, Creative confidence, Currency Publisher, 2013

Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCDM610L	**Machine Fault Diagnostics**	3	0	0	3
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives :

The main objectives of the course are to:

1. Understand advanced concepts of various condition monitoring methods
2. Enable them to identify the selection of NDT techniques for various applications.
3. Provide a basic understanding with case studies on different fault diagnosis method.
4. Apply specific Code, Standard, or Specification related to each testing method

Course Outcome :

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

1. Apply advanced knowledge about various condition monitoring methods in accordance with the established procedures.
2. Analyze the importance of NDT and vibration based techniques for fault detection
3. Distinguish how the various types of wear particles are associated with different wear modes and monitoring methods
4. Demonstrate different temperature monitoring methods and applications
5. Differentiate various defect types and select the appropriate NDT methods for better evaluation.
6. Discuss and evaluate the acoustic emission method in fault detection and evaluation.

Module:1	**Introduction to condition monitoring**	**7 hours**

Maintenance strategies, criticality index, various techniques for fault detection, Introduction to condition monitoring, Introduction to non-destructive testing, role of non-destructive testing in condition monitoring.

Module:2	**Vibration analysis of rotating machines**	**7 hours**

Basics of Machine Vibration, Identification of machine faults and frequency range of symptoms, Signal Analysis, and Computer aided data acquisition, Time Domain Signal Analysis, Frequency Domain Signal Analysis, Fault Detection Transducers and instrumentation , Vibration Monitoring, Noise monitoring.

Module:3	**Wear monitoring**	**6 hours**

Wear mechanisms, wear particles, wear process monitoring techniques, spectrometric oil analysis program, Ferrography.

Module:4	**Temperature monitoring**	**6 hours**

Need of temperature monitoring, IR thermography, Passive and active thermography, applications

Module:5	**Flaw detection using traditional non-destructive testing**	**6 hours**

Discontinuity-origin and classification, liquid penetrant testing, magnetic particle testing, Eddy current testing, Ultrasonic testing and industrial radiography.

Module:6	**Acoustic emission testing**	**6 hours**

Theory of AE sources and Waves, Equipment, Signal Features, Data display, source location, Applications

Module:7	**Case studies**	**5 hours**

Fault detection – Gearbox vibration, rolling element bearings and induction motors.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**
Text Book(s)		
1.	Handbook of Condition Monitoring: Techniques and Methodology- A. Davies, Springer Science & Business Media (2015).	
2.	Fakherchaari, RadoslawZimroz Walter Bartelmus, Advances in Condition Monitoring of Machinery in Non-Stationary Operations, 1st Edition, Springer (2015).	
Reference Books		
1.	Vibration and Acoustics- C. Sujatha, Measurement and Signal Analysis. McGraw Hill Education (India) Private Limited (2010).	
2.	Fault diagnosis applications- Isermann.R. Springer – Verlag, Berlin, (2011)	
3.	Practical Non-Destructive Testing- Baldevraj, Jayakumar T., Thavasimuthu M., Narosa Publishers (2008).	
4.	Luiz Octavio AmaralAffonso, Machinery Failure Analysis Hand Book, Gulf Publishing Company,Austin, United States (2013).	
Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT		

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCDM611L	Computer Aided Process Planning	3	0	0	3
Pre-requisite	NIL	Syllabus Version			
		1.0			

Course Objectives

The main objective of the course is to:

1. Provide the student with an understanding of the importance of process planning role in manufacturing and the application of Computer Aided Process Planning tool in the present manufacturing scenario.

