VIT UNIVERSITY
(Estd. u/s 3 of UGC Act 1956)
VELLORE ■ CHENNAI
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SCHOOL OF MECHANICAL ENGINEERING

CURRICULUM

M.Tech CAD/CAM

(2016-2017 Batch onwards)

Curriculum for M.Tech. (CAD/ CAM) – CAL

University Core

COURSE	CODE	COURES TITLE	L	T	P	J	C
MAT	5005	Advanced Mathematical Methods	3	0	0	0	3
ENG		Technical English I and Technical English II **(or)** Foreign Language	0 0	0 0	2 2	4 4	2 2
STS	5001 & 5002	Soft skills	-	-	-	-	2
SET	5001 & 5002	SET Projects	-	-	-	-	4
MEE	6099	Master's Thesis	-	-	-	-	16
		Total Credits	**27**				

University Electives

COURSE	CODE	COURES TITLE	L	T	P	J	C
		University Elective –I	3	0	0	0	3
		University Elective –II	3	0	0	0	3
		Total Credits	**6**				

PROGRAMME CORE

COURSE	CODE	COURSE TITLE	L	T	P	J	C
MEE	5013	Advanced Mechanics of Solids	2	0	0	4	3
MEE	5022	Applied Materials Engineering	2	0	0	4	3
MEE	5014	Computer Graphics and Geometric Modelling	2	0	2	0	3
MEE	5015	Finite Element Methods	2	1	2	0	4
MEE	xxxx	Integrated Manufacturing Systems	2	0	2	0	3
MEE	xxxx	Advanced Vibration Engineering	2	1	0	0	3
		Total Credits	**19**				

PROGRAMME ELECTIVES

COURSE	CODE	COURSE TITLE	L	T	P	J	C
MEE	xxxx	Advanced Finite Element Methods	2	0	0	4	3
MEE	xxxx	Computational Fluid Dynamics	2	0	2	0	3
MEE	5023	Design For Manufacture And Assembly	2	0	0	4	3
MEE	xxxx	Product Design And Life Cycle Management	2	0	0	4	3
MEE	xxxx	Fracture Mechanics	2	0	0	4	3
MEE	xxxx	Manufacturing and Mechanics Of Composites Materials	2	0	0	4	3
MEE	xxxx	Design and Analysis of Experiments	2	0	0	4	3
MEE	xxxx	Computational and Experimental Vibration Analysis And Control	2	0	2	0	3
MEE	xxxx	Optimisation Methods	2	0	0	4	3
MEE	xxxx	Design Thinking And Innovation	2	0	0	4	3
MEE	xxxx	Machine Fault Diagnostics	2	0	0	4	3
MEE	xxxx	Computer Aided Process Planning	2	0	0	4	3
MEE	xxxx	Additive Manufacturing Technology	2	0	0	4	3
MEE	xxxx	CNC Technology and Programming	2	0	0	4	3
MEE	5024	Advanced Manufacturing Technology	2	0	0	4	3
MEE	xxxx	Industrial/Research Internship	0	0	0	8	2
		Total Credits	**18**				

Credit Summary	Credits
Minimum number of credits for Qualifying degree	70
University Core	27
University Elective	06
Programme core	19
Programme Electives	18

Proposed Programme Core

Course Code : MEE 5013	ADVANCED MECHANICS OF SOLIDS					
		L	T	P	J	C
Pre-requisite : NIL		2	0	0	4	3

Module	Topics	L Hrs	SLO
1	**Stress and strain Relations:** 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	4	1, 2, 5, 9, 17
2	**2D elasticity solutions:** 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	4	1, 2, 5, 9, 17
3	**Torsion of non-circular shafts:** Torsion of rectangular cross sections - St. Venant theory, Prandtl stress function, membrane analogy, torsion of hollow thin-walled tubes- Problems	4	1, 2, 5, 9,17
4	**Energy methods:** Principle of minimum potential energy, Castigliano's theorems- Problems	4	1, 2, 5, 9,17
5	**Shear centre:** Bending axis and shear center - shear center for axi-symmetric and unsymmetrical sections-shear flow-problems	3	1, 2, 5, 9,17
6	**Unsymmetrical bending:** Stresses and deflections in beams subjected to unsymmetrical loading- Problems	4	1, 2, 5, 9, 17
7	**Curved beams:** 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	5	1, 2, 5, 9, 17
8	**Contemporary Discussion**	2	
	Total Lecture Hours	**30**	

 # Mode: Flipped Class Room, Use of computer models to lecture, Industrial Visit, Challenging assignments (innovative practical - oriented) and minimum of 2 guest lectures by industry experts.

Project # Mode: (i) Generally a team size of Three (ii) Concepts studied in modules should have been used (iv) Assessment based on three reviews spread over the length of the Semester. **Sample Projects** 1. Determination of stress, strain and displacement fields near the tip of a crack 2. Calculation of dispersion relations of Love waves 3. Determination of stress fields due to inclusions and dislocations 4. Behavior of thin-walled circular hollow section tubes subjected to bending 5. Wing–box structural design optimization 6. Finite element analysis on curved beams of various sections 7. Design and Stress Analysis of various cross sections of crane Hook 8. Analysis of wear and contact stresses in railways 9. Simulation of airplane skin under vibration 10. Failure investigation of Columbia shuttle 11. Fatigue failure analysis of composites/smart materials/polymeric materials. 12. Finite element analysis of a rotating disc 13. Optimization of profile for rotating disk 14. Out of plane vibration of curved beams	**60** [Non Contact hrs]	1, 2, 5, 9, 17

Text Books

1. A. P. Boresi and R. J. Schmidt, Advanced Mechanics of Materials, Wiley India, 2009

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

Mode of Evaluation	Digital Assignments/Seminars/MID Term exam /FAT
Syllabus Compiled by:	Dr.Ranjit Kunnath and Dr.Bhaskara Rao

Course Code : MEE 5022	APPLIED MATERIALS ENGINEERING					
Pre-requisite : NIL		L	T	P	J	C
		2	0	0	4	3

Module	Topics	L Hrs	SLO
1	**Review of basic concepts:** 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	4	2,9, 12,18
2	**Fatigue, Fracture and Creep mechanisms:** 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.	4	2,9, 12,18
3	**Modern materials and alloys** 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	5	2,9, 12,18
4	**Surface modifications of materials** 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	4	2,9, 12,18
5	**Review of Metal Working:** 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.	4	2,9, 12,18
6	**Forging:** 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.	3	2,9, 12,18
7	**Extrusion and Sheet metal forming:** Classification, Analysis of extrusion process, Deformation,	4	2,9, 12,18

	lubrication and defects. Forming methods, shearing and blanking, bending, stretch forming, deep drawing, Limit criteria, Defects.		
8	**Contemporary Discussion**	2	
	Total Lecture Hours	**30**	
# Mode: Flipped Class Room, [Lecture to be videotaped], Use of physical and computer models to lecture, Visit to Industry , Min of 2 lectures by industry experts			
Project # Generally a team project of Five # Concepts studied in Modules should have been used # Down to earth application and innovative idea should have been attempted **Sample Projects** 1. Predict the fatigue life of a typical sample SAE 4340 and E-4330 M crankshaft material 2. Perform the tension tests on SS316 weldment to obtain the stress-strain relationship for the material and evaluation of its yield stress, ultimate stress and fracture stress 3. Estimate the life of a machined gear shaft 4. Find the residual stresses found in a formed chain drive 5. Identify the stresses found in a forged engine crankshaft and their reasons.		**60** [Non Contact hrs]	5,6,7, 11

