VEERMATA JIJABAI TECHNOLOGICAL INSTITUTE
(VJTI)

MATUNGA, MUMBAI 400 019

(Autonomous Institute affiliated to University of Mumbai)

Curriculum

(Scheme of Instruction & Evaluation and Course contents)

For

Two Year Postgraduate Programme Leading to

Master of Technology (M.Tech.) Degree in

Mechanical Engineering with specialization in Machine Design

Implemented from the batch admitted in Academic Year 2014-15

PROGRAMME EDUCATIONAL OBJECTIVES

I. To achieve competency in the subject domain of Machine Design, Manufacturing, Material Science, Vibration, Mechatronics, Reliability; required for Mechanical Engineering problems.

II. To implement analytical and computational skills to formulate and solve problems related to thrust area.

III. To carry out research and development activity and recognize the need for lifelong learning with ethical and professional responsibility.

PROGRAMME OUTCOMES

The students should have –

PO 1 Ability to apply knowledge to solve complex problems in Machine Design.

PO 2 Ability to design experiments, as well as to analyze and interpret data & results.

PO 3 Ability to design a system/process for sustainability.

PO 4 Ability to communicate effectively and develop managerial skills to function in multidisciplinary teams

PO 5 Strong Desire and ability to do research work.

PO 6 Ability to use and update the techniques, skills, and modern engineering tools necessary for engineering practice.

PO 7 Ability to understand professional and ethical responsibility.

SEMESTER I

Scheme of Instruction				Scheme of Evaluation				
S. No	Course code	Course Title	L-T-P (Hours / week)	Credits	TA	IST	ESE	ESE hours
1.	ME5011S	Computational Methods	3-1-0 =4	4	20	20	60	3
2.	ME5031S	Tribology	3-1-0 = 4	4	20	20	60	3
3.	ME5014T	Machine Dynamics & Vibration	3-0-0 = 3	3	20	20	60	3
	ME5014P	Machine Dynamics & Vibration lab	0-0-2 = 2	1	100 % CIE			-
4.	ME5033T	Theory of Elasticity Plasticity & Material Behaviour	3-0-0 = 3	3	20	20	60	3
	ME5033P	Theory of Elasticity Plasticity & Material Behaviour Lab	0-0-2 = 2	1	100 % CIE			-
5.		Program Elective Course 1	3-1-0 = 4	4	20	20	60	3
6.		Program Elective Course 2	3 -0 -0 =3	3	20	20	60	3
		Program Elective Course 2 Lab	0-0-2 = 2	1	100 % CIE			-
		Total	26	24				

Abbreviations: **L**: Lecture, **T**: Tutorial, **P**: Practical, **TA**: Teacher Assessment / Term work Assessment,**IST**: In Semester Tests (comprise of average of twoIn semester tests),**ESE**: End Semester Written Examination, **CIE**: Continuous In-semester Evaluation

SEMESTER II

Scheme of Instruction				Scheme of Evaluation				
S. No	Course code	Course Title	L-T-P (Hours / week)	Credits	TA	IST	ESE	ESE hours
1.	ME5015S	Research Methodologies	3-1-0 =4	4	20	20	60	3
2.	ME5034S	Mechanical Transmission Systems Design	3-1-0 = 4	4	20	20	60	3
3.	ME5035T	Computer Aided Design-Computer Aided Manufacturing	3-0-0 = 3	3	20	20	60	3
	ME5035P	Computer Aided Design-Computer Aided Manufacturing Lab	0-0-2 = 2	1	100 % CIE			-
4.	ME5036T	Finite Element Methods	3-0-0 = 3	3	20	20	60	3
	ME5036P	Finite Element Methods Lab	0-0-2 = 2	1	100 % CIE			-
5.		Program Elective Course 2	3 -0 -0 =3	3	20	20	60	3
6.		Program Elective Course 3	3 -0 -0 =3	3	20	20	60	3
		Program Elective Course 3 Lab	0-0-2 = 2	1	100 % CIE			-
	ME5801D	Technical Seminar	0-0-4 = 4	2	100 % CIE			
		Total	30	25				

Abbreviations: **L**: Lecture, **T**: Tutorial, **P**: Practical, **TA**: Teacher Assessment / Term work Assessment,**IST**: In Semester Tests (comprise of average of twoIn semester tests),**ESE**: End Semester Written Examination, **CIE**: Continuous In-semester Evaluation

List of Electives:

S. No	Course code	Course Title
Elective - I		
1.	ME5118S	System Modeling&Analysis
2.	ME5119S	Energy Conservation &Management
3.	ME5120S	Reliability Engg
Elective – II		
4.	ME5124T ME5124P	Fluid power Automation Fluid power Automation Lab
5.	ME5121T ME5121P	Rapid Product Development Rapid Product Development Lab
6.	ME5126T ME5126P	Operations management Operations management Lab
Elective – III		
7	ME5133S	Pressure Vessel Design
8	ME5122S	Process Equipment Design
9	ME5123S	Design of material handling equipment
Elective – IV		
10	ME5127T ME5127P	Advanced Machine Design Advanced Machine Design Lab
11	ME5114T ME5114P	Computational Fluid Dynamics Computational Fluid Dynamics Lab