Course Outcome

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

1. Discuss the information requirement for process planning system
2. Explain the Group technology
3. Identify the requirements of Process engineering and Process planning
4. Evaluate the optimal selection of machining parameters
5. Identify the importance of machinery tolerances and requirements
6. Analyze the Implementation techniques for CAPP and Integrated Process Planning Systems

Module	Title	Hours
Module:1	**Introduction to CAPP**	**6 hours**
Information requirement for process planning system, Role of process planning, advantages of conventional process planning over CAPP, Structure of Automated process planning system, feature recognition methods.		
Module:2	**Group Technology**	**6 hours**
Part families; classification and coding systems, production analysis. Design of machine cells, - GT coding - The optiz system - The MICLASS system.		
Module:3	**Process engineering and Process planning**	**7 hours**
Experienced based planning - Decision table and decision trees - Process capability analysis - Process Planning -Variant process planning - Generative approach - Forward and Backward planning, Input format. Principle of Generative CAPP system, automation of logical decisions, Knowledge based systems, Inference Engine, implementation, benefits.		
Module:4	**Determination of machining parameters**	**7 hours**
Reasons for optimal selection of machining parameters, effect of parameters on production rate, cost and surface quality, different approaches, advantages of mathematical approach over conventional approach, solving optimization models of machining processes.		
Module:5	**Determination of manufacturing tolerances**	**6 hours**
Design tolerances, manufacturing tolerances, methods of tolerance allocation, sequential approach, integration of design and manufacturing tolerances, advantages of integrated approach over sequential approach.		
Module:6	**Implementation techniques for CAPP**	**6 hours**
MIPLAN system, Computer programming languages for CAPP, criteria for selecting a CAPP system and benefits of CAPP. Logical Design of process planning – Implementation considerations- Manufacturing system components, Production Volume, No. of production families- CAM-I, CAPP, MIPLAN, APPAS, AUTOPLAN and PRO, CPPP.		
Module:7	**An Integrated Process Planning Systems**	**5 hours**
Totally integrated process planning systems – An Overview – Modulus structure – Data structure – Operation – Report Generation, Expert process planning. Artificial intelligence-overview & application; search strategies for AI production systems; resolution and reduction systems; knowledge acquisition; machine selection; cutting tool selection.		
Module:8	**Contemporary Issues**	**2 hours**

	Total Lecture hours:		**45 hours**	
Text Book(s)				
1.	Mikell. P. Groover, Automation, Production systems and Computer Integrated Manufacturing System, Addison Wesley, 5th edition (2020).			
Reference Books				
1.	Computer Aided Design and Manufacturing, Sadhu Singh, Khanna Publishers, 2009			
2.	P.N.Rao,N.K.Tewari,T.K. Kundra, “ Computer Aided Manufacturing”, Tata McGraw-Hill Education Publishing Co., 2017.			
3.	Tien-Chien-Chang, Richard A.Wysk, “An Introduction to automated process planning systems”, Prentice Hall 1985.			
4.	Gideon Halevi and Roland D.Weill, “Principle of process planning”, A logical approach, Springer, 2012.			
Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT				
Recommended by Board of Studies		27-07-2022		
Approved by Academic Council		No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCDM612L	Advanced Manufacturing Technology	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

The course objectives are to:

1. Provide a thorough coverage of traditional and non-traditional machining processes.
2. Develop and understanding of various fundamental mechanisms of machining processes.
3. Provide an insight in high-speed machining, micro-machining and nano-fabrication techniques.
4. Introduce the semi-conductor, IC chips and micro actuator fabrication techniques.
5. Train the student in NC part programming, metal cutting concepts, generation of manufacturing drawings and process planning.

Course Outcome

Student shall be able to:

1. Discuss the advanced machining mechanisms and procedures
2. Analyze the high-speed machining characteristics and applications
3. Evaluate AWM, AWJM and USM processes.
4. Select EDM, ECM, LBM and EBM process.
5. Demonstrate Special machining processes such as deep hole boring and gun boring
6. Design the Advanced abrasive finishing and foundry processes

Module	Title	Hours
Module:1	**Advanced Machining Theory**	**6 hours**

Mechanisms of chip formation, shear angle relations, and theoretical determination of cutting forces in orthogonal cutting, thermal aspects of machining and tool wear.

Module	Title	Hours
Module:2	**High speed machining**	**6 hours**

High speed machining (HSM) – Characteristics of HSM - Machine tools requirements for HSM – Cutting tools for HSM - Design of tools for HSM – Tool clamping systems - Applications of HSM.

Module	Title	Hours
Module:3	**Advanced machining processes - I**	**6 hours**

Water jet machining - Abrasive water jet machining - Ultrasonic machining – working principle, machining system, process variables, parametric analysis, process capabilities and applications.