Text Books

1. George E. Dieter, Mechanical Metallurgy, Mc Graw Hill, 2013.

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	Digital Assignments / Surprise Tests / Seminars / CATs /FAT
Syllabus Compiled by:	Dr.Kuppan and Dr.Senthil

Course Code : MEE5014	COMPUTER GRAPHICS AND GEOMETRIC MODELLING	L	T	P	J	C
Pre-requisite : NIL		2	0	2	0	3

Module	Topics	L Hrs	SLO
1	**Review of CAD/CAM systems** Product life cycle, CAD/CAM systems and applications,3D modeling concepts, PLM and associated databases	3	6,8,11 ,15
2	**Computer graphics** Transformations – 2D & 3D, Homogenous representation, concatenated transformations, Visualisation – Hidden line, surface and solid algorithms, shading, colors	4	1,5,7, 17
3	**Geometric modeling – Curves** Curve entities and representation, analytic curves – line,circle,ellipse,parabola,synthetic curves – Hermite cubic spline, Bezier curve, B-spline curve, NURBs, Curve manipulations	6	1,5,7
4	**Geometric modeling – Surfaces** Surface entities and representation, surface analysis, Analytical surfaces, synthetic surfaces – Hermite bicubic surface, Bezier surface, B-spline surface, Coons surface, surface manipulations	5	1,5,7
5	**Geometric modeling – Solids** Geometry and topology, solid entities and representation, Boundary representation, Constructive solid geometry, Features	4	1,5,7,
6	**Assembly modellling** Introduction, assembly tree, assembly planning, mating conditions, assembly approaches,testing mating conditions, managing assemblies, inference of position and orientation, assembly analysis	3	1,5,6, 7
7	**Mass properties and Product data exchange** Calculation of mass properties, Types of translators, IGES, STEP, ACIS and DXF, processors	3	5,8
8	**Contemporary Discussion**	2	
	Total Lecture Hours	**30**	

 # Mode: Flipped Class Room,power points, Lectures by Experts from Industry (two sessions). Assignment component will have programming of various algorithms.

The lab course would 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 . Toward the end of this couse students should be able to do industry scale drawings, customization, programming for design automation, Macro writing, etc.	Total Hrs	SLO
Challenging exercises 1. 2D view sketches and solid models of shaft support, machine block, sliding block & support, bearing bracket, vice-body, depth stop & flange connector	30	1,2,4, 5,6,7, 14

[Design tree, visualisation tools, command and GUI managers, units etc.; Sketcher tools – profiles, dimensional & geometric constraints, transformation tools, coordinate systems etc.]

2. Solid modelling and assembly of Universal coupling – use design tables/macros

[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.

Assembly modelling : Assembly planning - Insert, position and orientation, assembly mating and simulation, interference and assembly analysis, assembly properties like CG etc., assembly approaches

3. Solid modelling, assembly and drafting with GD&T of a tool post

Drafting – standard views, dimensioning, layouts, GD&T, Bill of materials, exploded views etc]

4. Solid modelling, assembly of a windmill and a study of assembly interference
5. Surface modelling of an mobile phone case

[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.]

6. Surface modelling of a soap bottle with its plastic tool design and design for sustainability
7. Creation of surfaces from reverse engineered data from a toy car
8. Design a concept of a hair dresser using concept tools
9. Preparation of a CAD model of an aerofoil for FEA/CFD analysis
10. For the above exercises make a professional CAD documentation for professional product presentations.

Text Books

1. Ibrahim Zeid, "Mastering CAD/CAM", McGraw Hill Education (India) P Ltd., SIE, 2007

Reference Books

1. Anupam Saxena, Birendra Sahay, Computer aided Engineering design, Springer, 2010.
2. Micheal E. Mortenson, Geometric Modeling, Wiley, 1997.

Mode of Evaluation	Digital Assignments Seminars CAT / FAT
Syllabus Compiled by:	Dr. Arun Tom Mathew and Dr. Davidson Jebaseelan

Course Code : ME xxxx	INTEGRATED MANUFACTURING SYSTEMS	L	T	P	J	C
Pre-requisite : NIL		2	0	2	0	3

Module	Topics	L Hrs	SLO
1	**Introduction** - 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, Lean Production	3	2, 11
2	**Introduction to automation** - Basic Elements of an Automated System, Advanced Automation Functions, Levels of Automation, Industrial control systems	2	2, 11, 12,17
3	**Control system components** - 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	3	2, 11, 12,17
4	**Industrial robotics** - 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	6	2, 11, 12,17
5	**Group technology and Cellular manufacturing** - Part families, Parts Classification and Coding, Production Flow Analysis, Cellular Manufacturing, Application Considerations in Group Technology, Quantitative Analysis in Cellular Manufacturing	5	2, 11, 12,17
6	**Assembly systems** - 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	5	2, 11, 12,17
7	**Manufacturing support systems** - 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	4	2, 11, 12,17
8	**Contemporary Discussion**	2	2, 11, 12,17
	Total Lecture Hours	**30**	

 # Mode: Flipped Class Room, [Lecture to be videotaped], Use of physical and computer models to lecture, Visit to Industry , Min of 2 lectures by

industry experts		
Challenging Lab Exercises 1. 3D solid modelling and assembly using a CAD/CAM system for a plastic injection molding die 2. Generation of CNC program by optimising tool path movement using CAM software for lathe and mill. 3. Inspection planning for automated inspection for an automotive component 4. Concurrent costing using DFMA software 5. Simulation of Product layout using plant simulation software 6. Industrial Robot Programming for spot welding and paint shop application 7. Optimization of a Computer aided Process planning plan 8. Virtual commissioning of pick and place robot by integrating PLC hardware using a suitable simulation software 9. Optimisation of production line using discrete event simulation and intelligent algorithms 10. Factory floor simulation using suitable simulation software		2,4,14, 17
Total Hours	**30**	

Text Book

1. M.P. Groover, Automation Production systems and Computer Integrated manufacturing, Pearson Education, 2008.

References

1. Xun Xu, 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 Evaluation	Digital Assignments / Seminars / CATs/FAT
Syllabus Compiled by:	Dr.Bharanidaran and Dr.Jafferson

Course Code : MEE 5015	**FINITE ELEMENT METHODS**					
Pre-requisite : NIL		**L**	**T**	**P**	**J**	**C**
		2	**1**	**2**	**0**	**4**

Module	**Topics**	**L**	**SLO**
1	**Fundamental concepts:** 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).	4	1,2
2	**General Techniques and Tools of Displacement Based Finite Element Analysis:** 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.	4	1,2,4, 5
3	**One Dimensional Problems: Bars & Trusses:** 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.	4	4,5,7, 8
4	**One Dimensional Problems – Beams and Frames:** 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.	4	4,5,7, 8
5	**Two Dimensional Analysis – Scalar Variable Problems:** 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.	4	

6	**Vector Variable problems - Plane stress, Plane Strain and Axi-symmetric Analysis**: 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.	4	7,8,12 , 14
7	**Analysis of Production Processes:** 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.	4	14,16, 17,19, 20
8	**Contemporary Discussion**	2	
	Total Lecture Hours **# Mode:** Flipped Class Room,power points, Lectures by Experts from Industry (two sessions). Assignment component will have programming of various algorithms.	**30**	
Tutorial : Each module will have two tutorial sessions		**15**	
Lab course is to introduce the mathematical and physical principles underlying the Finite Element Method (FEM) as applied to solid mechanics. To train the students in analysis software to perform various analysis like static, thermal, fatigue, Harmonic and transient analysis on components and structures. Software used to demonstrate the FEM is ANSYS. **Challenging Experiments Include:** 1. Finite Element Analysis of structural problem. 2. Finite Element Analysis of Heat transfer problems 3. Finite Element Analysis of fluid flow problems 4. Dynamic and normal Mode Dynamic Analysis using FEA Technique. 5. Fatigue and fracture analysis 6. Harmonic analysis on components 7. Transient analysis on components		