SEMESTER III and SEMESTER IV – Project work

S. No	Course Category	Course Title	Credits	Evaluation pattern	Semester
1.	Project	Stage –I Presentation	4	Graded evaluation by a committee of atleast two examiners including supervisor (guide)	III
2.	Project	Stage –II Presentation	4	Graded evaluation by a committee of atleast two examiners including supervisor (guide)	III
3	Project	Stage –III Presentation	4	Graded evaluation by a committee of atleast two examiners including guide (guide)	IV
4.	Project	Final Presentation and Viva Voce	12	Graded evaluation by a committee of atleast two examiners including supervisor (guide) and an external examiner	IV

Programme Name	**:**	**M. Tech. (Mechanical) All Branches SEMESTER –I**
Course Code	**:**	**ME5011S**
Course Title	**:**	**Computational Methods**
Outcomes		The students should be able to 1. Solve algebraic equations and Eigen value problems 2. Analyse data using interpolation and regression methods. 3. Apply concepts of vector spaces & different transformation techniques for problem solving. 4. Apply optimization, numerical methods , statistical methods to solve engineering problems

Sr.No.	CONTENTS
1	**Algebraic Equations** Formulation and solution of linear system of equations Gauss elimination LU, QR decomposition iteration methods (Gauss-Seidal) Convergence of iteration methods.- Eigen Value problems
2	**Interpolation & Regression Methods** Newton's divided difference interpolation polynomials Lagrange interpolation polynomials Linear and non-linear regression multiple linear regression general linear least squares
3	**Transform Techniques** Vector spaces, Basis vectors, Orthogonal/Unitary transform, Fourier transform, Laplace transform
4	**Optimization Techniques for Engineers** Local and global minima, Line searches, Steepest descent method, Conjugate gradient method, Quasi Newton method, Penalty function
5	**Numerical Methods Chapter** Trapezoidal rule, Simpson's $1/3^{rd}$ and $3/8^{th}$ rule. Newton RalphsonMethod , Numerical differentiation & integration.
6	**Statistical Methods** Uncertainty analysis for data reduction ,Data Sampling

Tutorials:

Two tutorials on each module covering relevant engineering applications

Text Books:

01 “Numerical Methods for Engineers’, Steven C. Chapra and Raymond P. Canale, McGraw Hill
02 “Probability and Statistics in Engineering and Management Studies”, Hines and Montrogmery, John Willey
03 “Numerical Methods for Engineers”, Santosh Gupta, New age international publishers

Programme Name	**:**	**M. Tech. (Mechanical) Machine Design SEMESTER –I**
Course Code	**:**	**ME5031S**
Course Title	**:**	**TRIBOLOGY**
Outcomes		The students should be able to - 1.Apply friction/lubrication mechanism to the practical engineering problem; 2. Justify the use of metallic and non-metallic materials. 3. Design mechanical components against wear. 4. Employ different methods to reduce the friction for engineering surface

Sr.No.	CONTENTS
1	HYDRODYNAMIC LUBRICATION AND BEARING DESIGN Basic concept, hydrodynamic lubrication: design of plain fixed pad and tilting pad, slider bearing for steady and varying –loads. Full and partial journal bearing of infinite length, design of journal bearing for steady loads and varying loads. Introduction to design of hydrostatic and Aerostatic bearings. Thrust and radial.
2	ELASTOHYDRODYANAMIC LUBRICATION Principles, Applications to Rolling contact bearings, cams and gears.
3	LUBRICANTS: Selection for general application and special application such as low temperature, high temperature,, extreme Pressure etc.
4	ROLLING CONTACT BEARING: Static and dynamic load capacity, left rating, selection of rolling contact bearing for different applications.
5	FRICTION AND WEAR:
	Types of wear and basic mechanism of wear. Wear properties of friction and anti-friction metallic and nonmetallic materials., experimental techniques in evaluation of materials. Design of mechanical components against wear. Design of friction surfaces used in clutches and brakes.

TEAM WORK

1 Assignments.

2 Seminars

REFERENACES

1 Fluid film lubrication theory & design- Andras Z. Szeri, 1st Ed, 2005

2 Advances in industrial tribology- J. Bhatia

Programme Name	**:**	**M. Tech. (Mechanical) Machine Design SEMESTER – I**
Course Code	**:**	**ME5014T**
Course Title	**:**	**Machine Dynamics and Vibration**
Course Outcomes		Students should be able to 1. Solve real life problems using 3D vector mechanics. 2.Develop mathematical model of vibratory system under given input conditions. 3. Estimate response of the system. 4. Evaluate response of the system