Module	Title	Hours
Module:4	**Advanced machining processes - II**	**7 hours**

Electro chemical Machining - Electric discharge machining - Laser beam machining – Electron beam machining - working principle, machining system, process variables, parametric analysis, process capabilities and applications.

Module	Title	Hours
Module:5	**Special Machining Process**	**6 hours**

Deep hole drilling – Gun drills – Gun boring – Trepanning- shaped tube electrolytic drilling – electro jet drilling, Hard turning and hard milling, thermal enhanced machining of hard to cut materials.

Module	Title	Hours
Module:6	**Advanced abrasive finishing processes**	**6 hours**

Honing – Lapping – Super finishing – High performance grinding - Abrasive flow machining – Magnetic abrasive finishing – Magnetic float polishing.

Module	Title	Hours
Module:7	**Advanced foundry processes**	**6 hours**

Metal mould, continuous, squeeze, vacuum mould, evaporative pattern, and ceramic shell casting

Module	Title	Hours
Module:8	**Contemporary Issues**	**2 hours**

	Total Lecture hours:		**45 hours**
Text Book(s)			
1.	Mikell P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, 7th Edition, 2019.		
Reference Books			
1.	Serope Kalpakjian and Steven R.Schmid, Manufacturing Engineering and Technology, Person, 2020.		
2.	J. Paulo Davim, Machining: Fundamentals and Recent Advances, Springer, 2008.		
3.	H. El-Hofy, Advanced Machining Processes: Nontraditional and Hybrid Machining Processes, McGraw-Hill, New York, 2005.		
4.	Bert P.Erdel, "High Speed Machining", Society of Manufacturing Engineers, 2003.		
Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCDM613L	**Statistics and Quality Management**	**3**	**0**	**0**	**3**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objective:
The goal of the course is to introduce students to statistical quality control (SQC) emphasizing those aspects which are relevant for SQC's practical implementation.
Course Outcomes :
At the end of the course, the student will be able to: 1. Validate the theoretical and practical aspects of SQC. 2. Apply the link between SQC and business analysis / business planning. 3. Demonstrate the Total Quality Management 4. Outline the Quality Management System Principles & Methodologies 5. Apply Quality System tools in Measurement System 6. Employ the World Class Quality and Problem Solving Tools

Module:1	**Introduction to Quality**	**5 hours**
Definition of Quality, Quality Concepts: Quality Dimensions – Quality definitions - Quality control – Quality Assurance – Quality planning - Quality costs – Economics of quality – Quality loss function.		
Module:2	**Statistical Process Control**	**6 hours**
Process variability – Control charts for variables, Pre control charts,Warning control limits – process capability, machine capability and gauge capability studies – Statistical tolerance, Other Control Charts: Control charts for attributes, control charts for individual measurement, moving range chart,.		
Module:3	**Introduction to Quality Management**	**6 hours**
Total Quality Management: Quality philosophies of Deming, Crosby, Miller - TQM concepts, Customer satisfaction model – Customer retention model, Quality system, seven tools of quality, 5S, QFD, KAIZEN, POKAYOKE,		
Module:4	**Quality Management System**	**6 hours**
ISO 9001, TS 16949 Principles & Methodologies, system requirements.		
Module:5	**Quality System tools**	**6 hours**
Advanced Product Quality Planning, Measurement System analysis, Process Failure Mode and Effect analysis.		
Module:6	**World Class Quality**	**6 hours**
Baldridge award, Shingo Award, Manufacturing Excellence- Benchmarking, Six sigma concepts – DMAIC/ DMADV approach, Taguchi Loss function.		
Module:7	**Problem Solving Tools**	**8 hours**
Seven QC tools and Seven Management tools, TRIZ etc.		
Module:8	**Contemporary Issues**	**2 hours**

		Total Lecture hours:	**45 hours**
Text Book(s)			
1.	Montgomery, D.C. (2013). Introduction to Statistical Quality Control, 7th Edition, John Wiley & Sons.		
Reference Books			
1.	Introduction to Statistical Process Control, Peihua Qui, CRC Press, 2014.		
2.	Krishnaiah.K, (2014) Applied Statistical Quality Control and Improvement, Prentice Hall of India.		
Mode of Evaluation: CAT ,Written Assignment, Quiz and FAT			

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCDM696J	**Study Oriented Project**				**02**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives:

1. The student will be able to analyse and interpret published literature for information pertaining to niche areas.
2. Scrutinize technical literature and arrive at conclusions.
3. Use insight and creativity for a better understanding of the domain of interest.