Text Books

1. Seshu.P, Finite Element Analysis, Prentice Hall of India,2004

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, 2005, Mcgraw Hill
4. Tirupathi R. Chandrapatla, Ashok D. Belegundu, Introduction to Finite Element in Engineering Prentice-Hall of India Private limited, 2002

Mode of Evaluation	Digital Assignments / Seminars / CATs/FAT
Syllabus Compiled by:	Dr.Venkatachalam and Dr. C. Jebaraj

Course Code: MEExxx	ADVANCED VIBRATION ENGINEERING	L	T	P	J	C
Pre-requisite: NIL		2	1	0	0	3

Module	Topics	L Hrs	SLO
1	**Introduction to Vibrations**: 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.	4	1,2,4,6
2	**Two degree of freedom system:** Free and Forced vibration analysis-Coordinate transformation and linear superposition- Vibration Absorption and Vibration Isolation	4	1,2,4,6
3	**Multi degree of freedom system:** Stiffness and Flexibility matrix-Eigen Value formulation- Lagrane's method-Principle of Orthogonality- Modal matrix and modal analysis of multi DOF	4	1,2,4,6
4	**Approximate numerical methods:** Raleigh's Method**,** Matrix inversion method, Studola's method, Holzer's method, Transfer Matrix method.	4	1,2,4,6
5	**Vibrations of Continuous systems:** 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	3	1,2,4,6
6	**Experimental methods:** Vibration exciters and measuring instruments- Free and forced vibration tests- Signal analysis-Industrial case studies	3	1,2,4,6
7	**Introduction to Random Vibration:** 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.	3	1,2,4,6
8	**Introduction to non-linear vibration-** 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	3	1,2,4,6
9	**Contemporary Discussion**	2	
	Total Lecture Hours	30	

#Mode: Flipped Class Room, Video Lectures, PPTs, Industrial Visits and Guest Lecture by Experts from Industry.

Tutorial

Each module will have two tutorial hours

Text Books

1. S. S. Rao, “Mechanical Vibrations”Pearson India, 2010

2. Kelly SG “Mechanical Vibrations” McGraw Hill India Ltd.,2010

Reference Books

1. Dukkipati RV, “Advanced Mechanical Vibrations”, Narosa Publications, 2008.

2. Benson H. Tongue, “Principles of Vibrations”, Pearson India Ltd.,2001

3. W.T. Thomson, M.D. Dahleh, Chandramouli P, “Theory of Vibrations with applications”, Prentice Hall India Ltd., 2008

4. Meirovitch L, “Fundamental of Vibration”, Waveland, Pr.Inc., 2010

Mode of Evaluation	Digital Assignments / Seminars / CATs/FAT
Syllabus Compiled by:	Dr.Vasudevan R. and Dr. Lenin Babu

Proposed Electives

Course Code : ME xxxx	ADVANCED FINITE ELEMENT METHODS	L	T	P	J	C
Pre-requisite : FEM		2	0	0	4	3

Module	Topics	L Hrs	SLO
1	**Finite Element Methods-A review:** 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	**4**	1,2
2	**Bending of Plates and Shells:** 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.	**4**	2,5,7
3	**Three dimensional solids:** Introduction - Tetrahedra element - Hexahedron element-Linear and higher order elements - Elements with curved surfaces	**3**	7,8,12
4	**Special Purpose elements:** Crack tip elements – Transition elements - Finite strip elements-Strip element methods- Method of infinite domain – nodeless elements	**4**	12,17,18
5	**Nonlinear Analysis**: 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	**4**	12,14,17,18
6	**Nonlinear Analysis -Geometrical nonlinearity**-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	**4**	12,14,17,19
7	**Dynamic Analysis:** 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	**4**	11,14,18,19,20
8	**Contemporary Discussions**	**2**	

Total Hours **#Mode:** Flipped Class Room, Video Lectures, PPTs, Industrial Visits and Guest Lecture by Experts from Industry	30	
Sample Projects - A Study using Nonlinear material models - Analysis using Nonlinear geometry - Analysis using Nonlinear contact - An explicit analysis to study a crash situation - Convergence and error estimation for a typical 3D problem • Generally a team project [Maximum of 3 members only] • Concepts studied should have been used. • Down to earth application and innovative idea should have been attempted • Assessment on a continuous basis with a minimum of 3 reviews.	**60 (Non Contact Hours)**	**2,6,9, 11,16 ,17,1 8**

Text 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

References:

1. Bathe K.J. Finite Element Procedures. Prentice Hall, 2006.
2. O.C. Zienkiewicz, R.L. Taylor, J.Z. Zhu, Finite element method: Its Basic and fundamentals- 2013, Butterworth Heinemann.
3. M.A.Crisfield, Non-linear finite element analysis of solids and structures, Vol. 1, John Wiley & Sons, Incl.2000
4. S.S.Rao, Finite element method in Engineering, Butterworth Heinemann,2011
5. J.N.Reddy, An introduction to nonlinear finite element analysis, Oxford University Press,2013

Mode of Evaluation	Digital Assignments / Seminars / CATs/FAT
Syllabus Compiled by:	Dr.Vasudevan R. and Dr. C. Jebaraj

Course Code : MEExxxx	COMPUTATIONAL FLUID DYNAMICS					
Pre-requisite : NIL		L	T	P	J	C
		2	0	2	0	3

Module	Topics	L Hrs	SLO
1	**Governing Equations of Fluid flow and Heat Transfer:** 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	7	1,2
2	**Classification of Physical behavior and FDM:** Elliptical, parabolic and hyperbolic equations. Finite difference discretization (FDM), Forward, backward and central difference, Order of accuracy, different types of errors and boundary conditions.	4	1,2
3	**Finite Volume Method(FVM) for Diffusion Problems:** FVM for 1D and 2D steady state diffusion, Solution of discretized equations-TDMA scheme for 2D flow.	3	1,2
4	**FVM for Convection-Diffusion Problems:** 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.	4	1,2,4
5	**FVM for Unsteady Flows:** 1D unsteady heat conduction (Explicit, Crank-Nicolson, fully implicit schemes), Implicit methods for 2D problems, Discretization of transient convection diffusion problems.	3	1,2,4
6	**Solution Algorithm for Pressure-velocity Coupling in Steady Flows:** Concept of staggered grid, SIMPLE, SIMPLER, SIMPLEC, PISO algorithm.	4	1,2,4
7	**Turbulence Modeling:** 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**.**	4	1,2
8	**Contemporary Discussion**	1	
	Total Lecture Hours	**30**	

 # Mode: Flipped Class Room, Use of physical and computer models to lecture, Visit to Industry , Min of 1 lecture by industry experts

Practical **Challenging 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 a Engine manifold 7. Analysis of flow in a gear/vane pump	**30**	12,14, 17

Text Books

1. H.K Versteeg and W Malalasekera (2007), 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	Digital Assignments / Surprise Tests / Seminars / CATs /FAT
Syllabus Compiled by:	Dr. Thundil Karuppa Raj R And Dr.Sivakumar R

Course Code : MEExxxx	DESIGN FOR MANUFACTURE AND ASSEMBLY					
Pre-requisite : NIL		L	T	P	J	C
		2	0	0	4	3