Sr.No.	CONTENTS
	I. Machine Dynamics
1	Kinematics of Rigid bodies: First and Second time derivatives of a vector fixed in moving reference frame – velocity and acceleration of a point on rigid body – moving on rigid body. Relationship of time derivatives of vector for different reference frames, Coriolis force .
2	Inertia tensor: Definition of inertia quantities, Translation of coordinate axes, transformation properties of inertia terms, Tensor notations of transformation, Ellipsoid of inertia, Principal moment of inertia.
3	Dynamics of Rigid Bodies: Angular momentum and its time derivative for a particle and system of particles. Euler's Equation of motion, Applications of Euler's equation, Fixed point rotation.
	II. Mechanical Vibration
4	Single degree of freedom: Undamped & Damped vibration, forced vibration. Multi degree of freedom: Free vibration, modes & mode shape, nodes, Exact and approximate solution methods. Lagrange equation for problem formulation. Two degree of freedom system – co-ordinate coupling - solution.
5	Vibration under general force conditions: Response under periodic and Non periodic force, Solution using Laplace and Fourier transform, Numerical Methods.
6	Vibration of continues systems: Transverse vibration of cable, Longitudinal vibration of bar/rod, Lateral vibration of Beam, Torsion vibration of shaft Rayleigh's method; Rayleigh Ritz method.
7	Vibration control: Balancing of reciprocating and rotating masses, controlling natural frequencies, vibration isolation, vibration absorber
8	Vibration Measurement and applications: Vibration measuring instruments, Exciters/shakers, Signal analysis, Experimental modal analysis
9	Introduction to non-linear vibration

Term work:

Assignments

Seminars/ Case studies

References:

1. Mechanical Vibration – S. S. Rao, 5th Ed, 2004
2. Engineering Mechanics Statics &Dynamics I. H. Shames, 4th Ed,
3. Non-Linear mechanical vibration – Srinivasan,1stEd, 1996
4. Fundamentals of Mechanical vibration – S. Graham Kelly, 3rd Edition, McGraw Hill Book Company
5. Dynamics – Theory and Applications, Thomas Kane, 1st Ed. McGraw Hill Book Company.

Programme Name	**:**	**M. Tech. (Mechanical) Machine DesignSEMESTER – I**
Course Code	**:**	**ME5014P**
Course Title	**:**	**Machine Dynamics and Vibration Lab**
Course Outcomes		Students should be able to - 1. Analyse various mechanism. 2. Perform the Experiments, and interpret the results of various vibratory systems. 3. Use computer codes to solve vibration problems.

CONTENTS:-

1. Complete analysis of any 4 or higher bar Mechanism
2. Experimental analysis of –
   a. unbalanced rotor,
   b. Bent shaft,
   c. faulty bearing,
   d. Misalignments etc. using Machinery Fault simulator.
3. Solution to the multi degree problems using codes / software
4. Seminar / Case studies

Programme Name	**:**	**M. Tech. (Mechanical) Machine Design SEMESTER –I**
Course Code	**:**	**ME5033T**
Course Title	**:**	**Theory of Elasticity, Plasticity And Material Behavior**
Outcome		The student should be able to – 1. Apply various theories for analysis of material behaviour. 2. Execute stress analysis 3. Execute strain analysis. 4. Design component for various material failures.

Sr.No	CONTENT
1	**Revision** Stress transformation and strain transformation at a point in an elastic body, 3D problems, rigid body translation and rotation of an element in space. Generalized Hook's law, separation of elastic strain and rigid body displacement for a general displacement field u, v, w. Principal stresses and strains.
2	**Two dimensional problems in elasticity** plane stress and plain strain problems. Differential equations and equilibrium and compatibility equations. Boundary condition stress function
3	**Problems in rectangular coordinates** Polynomial solutions, cantilever loaded at the end, simply supported beam under uniformly distributed load, linear loading.
4	**Two dimensional problem in polar coordinates** stress distribution about an axis. Pure bending of curved bars, displacement for symmetrically loaded cases, bending of curved bar by forces at end. Effect of circular hole in a plate under in plane loading concentrated load at a point of a straight boundary. Stresses in circular disk. Forces acting on the end of a wedge.
5	**Torsion of prismatic bars** Torsion of prismatic elliptical, rectangular, triangular and other sections. Membrane analogy—Torsion of narrow rectangular bars. Torsion of hollow shafts and thin tubes.
6	**Energy Theorems** Applications of complementary energy theorems to the problem of elasticity.
7	**Introduction to Plasticity** Criterion of yielding, strain hardening, rules of plastic flow, different stress- strains relations. Total strain theory, theorems of limit analysis. Elstoplastic bending and torsion of bars. Computational Elasticity:-AmeenNarosa Publishing House.
8	**Introduction to fatigue and fracture** Mechanics of ductile and brittle fractures mechanism of fatigue failure. Factors affecting fatigue, methods of improving fatigue strength, cumulative damage theories. Linear elastic fracture mechanics. Finite life, infinite life, deign of components.
9	**Creep** Mechanism of creep failure, constant load constant temperature tests, extrapolation of creep and creep rupture curves. Creep relaxation, influence of combined load in different direction. Design of machine elements used in high temperature services.

Text Books:

1. Wag, Applied Elasticity, McGraw Hill book co.5th Ed, 2000
2. Timoshenko, Theory of Elasticity, McGraw Hill book co. 4th Ed, 1981
3. J. Chakrabarti, Theory of Plasticity , McGraw Hill book co.5th Ed, 2001
4. Advances in Engineering , Vol-4, Fatigue design handbook (SAE)
5. Failure of Materials on mechanical Design – J.A. Collins.5th Ed, 2001

Programme Name	**:**	**M. Tech. (Mechanical) Machine DesignSEMESTER –I**
Course Code	**:**	**ME5033P**
Course Title	**:**	**Theory of Elasticity, Plasticity And Material Behavior Lab**
Course Outcomes		The student should be able to – 1. Apply various theories for analysis of material behaviour 2. Execute stress analysis 3. Execute strain analysis. 4. Design component for various material failures.