Course Outcome:

1. Retrieve, analyse, and interpret published literature/books providing information related to niche areas/focused domains.
2. Examine technical literature, resolve ambiguity, and develop conclusions.
3. Synthesize knowledge and use insight and creativity to better understand the domain of interest.
4. Publish the findings in the peer reviewed journals / National / International Conferences.

Module Content **(Project duration: One semester)**

This is oriented towards reading published literature or books related to niche areas or focussed domains under the guidance of a faculty.

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Report to be submitted, presentation and project reviews – Presentation in the National / International Conference on Science, Engineering Technology.

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCDM697J	**Design Project**				**02**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives:

1. Students will be able to design a prototype or process or experiments.
2. Describe and demonstrate the techniques and skills necessary for the project.
3. Acquire knowledge and better understanding of design systems.

Course Outcome:

1. Develop new skills and demonstrate the ability to upgrade a prototype to a design prototype or working model or process or experiments.
2. Utilize the techniques, skills, and modern tools necessary for the project.
3. Synthesize knowledge and use insight and creativity to better understand and improve design systems.
4. Publish the findings in the peer reviewed journals / National / International Conferences.

Module Content **(Project duration: One semester)**

Students are expected to develop new skills and demonstrate the ability to develop prototypes to design prototype or working models related to an engineering product or a process.

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Report to be submitted, presentation and project reviews – Presentation in the National / International Conference on Science, Engineering Technology.

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCDM698J	**Internship I/ Dissertation I**				**10**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives:

To provide sufficient hands-on learning experience related to the design, development and analysis of suitable product / process so as to enhance the technical skill sets in the chosen field and also to give research orientation.

Course Outcome:

1. Considerably more in-depth knowledge of the major subject/field of study, including deeper insight into current research and development work.
2. The capability to use a holistic view to critically, independently and creatively identify, formulate and deal with complex issues.
3. A consciousness of the ethical aspects of research and development work.
4. Publications in the peer reviewed journals / International Conferences will be an added advantage.

Module Content **(Project duration: one semester)**

1. Dissertation may be a theoretical analysis, modeling & simulation, experimentation & analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, applied research and any other related activities.
2. Dissertation should be individual work.
3. Carried out inside or outside the university, in any relevant industry or research institution.
4. Publications in the peer reviewed journals / International Conferences will be an added advantage.

Mode of Evaluation: Assessment on the project - Dissertation report to be submitted, presentation, project reviews and Final Oral Viva Examination.

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	**Course Title**	**L**	**T**	**P**	**C**
MCDM699J	**Internship II/ Dissertation II**				**12**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives:

To provide sufficient hands-on learning experience related to the design, development and analysis of suitable product / process so as to enhance the technical skill sets in the chosen field.

Course Outcome:

Upon successful completion of this course students will be able to

1. Formulate specific problem statements for ill-defined real life problems with reasonable assumptions and constraints.
2. Perform literature search and / or patent search in the area of interest.
3. Conduct experiments / Design and Analysis / solution iterations and document the results.
4. Perform error analysis / benchmarking / costing.
5. Synthesize the results and arrive at scientific conclusions / products / solution.
6. Document the results in the form of technical report / presentation.

Module Content **(Project duration: one semester)**

1. Dissertation may be a theoretical analysis, modeling & simulation, experimentation & analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, applied research and any other related activities.
2. Dissertation should be individual work.
3. Carried out inside or outside the university, in any relevant industry or research institution.
4. Publications in the peer reviewed journals / International Conferences will be an added advantage.

Mode of Evaluation: Assessment on the project - Dissertation report to be submitted, presentation, project reviews and Final Oral Viva Examination.

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022