Module	Topics	L Hrs	SLO
1	**Introduction:** Objectives and Principles of DFMA, **Geometric Tolerancing and Dimensioning:** Process capability studies, Feature tolerances, Geometric tolerances and Dimensioning -Assembly limits- Datum features- Tolerance stacks.	5	1, 2, 5,6,
2	**Selection of Materials and Manufacturing process:** Selection of Materials and Manufacturing process, Design requirements, Materials choice for metal forming process and machining process	3	1, 2, 5,6,
3	**Design for Casting:** Design of castings based on parting line considerations, minimizing core requirements, Metal injection moulded parts: Process, suitable materials, Design recommendations for metal injection-molded parts.	4	1, 2,5, 6
4	**Design for Metal Extrusion:** Design recommendation for metal extrusion, stamping, fine blanked parts, Rolled formed section. Design for Forging: Forging processes, Suitable materials for forging, Design recommendations,	4	1, 2,5, 6
5	**Design for Machining:** Economics of machining, Features to facilitate machining – surface finish, review of relationship between attainable tolerance grades and different machining processes, Design for Turning, drilling and milling etc.,	4	1, 2,5, 6,
6	**Design for Assembly:** Design for Assembly principles and process, Design for Welding, Brazing and Soldering and Design for Joining of Plastics	4	1, 2,5, 6,10
7	**Redesign for Manufacture**: Design for economy, Identification of uneconomical design – Modifying the design –Computer Applications for DFMA – Case Studies.	4	1, 2,6 10
8	**Contemporary Discussion**	2	
	Total Lecture Hours	**30**	
# Mode: Flipped Class Room, [Lecture to be videotaped], Use of physical and computer models to lecture, Visit to Industry , Min of 2 lectures by industry experts			
Project ➢ Generally a team project [Maximum of 3 members only] ➢ Concepts studied should have been used. ➢ Down to earth application and innovative idea should have been attempted		**60** [Non Contact hrs]	5,6,7, 11

➢ Assessment on a continuous basis with a minimum of 3 reviews. Sample projects such as DFMA of white good industry products DFMA of engineering products DFMA of new products DFMA of furniture products etc.		

Text Books:

1. Boothroyd, G.,Peter Dewhurst, Winston A. Knight (2010), Product Design for Manufacture and Assembly, Third Edition, CRC Press, Taylor & Fancis

Reference Books:

1. Bralla James G., "Hand Book of Product Design for Manufacturing", McGraw Hill.
2. Geoffrey Boothroyed et al Product Design for Manufacture and Assembly, 'Mercel Dekker Inc. New York.

Mode of Evaluation	Digital Assignments / Seminars / CATs/FAT
Syllabus Compiled by:	Dr. C.D. Naiju and Dr.K.Annamalai

Course Code: MEExxx	PRODUCT DESIGN AND LIFE CYCLE MANAGEMENT					
Pre-requisite: NIL		L	T	P	J	C
		2	0	0	4	3

Module	Topics	L Hrs	SLO
1	**Introduction to design- product design**. 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.	3	1, 2, 5,6, 15,17
2	**Product Planning**- 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.	5	1, 2,5, 6, 10, 15, 17
3	**Identifying Customer Needs**- 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.	5	1, 2, 5,6, 17,18
4	**Concept Generations**- Clarify the problem- Search externally- search internally- Systematic exploration. Concept Selection- Concept Screening- Concept Scoring. Concept Testing- Purpose-Survey population-Survey format-Communicate-Response.	4	1, 2,5, 6, 0,17
5	**Product Architecture**- 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.	4	1, 2,5, 6,10,17
6	**Design for X** – 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..	5	1, 2,5, 6,10,17
7	**Patents and Intellectual Property**- 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.	2	1, 2,6 10, 17
8	Contemporary Discussion	2	1, 2,6

			10, 17
Total Lecture Hours		**30**	
# Mode: Flipped Class Room, [Lecture to be videotaped], Use of physical and computer models to lecture, Visit to Industry and study the metallurgical equipment, Min of 2 lectures by industry experts			
Project • Generally a team project [Maximum of 3 members only] • Concepts studied should have been used. • Down to earth application and innovative idea should have been attempted Assessment on a continuous basis with a minimum of 3 reviews. Sample projects such as • New product development starting from customer survey, product specification, concept generation, concept selection, concept testing and prototyping. • Redesign of an existing product from customer survey, product specification, concept generation, concept selection, concept testing and prototyping. • Design modification of an existing product from customer survey, product specification, concept generation, concept selection, concept testing and prototyping.			1, 2, 5, 6,9, 10, 17,18

Text Books

1. Karl T. Ulrich, Steven D. Eppinger, "Product Design and Development", McGraw-Hill, 2015.

Reference Books

1. John W. Priest and Jose M. Sanchez, "Product development and design for manufacturing-
A collaborative approach to produciability and reliability", Marcel Dekker Publications, 2001.

2. Stephen C. Armstrong, "Engineering and product development management – the holistic approach", Cambridge university press, 2001.

Mode of Evaluation	Digital Assignments /Surprise Test /CATS/FAT
Syllabus Compiled by:	Dr. C.D. Naiju and Dr.K.Janardhan Reddy

Course Code: MEExxx	FRACTURE MECHANICS					
Pre-requisite: NIL		**L**	**T**	**P**	**J**	**C**
		2	**0**	**0**	**4**	**3**

Module	Topics	L Hrs	SLO
1	**INTRODUCTION** 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.	2	1, 2, 6, 14, 17
2	**ENERGY RELEASE RATE AND RESISTANCE OF CRACK** 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.	5	1, 2, 6, 14, 17
3	**LINEAR ELASTIC FRACTURE MECHANICS** 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.	8	1, 2, 6, 14, 17
4	**ELASTIC PLASTIC FRACTURE MECHANICS** Relevant and scope, J-Integral, Path independence, Stress-Strain relation, Engineer Approach.	4	1, 2, 6, 14,17
5	**CRACK TIP OPENING DISPLACEMENT**Introduction, Relationship between CTOD, K_I, G_I for small scale yielding, Equivalence between CTOD and J	3	1, 2, 6, 14, 17
6	**EXPERIMENTAL AND NUMERICAL APPROACHES** Test methods to measure material fracture toughness and critical J integral value, Correlations between impact energy and fracture toughness. Finite element modeling of crack and evaluation of J integral and stress intensity parameter-Direct and indirect methods.	3	1, 2, 6, 14,17
7	**FATIGUE FAILURE :** S-N curve, crack initiation, crack propagation, effect of overload, variable amplitude fatigue load	3	1, 2, 6, 14, 17
8	**Contemporary Discussion**	2	1, 2,6 14, 17
Total Lecture Hours		**30**	

# Mode: Flipped Class Room [Lecture to be videotaped], Industrial visit to see different types of crack sensitive equipment's, Lectures by Experts from Industry (two or more sessions)		
Total tutorial Hours	**15**	
Project # Generally a team project of Five # Concepts studied in different Modules , as relevant, should have been used Sample projects such as 1. Finite Element Analysis of stress field around crack tip in Mode I, II and III cracks 2. Finite Element Analysis of stress intensity factor for various loading conditions 3. Finite Element Analysis of J-integral for various loading conditions 4. Fracture Toughness testing as per ASTM standards 5. Fracture testing at different environment and operating conditions 6. Fracture testing of modern materials # **Mode:** Assessment based on two reviews spread over the length of the Semester.	**60** [Non Contact hrs]	1, 2, 5, 6, 17

Text Books

1. T.L. Anderson , Fracture mechanics: Fundamentals and Applications, CRC Press, 2005

Reference Books

1. Prashant Kumar, Elements of fracture mechanics, Tata McGraw-Hill, 2009
2. Arun Shukla, Practical fracture mechanics in design, Marcel Dekker, 2005
3. Steven R. Lampman, ASM Handbook, Vol. 19, Fatigue and Fracture, etc., ASM International, 2002
4. K. Ramesh, E-Book: Engineering Fracture Mechanics (With Trouble shooting and searching, multimedia facilities) by, IIT, Chennai.