Seminars on –

1. Design of machine element used in high temperature services and Creep under combined stresses.
2. Prandlt's MEMBRANE ANALOGY
3. Membrane analogy and its application
4. Torsion of Prismatic Bar
5. Factors affecting Fatigue Strength
   and the Methods to Improve it Extrapolation of creep
6. Displacement for symmetrical load cases and bending of curved bar by concentrated force
7. Energy theorems
8. Torsion of Non Circular Sections
9. Strain Hardening and Flow Rules
10. Different stress strain relations and total strain theory of plasticity.
11. Theories of Failure.
12. Cumulative fatigue damage theory.
13. Finite and infinite life for design of components.
14. Creep.
15. Pure bending of curved Bars
16. Effect of circular hole in plate under plane loading
17. Simply Supported Beam Under UDL.
18. Polynomial Solution of cantilever loaded at end

Programme Name	**:**	**M. Tech. (Mechanical) Machine DesignSEMESTER –I**
Course Code	**:**	**ME5121T**
Course Title	**:**	**Elective II - Rapid Product Development**
Outcomes		The student should be able to – 1. Analyze and evaluate various existing Product Development processes 2. Develop various Virtual Simulations techniques for industrial applications 3. Develop new technologies in the field Rapid Prototyping & Manufacturing. 4. Generate innovative ideas to reduce time and cost by developing new methods and materials for the modern manufacturing industry.

Sr.No.	Contents
1	**Introduction to Rapid Product Development:** Essentials of Good Product Development, Influencing Factors of This Era, Types of Businesses, Product & Its classification, Product Cycle, Groupings of Activities, Bottlenecks in Product Development,An Overview of Rapid Product Development (RPD)
2	**Virtual Reality :** Introduction to Geometric Modeling, Types of Geometric Modeling, Features of Wireframe, Surface and Solid models, Definition of VR , Features of VR, Real time Response, Optimization of the Rendering Process, Technologies used in VR, Stereo Displays,Interactions in VR, Tracking based interaction, Data Generation for VR, Haptic Rendering, Applications of VR, Simulation in VR, Augmented Reality.
3	**Virtual Prototyping & Manufacturing** Introduction to CNC, Applications of CNC, Advantages and Limitations of CNC, Introduction to Virtual Prototyping & Manufacturing, Objectives of VP&M, Benefits of VP&M, Tools for VP&M, Applications of VP&M, Virtual Machining (VM) or Volumetric NC Simulation (VolSIM), Conventional NC Simulation Systems, Volumetric NC Simulation System, Applications of Volumetric NC Simulation System, Important issues in VolSIM, Architecture of a Volumetric NC Simulation System, Offline Adaptive Control.
4	**Rapid Prototyping :** Rapid PrototypingDefinition, Principle of RP, Comparison of CNC and RP, RP Processes like, Laminated Object Manufacturing(LOM), *OptiLOM* (Optimization OF LOM), Fused Deposition Modeling (FDM),Stereo-lithography Apparatus(SLA), Photo-masking or Solid Ground Curing (SGC), Objects, Perfactory, Selective Laser Sintering (SLS), 3DPrinting (3DP), Applications/ Case studies/ Advantages, Important Issues in RP,
5	**Rapid Tooling :**

	Types of objects, Virtual Objects, Physical Objects, Types of approaches: Layered Manufacturing and Material Translation,Need for Rapid Tooling & Metallic/ Ceramic Prototyping, Conformal Cooling Channels, Various types of tools- Metallic and Non-metallic tools, Direct and Indirect Methods of Rapid Tooling. Applications of Rapid Tooling.
6	**Reverse Engineering :** Need for Reverse Engineering, Digitizing Methods and its Principles,Types measurements, Contact & Non-contact Types, Coordinate Measuring Machine (CMM),Capture devices, Sensors, Scanning Methods, Data representation, Data processing and manipulation techniques. Applications
7	**Polyhedral Modeling :** Introduction,Types of CAD formats, IGES Format, Possible defects in IGES files, STL Format, Possible Defects in STL Files, Polyhedral B-Rep Kernel, Repairing STL Files, Repairing Missing Faces, Repairing Flipped Faces, Slicing and Other Operations, Feature Recognition from STL Files, Curvatures of Polyhedral Objects.
8	**Rapid Manufacturing :** Introduction to Rapid Prototyping, Definition of Rapid Manufacturing, Roadmap to Rapid Manufacturing, Comparison of Various Processes for Rapid Manufacturing of Metallic Objects, Rapid Manufacturing of Polymeric Objects, Rapid Casting, other RM Processes like Hybrid Layered Manufacturing, Material Translation using Segmented Object Manufacturing.
9	**Synergic Integration :** Introduction to Concurrent Engineering, Methodology of Concurrent Engineering, Integration in Concurrent Engineering,, Benefits of Concurrent Engineering, Introduction to Product Data Management, Product Data Classification, Process Maagement, Benefits of PDM, Introduction Product Life Cycle Management, Evolution and Components of PLM, Case Studies/Applications.