Mode of Evaluation	Digital Assignments / Seminars / CATs/FAT
Syllabus Compiled by:	Dr.K.Annamalai and Dr. Velu M.

Course Code: MEExxx	MANUFACTURING AND MECHANICS OF COMPOSITE MATERIALS					
Pre-requisite: NIL		L	T	P	J	C
		2	0	0	4	3

Module	Topics	L Hrs	SLO
1	**Manufacturing of Composites**: Raw Materials: Introduction, Reinforcements manufacturing, Matrix materials manufacturing, Fabric constructions, 3D Braided performs,Pepregs, Moulding compounds-Materials selections, guidelines.	4	2,6,9,11
2	**Manufacturing composite laminates**- 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.	3	2,6,9,11
3	**Micro and Macro mechanical analysis of composite materials:** 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.	6	2,6,9,11
4	**Stress and Strain** - 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	4	2,6,9,11
5	**Classical Lamination Theory:** 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.	4	2,6,9,11
6	**Theories of Failures of Laminates:** 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	4	2,6,9,11

	effects- Effect of laminate classification on the unit thermal force and moment resultants.		
7	**Design and Analysis:** 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.	3	2,6,9,11
8	**Contemporary Discussion**	2	
Total Lecture Hours **# Mode:** Flipped Class Room, [Lecture to be videotaped], Use of physical and computer models to lecture, Visit to Industry , Min of 2 lectures by industry experts		**30**	
Project • Generally a team project [Maximum of 3 members only] • Concepts studied should have been used. • Down to earth application and innovative idea should have been attempted • Assessment on a continuous basis with a minimum of 3 reviews.		**60** [Non Contact hrs]	**2,6,9,11,16,17,18**

Text Books:

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	Digital Assignments / Surprise Tests / Seminars / CATs /FAT
Syllabus Compiled by:	Dr. Vasudevan R. and Dr.Sasikumar

Course Code : MEExxx	DESIGN AND ANALYSIS OF EXPERIMENTS					
Pre-requisite : NIL		L	T	P	J	C
		2	0	0	4	3

Module	Topics	L Hrs	SLO
1	**Experiments with a Single Factor** 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 softwares	4	1, 9, 14
2	**Randomized Block Designs** Randomized complete block design – Latin square designs – Graeco-Latin square design – Balanced incomplete block designs	4	1, 9, 14
3	**Factorial Designs** Two levels – 2^k factorial designs – Confounding and Blocking in factorial designs	4	1, 9, 14
4	**Fractional Factorial Designs** The One-Half and One-Quarter Fraction of the 2^k Design – General 2^{k-p} Fractional Factorial Design – Resolution	4	1, 9, 14
5	**Robust Design** Comparison of classical and Taguchi's approach - orthogonal designs – S/N ratio – application to Process and Parameter design.	4	1, 9, 14
6	**Regression Analysis** Introduction – Simple Linear Regression Analysis – Multiple Linear Regression Model – Model Adequacy Checking	3	1, 9, 14
7	**Response Surface Methodology** Response surface methodology, parameter – optimization - robust parameter design and itsapplication to control of processes with high variability. **Multi objective Optimization** Industrial problems with multiple objectives – Case studies	5	1, 9, 14
8	**Contemporary Discussion**	2	1, 9, 14
	Total Lecture Hours	**30**	

 # Mode: Flipped Class Room [Lecture to be videotaped], Industrial visit., Lectures by Experts from Industry (two or more sessions)

Proposed projects

To provide the knowledge of the DOE softwares by solving the real time problems and casestudiesusing

1.Randomiseddesign,block design.

2.Factorial Designs

3.Regression Analysis

4.Response surface methodology

5.Case studies using optimization techniques.

Text Books

1. Douglas C. Montgomery, Design and Analysis of Experiments, John Wiley & Sons, Inc., 2013.

Reference Books

1. Charles R. Hicks, Kenneth V. Turner Jr., Fundamental concepts in the Design of Experiments, Oxford University Press, 1999.
2. Bagchi, T.P. Taguchi Methods explained, PHI, 2002.
3. Philip J. Rose, Taguchi Techniques for quality Engineering, Prentice Hall, 2000.
4. Pannerselvam.. Design and Analysis of Experiments, PHI learning.2015

Mode of Evaluation	Digital Assignments / Seminars / CATs/FAT
Syllabus complied by:	Dr.Jeevanandham A.K. and Dr.S. Jeyanthi

Course Code : NIL	COMPUTATIONAL AND EXPERIMENTAL VIBRATION ANALYSIS AND CONTROL					
Pre-requisite : Advanced Vibration		L	T	P	J	C
		2	0	2	0	3

Module	Topics	L Hrs	SLO
1	**Development of finite element energy functions**: Axial and torque elements, beam and plate bending elements, membrane element-three dimensional solids-axisymmetric solid-Development of equations of motion and boundary conditions	4	1,2,6,7, 9
2	**Finite element displacement method :** 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.	4	1,2,6,7, 9
3	**In-plane and flexural vibration of plates** 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.	4	1,2,6,7, 9
4	**Vibration of Stiffened and Folded Plates**: Stiffened Plates- Effect of membrane displacements-Folded Plates	4	1,2,6,7, 9
5	**Analysis of free and forced vibration** 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 MATLAB	3	1,2,6,7, 9
6	**Control of flexible structures** Control systems- stability theory-stability of multi-degrees of freedom systems-analysis of second order system- transfer function analysis.	3	1,2,6,7, 9
7	**State space form representation**-Control law design for state space system-linear quadratic regulator-modal control for second order systems-dynamic observer-MATLAB commands for control calculations. **Experimental methods:** Vibration exciters and measuring instruments- Free and forced vibration tests- Measurement of Damping- Industrial case studies and Contemporary Discussion	6	1,2,6,7, 9
9	**Contemporary Discussion**	2	1,2,6,7, 9
Total Hours		**30**	

Mode of Delivery
Flipped Class Room, Video Lectures, PPTs, Industrial Visits and Guest Lecture by Experts from Industry

Laboratory exercise: 1. Computation of natural frequencies and numerical simulation of time and frequency responses of uniform rod 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		

Text Books:

1. Maurice Petyt, "Introduction to finite element vibration analysis", Cambridge University Press, 2010.

2. K.Ogata, "Modern control engineering", Prentice Hall, 2010.

References:

1. S.S.Rao, "The finite element method in engineering", Pergamon Press, 2004.
2. J.N.Reddy, "An introduction to finite element method", McGraw Hill, 2005.
3. S.Graham Kelly, "Theory and problems of mechanical vibrations", McGraw Hill, 1996.
4. Richard C. Dorf and Robert H. Bishop, "Modern control system", Pearson Prentice Hall, 2008.
5. C.Sujatha, "Vibration and Acoustics: Measurement and Signal Analysis", McGraw Hill, 2010.

Mode of Evaluation	Digital Assignments / Seminars / CATs/FAT
Syllabus Compiled by:	Dr. Vasudevan R. and Dr.Lenin Babu

Course Code : MEExxx	OPTIMIZATION METHODS					
Pre-requisite : NIL		L	T	P	J	C
		2	0	0	4	3

Module	Topics	L Hrs	SLO
1	**Classical Optimization Techniques:** 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.	4	1,2,9
2	**One-Dimensional Nonlinear Optimization:** Unimodal function – Region elimination methods: Unrestricted search, Dichotomous Search, Fibonacci method, Golden Section method.	4	1,2,9
3	**Unconstrained Nonlinear Optimization:** 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.	4	1,2,9
4	**Constrained Non-linear Optimization:** Characteristics of a constrained optimization problem - Direct methods: Cutting plane method, methods of feasible directions – Indirect methods: Interior and exterior penalty function methods.	4	1,2,9
5	**Quadratic programming:** Introduction-applications-necessary conditions-solution to quadratic programming problem using Wolfe's method.	3	1,2,9
6	**Geometric programming:** Introduction to Geometric programming – Solution from differential calculus point of view – Solution from arithmetic-geometric inequality point of view.	3	1,2,9
7	**Advanced Non-linear Optimization:** 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.	3	1,2,4,7, 9,11,12, 17
8	**Design Optimization of Machine Elements:** 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	3	1,2,6,7, 9,14

	– constrained parameters and free variables – normal, redundant and incompatible specifications general planning.		
9	**Contemporary Discussion**	2	1,2
Total Lecture Hours		**30**	
# Mode of teaching: Flipped Class Room, [Lecture to be videotaped], Use of physical and computer models to lecture, Visit to Industry, Min of 2 lectures by industry experts.			
Project ▪ Generally a team project [Maximum 4 members] ▪ Tools and techniques studied in Optimization Methods are to be applied. ▪ Focus on practical real life applications such as aerospace design, civil engineering constructions, manufacturing, production planning and control etc. ▪ Report in digital format which includes features and assumptions of the model, notation used, mathematical model development, use of appropriate software/computer program for solving the model and sensitivity analysis/parametric analysis ▪ Assessment on a continuous basis with a minimum of 3 reviews.		**15** (Non contact hours)	1,2,4,6, 7,9,11, 12,13, 14,16, 17

Text Books:

Singiresu S. Rao, Engineering Optimization - Theory and Practice, John Wiley & Sons, Inc., 2009.

References:

1. Kalyanmoy Deb, Optimization for Engineering Design: Algorithms and Examples, PHI Learning Pvt. Ltd., 2012.
2. Wilhelm Forst, Dieter Hoffmann, Optimization - Theory and Practice, Springer, 2010.
3. A. Ravindran, G. V. Reklaitis, K. M. Ragsdell, Engineering Optimization: Methods and Applications, John Wiley & Sons, 2006.

Mode of Evaluation	Digital Assignments / Seminars / CATs/FAT
Syllabus Compiled by:	Dr.Dega Nagaraj and Prof.Sakthivel.K

Course Code : MEExxxx	DESIGN THINKING AND INNOVATION					
Pre-requisite : NIL		L	T	P	J	C
		2	0	0	4	3

Module	Topics	L Hrs	SLO
1	**What is design thinking? - Understanding and awareness** 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	4	1,2
2	**Observe and learn** 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	4	1, 2
3	**Develop Point of view and problem definition** 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	2	2,3,6
4	**Ideate and concept generation** Brain storming , nominal group technique, lateral thinking , synectics, Innovation- creativity model (Dr.Teena seelig), mind map, TRIZ, flow state , morphological analysis, SCAMPER ,design thinking team – Creativity culture – design thinking space – enhancing curiosity, questioning mind-set , mental blocks , story boarding , idea visualisation , T personality, team structure – team behaviour Concept generation – concept selection- combining solution	6	3,4,7
5	**Prototype and learn by doing**	4	3,7

	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		
6	**Test and Validate** Customer centric testing- lead users -user experience mapping – feedback- iteration- retesting – learnings – iteration	4	4,6
7	**Embodiment and detail design** 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	6	6,7,19
8	**Contemporary issues & Case-study/application Discussions**	2	
Total Lecture Hours # Mode: Flipped Class Room, [Lecture to be videotaped], Use of physical and computer models to lecture, Visit to Industry		30	
Project # Generally a team project of three. # Concepts studied in different Modules , as relevant, should have been used Review 1 - Comprising of modules 1, 2,3 Review 2 - Comprising of modules 4,5,6(I part) Review 3 - Comprising of modules 6(II part),7,8 # **Mode:** Assessment based on two reviews spread over the length of the Semester.		**60** [Non Contact hrs]	1, 2, 5, 6, 17

Text Book

1. Idris Mootee , Design thinking for Strategic Innovation , John Wiley and sons ,2013

Reference Books

1. Tim Brown, Change by Design, Thomson Press India Ltd ., 2009
2. Jeanne Liedtka and Tim Ogilvie, Design for growth, Columbia Business school, 2011
3. Karl T Ulrich and Steve D Eppinger, Product Design and Development, Mcgraw hill , 2016
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 , By ,Harper Collins , 2013

Mode of Evaluation	Digital Assignments / Surprise Tests / Seminars / CATs /FAT
Compiled by	Dr.C.Jebaraj / Dr.D.Davidson

Course Code : MEExxxx	MACHINE FAULT DIAGNOSTICS					
Pre-requisite :		L	T	P	J	C
		2	0	0	4	3

Module	Topics	L Hrs	SLO
1	**Introduction to condition monitoring** 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.	5	1, 2, 6, 9, 14, 17
2	**Vibration analysis of rotating machines** 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.	5	1, 2, 6, 9,14, 17
3	**Wear monitoring** Wear mechanisms, wear particles, wear process monitoring techniques, spectrometric oil analysis program, Ferrography.	5	1, 2, 6, 9, 14, 17
4	**Temperature monitoring** Need of temperature monitoring, IR thermography, Passive and active thermography, applications	4	1, 2, 6, 9,14, 17
5	**Flaw detection using traditional non-destructive testing** Discontinuity-origin and classification, liquid penetrant testing, magnetic particle testing, Eddy current testing, Ultrasonic testing and industrial radiography.	4	1, 2, 6, 9,14,17
6	**Acoustic emission testing** Theory of AE sources and Waves, Equipment, Signal Features, Data display, source location, Applications	2	1, 2, 6, 9, 14, 17
7	**Case studies** Fault detection – Gearbox vibration, rolling element bearings and induction motors.	3	1, 2, 6, 9,14,17
8	**Contemporary Discussion**	2	
	Total Lecture Hours	**30**	

 # Mode: Flipped Class Room [Lecture to be videotaped], Industrial visit to see different types of Condition monitoring equipments and various techniques of NDT being practiced, Lectures by Experts from Industry (two or more sessions)

Project # Generally a team project of Five # Concepts studied in different Modules , as relevant, should have been used **Sample projects:** 1. Vibration signal based signature analysis in bearing fault diagnosis using MATLAB 2. Vibration signal based signature analysis in gear fault diagnosis MATLAB 3. Temperature based condition monitoring of machine components 4. Wear monitoring based condition monitoring of machineries 5. NDT inspection on composite material 6. NDT inspection on welding component 7. NDT inspection on cating component 8. Study of grain size variations in metallic materials, using an appropriate non destructive test technique	**60** [Non Contact hrs]	1, 2, 5, 6, 14, 17
# **Mode:** Assessment based on two reviews spread over the length of the Semester.		
Text Books 1. Handbook of Condition Monitoring: Techniques and Methodology- A. Davies, Springer Science & Business Media (2012). **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., (2008), Narosa Publishers. 4. Introduction to Machinery Analysis and Monitoring –J.S.Mitchell, Pennwell Publishers. (1993)		