Text Books:

1 Rapid Product Development & Manufacturing by K.P.Karunakaran, IIT, Bombay, 2013
2 Virtual Reality by Ken Pimentel, Kevin Teixeira, Windcrest McGraw-Hill, 2003
3 Rapid Prototyping Principles and Applications by RafiqNoorani, John Wiley & Sons - 2006.

Reference Books :

1 Rapid Manufacturing , An Industrial Revolution for the digital age by N.Hopkinson, R.J.M.Hague -2006.
2 User's Guide to Rapid Prototyping, By Todd Grimm.
3 Rapid Tooling: Technologies and Industrial Applications by Marcel Dekker. Peter D. Hilton and Paul F. Jacobs (Ed.), 2000.
4 Virtual Reality Systems by John Vince, Addison-Wesley-1995.
5 Rapid Prototyping by Andreas Gebharatdt, Hanser Publishers – 2003

Programme Name	**:**	**M. Tech. (Mechanical) Machine Design SEMESTER –I**
Course Code	**:**	**ME5121P**
Course Title	**:**	**Rapid Product Development Laboratory**
Course Outcomes		The students should be able to - 1. Develop 3D models, assemblies and detailed 2D drawings 2. Build 'stl' files from 3D models. 3. Build rapid prototyping parts. 4. Apply surface finish enhancement techniques on FDM parts

Sr.No.	Contents
1	**Demonstration :** Demo of Rapid Prototyping Machine and Catalyst-EX RP software. **CAD Modeling using ProE/CATIA:** CAD Modeling and Conversion CAD models into STL files at least two parts
2	**Pre-Processing Settings :** • To setup the preprocessing settings like orientation of the part to optimize support material, part build options like 'Solid fill', Sparse fill of Model material and Basic fill, 'Sparse fill' and 'Surrounding fill' of Support mail. 3D Printer settings, Machine Control Panel settings etc. • To load and unload Model and Support materials.
3	**Post Processing Operations :** • Cleaning Support material from built part using by hand and by Ultrasonic Cleaning System. • Chemical Treatment on ABS parts to improve surface finish • Dimensional measurement of untreated ABS parts and treated ABS parts using CMM • Surface Roughness measurement of untreated ABS parts and treated ABS parts using Surface roughness tester
4	**Case Studies/Project :**A case study/project in the area of Rapid Product Development subject.

Term Work :

Assignments based on above mentioned contents and a Seminar related to RPD.

Programme Name	**:**	**M. Tech. (Mechanical) Machine DesignSEMESTER –I**
Course Code	**:**	**ME5118S**
Course Title	**:**	**Elective – I** **SYSTEM MODELLING AND ANALYSIS**
Outcomes		The students should be able to - 1. Model Mechanical, electro-mechanical, hydraulic and pneumatic systems. 2. Estimate and evaluate steady state and transient response for various input conditions. 3. Use numerical and state space approach for finding solutions.

Sr. No.	Contents
1.	Mathematical modeling of mechanical elements – inertia ,stiffness and damper and mathematical modeling of mechanical systems – vehicles, articulated vehicle and other mechanical systems. Modelling of Electro- Mechanical systems.
2.	Mathematical modeling of hydraulic elements and system – Pneumatic elements and system. Transfer function representation, block diagram, State variable representation, matrix equation.
3.	Numerical methods and other solution methods of differential & state variable equation.
4.	Transient reposne of first and second order system – Steady state response – step Response, ramp response, impulse response, sinusoidal response, input – convolution integral, stability of system.

TERM WORK

1. Assignments
2. Seminar

REFERENCE

1. Dynamics System Modelling& Analysis – Hung V Vu &R.S.Esfandi
2. System Dynamics – K.Ogata
3. Control System Engg. I.J. Nagarath&M.Gopal.
4. Vehicle Dynamics – Ellis
5. Vehicle Dynamics – Steed
6. Vehicle Dynamics – Gellipsy

Programme Name	**:**	**M. Tech. (Mechanical) Machine Design SEMESTER –I**
Course Code	**:**	**ME5120S**
Course Title	**:**	**Elective – I** **Reliability Engineering**
Outcomes		The students should be able to - 1. Analyse the interference between strength and stress, or life data for estimating reliability; 2. Apply the appropriate methodologies and tools for enhancing the inherent and actual reliability of components and systems, taking into consideration cost aspects; 3. Use statistical tools to characterise the reliability of an item 4. Conduct life test plans for reliability validation.

Contents

Sr.No.	Content
1.	Modelling of Life Distribution Functions Quantification of reliability. Parameters of reliability: hazard rate and MTTF (for non-repairable items), failure rate and MTBF (for repairable items). Common failure patterns of systems and components; the bathtub curve for instantaneous failure rates.The memoryless property of items with a constant failure rate.Two- and three-parameter Weibull models.
2.	Failure Mechanisms Stress-strength interference as a cause of failure. Approaches to minimise the chance of interference: safety margin, improving process capability, screening of items, and curtailment of load distribution.
3.	Modelling of System Reliability Reliability block diagrams. Series and parallel configurations; use of the Bayesian approach.Use of redundancy to improve reliability.Active and standby redundancies.
4.	Reliability Design Reliability programs.Reliability prediction in the preliminary design stage; the component count approach.Use of the component manufacturer's data and computer packages for reliability prediction.Simplification, derating, and use of redundancy.Fault tree analysis; failure modes, effects, and criticality analysis; development testing; failure reporting and corrective action systems; reliability growth models.

5.	Analysis of Life Data and Reliability Testing Non-parametric estimation of reliability functions. Parametric analysis of life data – probability plots of ungrouped and grouped data. Weibull analysis: parameter estimation, censored data, confidence limits, and Bq life. Hazard plots. Reliability validation tests, MIL-STD-781: the OC curve, discrimination ratio, producer's and consumer's risks. Failure truncation, time truncation, PRST. Confidence intervals for MTBF. Sudden death tests. Environmental testing. Accelerated tests.

TERM WORK

1. Assignments
2. Seminar

REFERENCE

1. Andrew K.S. Jardine and Albert H.C. Tsang, 2013, *Maintenance, Replacement and Reliability: Theory and Applications*, 2nd edition, CRC Press
2. O'Connor, D.T., 2002, Practical Reliability Engineering, 4thedn, Wiley
3. Elsayed, Elsayed A, 2012, Reliability Engineering, 2nd edition, John Wiley

Programme Name	**:**	**M. Tech. (Mechanical) Machine DesignSEMESTER – II**
Course Code	**:**	**ME5034S**
Course Title	**:**	**Mechanical Transmission System design**
Course Outcomes		Students should be able to – 1. Select the appropriate transmission system by making comparative analysis 2. Design or select various components of Mechanical Power transmission system. 3. Justify the use of hydraulic and Pneumatic system.

Sr.	**Content**
1	Introduction to Power transmission devices, comparison, selection criteria, characteristics, Limitations, applications
2.	Mechanical Power transmission systems – Design/ selection of various mechanical drives viz. Gears, Belts clutches, chains etc., Use of various standards, Analysis of the solution further with respect to vibration, wear, life of critical components, reliability, assembly, maintenance and cost.
3.	Hydraulic Transmission systems: Introduction to fluid Power and Physical Properties. applications of Pascal's law, conservation of energy, hydraulic power, Bernoulli's equation, laminar and turbulent flow Hydraulic pumps, Hydraulic Motors. Hydraulic cylinders. Hydraulic cylinders operating features, cylinder velocity and power, cylinder designs. Hydraulic Valves. Hydraulic Circuit Design and Analysis. Hydraulic oils; Desirable properties, general type of fluids, sealing devices, reservoir system, filters and strainers
4.	Pneumatic Transmission systems: Choice of working medium, characteristics of compressed air. Structure of Pneumatic control system. Pneumatic Actuators, Design parameters, selection. ISO symbols Valves: Design and constructional aspects, poppet valves, slide valves spool valve, suspended seat type slide valve. Pressure dependent controls, Time dependent controls Electro-Pneumatic control Compressed air: Production of compressed air – compressors, preparation of compressed air- Driers, Filters, Regulators, Lubricators, Distribution of compressed air- Piping layout.

TERM WORK

1. Assignments
2. Seminar

REFERENCE

1. Vicker's Manual
2. Industrial Hydraulic – Rhoner, 3rd Ed, 1994, John Wiley & Sons
3. Industrial Hydraulic – John Pippenger, 3rd Ed, 1979, McGraw Hill Publications
4. Fundamentals of Pneumatics – Festo
5. Fluid power applications – A.Esposito, 7th Ed, 2013, Pearson Education
6. Industrial Fluid Power – Andrew Parr, Butterworth-Heinemann; 2 edition (March 22, 1999)
7. Gear Design Handbook – GitinMaitra, Tata McGraw-Hill Education, 1994
8. Design of machine elements – Spotts, Prentice Hall; 8 edition (October 24, 2003)
9. Design of Machine elements – V M Faires, 4th Ed, 1965, MacMilan Co.

Programme Name	**:**	**M. Tech. (Mechanical) Machine DesignSEMESTER – II**
Course Code	**:**	**ME5035T**
Course Title	**:**	**CADCAM**
Course Outcomes		The student should be able to – 1. Construct and transform geometric objects. 2. Employ various techniques of geometric modelling. 3. Develop Part programs for NC-CNC Machines.