Mode of Evaluation	Digital Assignments / Surprise Tests / Seminars / CATs /FAT
Syllabus complied by:	Prof. Devendiran S and Dr.Sugumaran

Course Code : MExxx	COMPUTER AIDED PROCESS PLANNING					
Pre-requisite : NIL		L	T	P	J	C
		2	0	0	4	3

Module	Topics	L Hrs	SLO
1	**Introduction to CAPP** 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.	3	1,2,5.
2	**Group Technology** Part families; classification and coding systems, production analysis. Design of machine cells, - GT coding - The optiz system - The MICLASS system.	4	1,2,5.
3	**Process engineering and Process planning** 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.	4	1,2,5.
4	**Determination of machining parameters** 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.	3	1, 2, 6.
5	**Determination of manufacturing tolerances** Design tolerances, manufacturing tolerances, methods of tolerance allocation, sequential approach, integration of design and manufacturing tolerances, advantages of integrated approach over sequential approach.	4	1, 2, 8, 17,20
6	**Implementation techniques for CAPP** 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.	7	1, 2, 8, 17, 20.
7	**An Integrated Process Planning Systems** Totally integrated process planning systems – An Overview –	3	1, 2, 8, 17, 20.

	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.		
8	Contemporary discussion	2	
	Total Lecture Hours	**30**	
	# Mode: Flipped Class Room, [Lecture to be videotaped], Use of physical and computer models to lecture, Visit to Industry , Min of 2 lectures by industry experts		
Project # Concepts studied in different Modules, as relevant, should have been used. Sample projects such as 1. Computer aided selection of optimum machining parameter in multi pass turning. 2. Computer aided process planning for sheet metal bending. 3. Feature based process planning in sheet metal forming. 4. CAPP system based on feature technique used in stamping processes for automobile panels. 5. Application of fuzzy logic in the selection of part orientation and probe orientation sequencing for prismatic parts. 6. Artificial intelligence in automated process planning. 7. A graph representation scheme for process planning of machined parts. 8. Automatic production planning of press brakes for sheet metal bending. # **Mode:** Assessment based on Four reviews spread over the length of the Semester.		**60** [Non-Contact hrs]	1, 2, 5, 6, 17, 20.

Text Books

1.Mikell .P .Groover, Automation, Production systems and Computer Integrated Manufacturing System,PHI, 2007

References

1. Computer Design and Manufacturing, Sadhu Singh, Khanna Publishers, 2009
2. Rao, " Computer Aided Manufacturing", Tata McGraw Hill Publishing Co., 2000.
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", Alogical approach, chapman & Hall, 1995.

Mode of Evaluation	Digital Assignments / Seminars / CATs/FAT
Syllabus Compiled by:	Dr.Rajkumar E and Dr.Giridharan

Course Code : MEExxxx	ADDITIVE MANUFACTURING TECHNOLOGY					
Pre-requisite : NIL		L	T	P	J	C
		2	0	0	4	3

Module	Topics	L Hrs	SLO
1	Introduction to the Basic Principles of Additive Manufacturing, Additive Manufacturing Processes, Extrusion, Beam Deposition, Jetting, Sheet Lamination, Direct-Write, Photopolymerization, Sintering, Powder Bed Fusion	4	4, 5, 6, 18
2	Design/Fabrication Processes: Data Sources, Software Tools, File Formats, Model Repair and Validation, Pre- & Post-processing, Reverse engineering: digitizing, laser scanning, CT-scanning, point cloud manipulation, data segmentation, surface reconstruction, model further processing.	4	4, 5,6, 17
3	Materials Science for Additive Manufacturing- Polymer and Photopolymerization, Process& Material Selection, Direct Digital Manufacturing and AM; parts and their uses. Process Monitoring and Control for AM-Defects, Geometry, Composition, Temperature, Phase Transformation.	4	2, 3, 5, 11
4	Design for Additive Manufacturing, Multiple Materials, Hybrids, Functionally Graded Materials, Composite Materials, current and future directions Process Modeling of AM process- Design optimization through finite-element modeling of AM- Simulation of phase transformations- heating, melting, forming, solidification and finishing and rheological studies of various AM materials.	4	1, 2, 5, 6
5	An Automotive Perspective to Rapid Tooling utilizing Rapid Prototyping and Manufacturing, Precision Stratiform Machining, CAD/LAM- integration of CAD with CAM lasercutting, Profile Edge Lamination, Slice Control Machining, Subsequent Casting Operations, Rubber Mold Casting, Plaster/Sand Molding, Spin Casting, prototyping methodology for automotive product development.	4	1, 2, 17
6	Nickel Ceramic Composite (NCC) Tooling from RP & MModels, NCC Tools Based On Stereolithography Models, Integration Of Tool Forming With RP&M, Compression Tooling Nickel Vapor Deposition Technology-Need for NVD, NVD applications, properties of NVD nickel, comparison between NVD and Electroformed nickel tooling, comparison between NVD and Conventional tooling	4	1, 2, 17
7	The Express Tool Process- Conformal Cooling Channels, The Express tool Process, Finite-Element Analysis of Express Tool, limitations. Applications of AM: Aerospace, Automotive, Biomedical Applications of AM, Product Development, Commercialization, Trends and Future Directions in Additive Manufacturing.	4	1, 2, 17
8	**Contemporary Discussion**	2	

Total Lecture Hours		30
# Mode: Flipped Class Room, [Lecture to be videotaped], Use of physical and computer models to lecture, Visit to Industry, Min of 2 lectures by industry experts		
Project # Generally a team project of Five # Concepts studied in Modules should have been used # Down to earth application and innovative idea should have been attempted **Sample Projects** 1. Projects on CAD data generation for 3D printing using various tools including: various scanning and reverse engineering techniques and related software. 2. Projects on CAD data processing such as STL file corrections, orientation optimization, support and tool path generation for economically producing the components with desired properties. 3. Design and fabrication of working models for the conceptual testing applications. 4. Build complex engineering assemblies of polymeric materials with less process planning. **5.** Redesign the existing locomotive key-components for weight reduction without effecting the functionality that can be produced only by additive manufacturing. 6. Microstructural characterization of the additive manufactured materials. 7. Mechanical characterization of the additive manufactured materials.	**60** [Non Contact hrs]	5,6,7,11

Text Books

1. Ian Gibson, David W. Rosen, Brent Stucker, Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, (2015),

Reference Books

1. Dongdong Gu, Laser Additive Manufacturing of High-Performance Materials, Springer Publ. 2014
2. Andreas Gebhardt, Understanding Additive Manufacturing, Hanser Publishers, 2011
3. Hopkinson, Hague, Dickens, Rapid Manufacturing: An Industrial Revolution for the Digital Age. Wiley, 2005.
4. Peter D. Hilton,Paul F. Jacobs, Rapid Tooling-Technologies and Industrial Applications. Marcel Dekker, 2000

Mode of Evaluation	Digital Assignments / Surprise Tests / Seminars / CATs /FAT
Syllabus Compiled by:	Dr. Raja K. and Dr.Raghu

Course Code : MEExxxx	CNC TECHNOLOGY AND PROGRAMMING	L	T	P	J	C
Pre-requisite : NIL		2	0	0	4	3