Sr.No.	CONTENT
1.	**Overview of Computer aided Design** The design process , Computers for design. Hardware & Software requirements in CAD
2.	**Overview of Computer Graphics** Scan conversion algorithms for lines , circle, ellipse and general curves 2D & 3D Transformations: Translation, Rotation, Scaling, Mirror reflection, Shearing Projections: parallel , perspective
3.	**Geometric Modeling for Design** Curves : Explicit, Implicit, Parametric curves. Parametric and Geometric continuity of curves. Hermite, Bezier, B-Spline curves Surfaces: Planer, Sweep surfaces, Surface of revolution, Bi-linear , lofted, Coon's patch, Hermite, Bezier, B-Spline surfaces Solid representation : B-rep, CSG schemes. Feature Based Modeling.
4.	**CAM** Introduction to computer aided manufacturing NC,CNC Machines, constructional details, part programming exercises Information Systems : Group technology ,Computer Aided Process planning Integration of Manufacturing Systems: Flexible Manufacturing Systems , Computer Integrated Manufacturing CAD-Cam Data Exchange Rapid Prototyping
5.	**Develop concepts for Mechanical engineering CAD** Develop Algorithms, Flow Charts and Software for Mechanical Engineering Design Problems

Assignments: Based on above modules covering relevant engineering applications

Text Books:

1 Computer graphics, Schaum series

2 Mathematical Elements for Computer graphics Rogers & Adams Tata McGraw –Hill Edition

3 Computer graphics- Foley Van Dam

4 CAD/ CAM , Theory & Practice. by Ibrahim Zeid, R. Sivasubramanian, Tata McGraw Hill Publications

5 CAD/CAM/CIM by P. Radhakrishnan

6 CAD-CAM : P. N. Rao

Programme Name	**:**	**M. Tech. (Mechanical) Machine DesignSEMESTER – II**
Course Code	**:**	**ME5035P**
Course Title	**:**	**CADCAM Lab**
Course Outcomes		The student should be able to – 1. Construct and transform geometric objects. 2. Employ various techniques of geometric modelling. 3. Develop Part programs for NC-CNC Machines.

CONTENTS:-

Assignments

1 2D & 3D transformations
2 Projections (Parallel and Perspective)
3 Curves , Surfaces
4 Component & Assembly modeling using CAD softwares
5 Demonstration on Rapid prototyping machine , CMM & Part programming on CNC
6 Manual and APT part programming assignments
7 Programs for Mech Engg design problems

Programme Name	**:**	**M. Tech. (Mechanical) Machine DesignSEMESTER – II**
Course Code	**:**	**ME5036T**
Course Title	**:**	**FINITE ELEMENT ANALYSIS**
Course Outcome:		The student should be able to– 1. Formulate numerical model for a given system. 2. Obtain numerical Solutions for boundary value problems. 3. Solve mechanical engineering problems using Finite Element Methods.

Sr.No.	Contents
1	**Introduction to Finite Element Analysis** Introduction,Basic concept of Finite Element analysis,Discretization of continuum,Stiffness Matrix and Boundary Conditions,Introduction to elasticity ,Plane Stress and Plain strain Problem
2	**Finite Element Formulation Techniques** Virtual Work and variationalprinciple,Variational Formulation of Boundary Value problem, VariationalMethod such as Ritz and weighted Residual methods. Galerkin Method Potential Energy Approach, Displacement Approach
3	**Element Properties** Natural coordinates, Triangular Elements Rectangular Elements,Lagrange and Serendipity Elements,Solid Elements Isoparametric Formulation Stiffness Matrix for IsoparametricElements,Numerical Integration
4	**Displacement Models** Convergence requirements,Shapefunctions,Element stresses and strains Strain—Displacement Matrix for Bar Element ,Strain Displacement Matrix for CST Element ,Strain Displacement Relation for Beam Element
5	**Analysis of Frame Structure** Stiffness of Truss Members,Analysis of Truss,Stiffness of Beam Members Finite Elements analysis of Beam
6	**FEM for Two Dimensional Solids** Constant and Linear Stain Triangle. Rectangular Elements,Finite Element Formulation for 2D elements. Axisymmetric Elements.Finite Element Formulation of Axisymmetric Elements Heat Transfer by conduction and convection for one dimensional and two dimensional elements,
7	**Dynamic Analysis Using FEA** Introduction,Vibration Problems Equation of motion Based on weak form and Lagrange's Approach,Consistent and Lumped ass Matrices,Properties and Solution of Eigen Value Problems Transient Vibration Analysis ,Thermal transient-Unsteady heat Transfer in a Pin-Fin
8	**Non Linear Analysis** Introduction,Geometric and Material Non Linearity,Stability Problems Elastoplastic analysis by FEM

TERMWORK

1. Assignments
2. Seminar

REFERENCE BOOKS

1.FiniteElemenet Analysis By S.S.Bhavikatti,New Age International Publication
2. Introduction to FEM by Desai and Abel
3. The Finite Element Method for Solid and Structural Mechanics –Zienkiewicz& Taylor,Elsevier Publications
4. Finite Element Analysis by J.N.Reddy,McGraw Hill Book Co.
5. Finite Element Method in Engineering by S.S.Rao,Pergamon Press
6. Textbook on Finite Element Analysis by P.Sheshu,Prentise Hall Publications
7. Finite Element Analysis By Bathe and Wilson
8. Introduction to Finite Element Analysis by T. *Chandrupatla* and A. D. Belegundu, Prentice Hall
9. Finite Element Modeling For Stress Analysis for Robert D.Cook , John Wiley & Sons.
10.Computational Elasticity by Mohammad Ameen, Narosa Publishing House.