Module	Topics	L Hrs	SLO
1	**Types of NC** - Need of CNC machines, NC, CNC and DNC systems, Structure of NC systems, Applications of CNC machines in manufacturing, Advantages of CNC machines	5	1,2
2	**Constructional Details of CNC Machines :** Machine structure ,Slide –ways, Motion transmission elements, Swarf removal and safety considerations, Automatic tool changers and multiple pallet systems, Sensors and feedback devices in CNC machines ,Constructional detail of CNC turning center and CNC machining center ,Classification of CNC control systems.	6	1,2,5
3	**CNC Part Programming:** CNC programming such as types of motions, cutter compensations, work offsets, coordinate transformations, canned cycles, subprograms, macros etc. Programming examples and exercises for lathes and milling machines	5	1,2,5
4	**Tooling of CNC Machines:** Tooling requirements of CNC machines, ISO specification of cutting tools, Pre-set & qualified tools, Combination Tooling, Effects of machining parameters on Tool Life, Tool Wear and performance, Conventional & Advanced Cutting Tool Materials. Work&tool holding devices in CNC machines	4	1,2,5, 9
5	**Advances in CAM Programming**: Free form machining and Feature Based Machining using MASTER CAM, CATIA software. Comparison of different Toolpath strategies in MASTERCAM and CATIA software, knowledge-based machining in CAM Software.	4	1,2,5
6	**Advances in CNC Machines**: Multitasking Machines, Turn Mill, Mill Turn, Multiaxis machining, Parallel Kinematic Machine Tools, Improve Machining Productivity through Dynamic Analysis and Simulation.	2	1,2,5, 9
7	**CNC Machining Process Improvements:** In-process assessment of the condition of tools, work pieces, cutting processes, and machine tools; sensors and signal processing for machining monitoring; Case study of monitoring and control in other manufacturing processes.	2	1,2,5, 9
8	**Contemporary Discussion**	2	
	Total Lecture Hours	**30**	
	# Mode: Flipped Class Room, [Lecture to be videotaped], Use of physical and computer models to lecture, Visit to Industry , Min of 2 lectures by industry experts		
	Practical **Challenging Experiments**	**30**	5,7,9

1. Toolpath Simulation for Linear & Circular Interpolation using using a CAM simulation software 2. Tool path Simulation for BSPLINES & NURBS Interpolation using using A CAM simulation software for free form surfaces. 3. Feature based Machining using using a CAM simulation software 4. Feed rate Optimization Techniques in using a CAM simulation software 5. Knowledge-Based Machining using using a CAM simulation software. 6. Effects of machining parameters on Tool Life, Tool Wear and performance simulation using manufacturing FEA software. 7. Online Tool wear monitoring for turning & milling process , ISO 13399 standard for cutting tool data representation and exchange.		
Project # Generally a team project of Five # Concepts studied in Modules should have been used # Down to earth application and innovative idea should have been attempted **Sample Projects** 1. Estimation of Tool wear studies using using a manufacturing FEA software for turning and milling simulation, 2. Comparison of Feature Based Machining using a CAM software 3. Compare the different Toolpath strategies in CAM software software. 4. Improve Machining Productivity through Dynamic Analysis and Simulation 5. Multiaxial machining process using CAM software 6. Feature Based Machining using CAM software for automotive component, 7. Comparison of Free from machining using CAM software. 8. Online Tool wear monitoring using Machine vision techniques. 9. Study the simulation process of components in a CAD/CAM system 10. Simulation Techniques in CAD-CAM Processing by Milling of Surfaces on NC Machine-Tools	**60** [Non Contact hrs]	5,6,7, 11

Text Books

1. Ken Evans , Programming of CNC Machines, Industrial Press Inc. ,2016

Reference Books

1. Peter Smid, CNC Programming Handbook, 2008
2. Lendel, Mariana. Mastercam X6 – Lathe, Cambridge, ON: In-House Solutions, 2009
3. Kundra, Rao and Tewari, "Numerical Control and Computer Aided Manufacturing" Tata McGraw-Hill, New Delhi.
4. Gizelbach, Richard A. CNC Machining: Fundamentals and Applications. Tinley Park, IL: Goodhart-Wilcox Co., Inc., 2009

Mode of Evaluation	Digital Assignments / Surprise Tests / Seminars / CATs /FAT
Syllabus Compiled by:	Dr. Raja K. and Dr.Senthil Kumar.M

Course Code : MEExxxx	Advanced Manufacturing Technology					
Pre-requisite : NIL		L	T	P	J	C
		2	0	0	4	3

Module	Topics	L Hrs	SLO
1	**Advanced Machining Theory:** Mechanisms of chip formation, shear angle relations, and theoretical determination of cutting forces in orthogonal cutting, thermal aspects of machining and tool wear.	4	2,9,12, 17
2	**High speed machining:** 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.	4	2,9,12, 17
3	**Advanced machining processes - I :** Water jet machining - Abrasive water jet machining - Ultrasonic machining – working principle, machining system, process variables, parametric analysis, process capabilities and applications.	4	2,9,12, 17
4	**Advanced machining processes - II :** Electro chemical Machining - Electric discharge machining - Laser beam machining – Electron beam machining - working principle, machining system, process variables, parametric analysis, process capabilities and applications.	4	2,9,12, 17
5	**Special Machining Process:** Deep hole drilling – Gun drills – Gun boring – Trepanning- shaped tube electrolytic drilling – electrojet drilling, Hard turning and hard milling, thermal enhanced machining of hard to cut materials.	4	2,9,12, 17
6	**Advanced abrasive finishing processes :** Honing – Lapping – Super finishing – High performance grinding - Abrasive flow machining – Magnetic abrasive finishing – Magnetic float polishing.	4	2,9,12, 17
7	**Advanced foundry processes:** Metal mould, continuous, squeeze, vacuum mould, evaporative pattern, and ceramic shell casting	4	2,9,12, 17
8	**Contemporary Discussion**	2	
	Total Lecture Hours	**30**	
	# Mode: Flipped Class Room, [Lecture to be videotaped], Use of physical and computer models to lecture, Visit to Industry , Min of 2 lectures by industry experts		
		30	

Project # Generally a team project of Five # Concepts studied in Modules should have been used # Down to earth application and innovative idea should have been attempted **Lab Experiments** The Lab experiments are designed to train the student in Unconventional machining processes NC part programming, metal cutting concepts, process planning, manual part programming, generation of CNC part programs using softwares and high speed machining. Challenging Experiments include 1. Experiments on Unconventional machining processes – EDM, WEDM, Laser 2. Study and programming of CNC production machines – Lathe, Milling 3. Cutting force measurement using Tool force dynamometer 4. Tool wear and surface finish measurements during machining 5. Study and experiments on grinding 6. Experiments on precision machining 7. Inspection using Vision system and laser interferometer 8. Profile measurement by video measurement system 9. Measurements of parts using CMM	**60** [Non Contact hrs]	5,6,7, 11

Text Books

Mikell P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, Wiley, 2012.

Reference Books

1. 1. J. Paulo Davim, Machining: Fundamentals and Recent Advances, Springer, 2008.
2. Bert P.Erdel, "High Speed Machining", Society of Manufacturing Engineers, 2003.
3. H. El-Hofy, Advanced Machining Processes: Nontraditional and Hybrid Machining Processes, McGraw-Hill, New York, 2005.
4. Serope Kalpakjian and Steven R.Schmid, Manufacturing Engineering and Technology, Prentice Hall, 2013

Mode of Evaluation	Digital Assignments / Surprise Tests / Seminars / CATs /FAT
Syllabus Compiled by:	Dr.T.R.Vijayaram and Dr. Kuppan