Programme Name	**:**	**M. Tech. (Mechanical) Machine DesignSEMESTER – II**
Course Code	**:**	**ME5036P**
Course Title	**:**	**FEM Lab**
Course Outcome		The student should be able to– 1. Use commercial FEA software, to solve problems related to mechanical engineering.

CONTENTS:-

Assignment

Structural Analysis

1 1-D Element Problems –Linear Static Analysis
2 2-D Element Problems – Linear Static Analysis
3 3-D Element Problems – Linear Static Analysis
4 Free Vibration Analysis on Beam, Bars ,Plates
5 Non-Linear Analysis of 1-D Element Problems Like Beams,Bars
Thermal Analysis(Conduction,Covection and Insulation Boundary Conditions.
6 1-D Element Problems-Steady state And Transient Analysis
7 2-D Element Problems of Homogeneous and Composite Slap in Steady State and Transient Analysis
8 3-D Element Problems Steady State Analysis
9 Project-Creating or Importing and Map Meshing of 3-D component /Assembly of practical application and FEA Analysis of Same component /Assembly

Note:-Well Reputed FEA software like Hyper Mesh /Ansys Will be used for the above mentioned Assignments.

Assessment:-

1.TermworkAssessment based on the submission (Softcopy and Hard Copy) of the above assignment

Reference Material:

1. Finite Element Analysis using Ansys 11.0 by PaletiShrinivas, KrishaChaitnaySambana,Rajesh Kumar Datti.
2. Finite Element Analysis Theory and Applications with ANSYS by SaeedMoaveni
3. Engineering Analysis with ANSYS Software by Y. Nakasone and S. Yoshimoto
4.The finite element method And applications inEngineering using ansys® by ErdoganMadenci,IbrahimGuven
5. Practicle Finite Element Analysis by NitinGokhale of M/S Finite to Infinite.
6. Reference Manual of Hypermesh Software
7. Online Tutorial HyperMesh Software.
8. Tutorial of Ansys Software.

Programme Name	**:**	**M. Tech. (Mechanical) Machine DesignSEMESTER – II**
Course Code	**:**	**ME5133S**
Course Title	**:**	**Elective III - Pressure Vessel design**
Course Outcomes		Students should be able to – 1. Design vessels for internal and external pressure. 2. Evaluate the effect of other requirement like wind load, seismic load, etc. 3. Select appropriate material as per the working conditions. 4. Examine the requirements of transportation, Testing and erection of vessel.

Sr.No.	Contents
1	Introduction to Pressure Vessel& Review of Pressure VesselCodes
2	Theory of Pressure Vessel Design
3	Selection of material for Pressure vessel, ASME Material codes for Pressure Vessel
4	Design of Shell / Head for Internal Pressure & Examples
5	Design of Shell / Head for External Pressure & Examples
6	Understanding Requirements of Part UG, UW, UCS of ASME Sec VIII Div 1 & Examples
7	Design of Nozzles & Examples
8	Pressure Vessel Design for External load – Wind/ Seismic & Support Design & Examples
9	Design of Flanges & examples
10	Use of Pressure Vessel Elite software
11	Evaluation of Pressure Vessel for various conditions like lifting, transportation, Hydro test etc.
12	Combination of creep-fatigue, creep bucking on Pressure Vessel.

Term work

1. Assignment
2. Seminar

Reference Books

1. "Pressure vessels design and practice", By: SomnathChattopadhyay. Publication: CRC Press. Ed: 2005
2. "Overview of pressure vessel design", By: Vincent A. Carucci. Publication: ASME International
3. "Process equipment design", By: Brownell and Young. Publication: Wiley Eastern Limited. Ed:1959, sixth reprint Sept 1991.
4. "Review of code for pressure vessels, IS 2825 as compared to ASME/BS/ADMerkblatter", By: N K Roy. Publication: Journal for Process Equipment & Piping Technology. Vol 1, No 1, June 1994
5. "A special report : Worldwide pressure vessel codes". Publication: Hydrocarbon

6. Processing, Dec 1978.
7. ASME Section VIII Div- 1, 2 & 3 Ed. 2010 Addenda 2011a.
8. "Theory & Design of Pressure Vessels", By: John F Harvey, 15th Edition, Van Nostrand Reinhold Company Ltd.
9. "Pressure Vessel Design Handbook" By H. Bedner
10. Pressure Vessel Design Manual – Dennis Moss

Programme Name	**:**	**M. Tech. (Mechanical) Machine Design SEMESTER – II**
Course Code	**:**	**ME5122S**
Course Title	**:**	**Elective III – Process Equipment Design**
Course Outcomes		Students should be able to – 1. Design pressure vessels subjected to internal and external pressure. 2. Design special vessels (e.g. tall vessels) and various parts of vessels (e.g. heads) 3. Examine other requirements of equipment fabrication and testing.

Sr. No.	Content
1.	Type of vessels and factors influencing the design of vessels. Classification of vessels such as tank, flat, bottomed and vertical cylinder tank, vertical cylindrical and horizontal vessels with formed ends as well as spherical or modified spherical vessels.
2.	Criteria in vessel design. Elastic bending, plastic instability, cyclic loading stress reversals. Brittle rupture and creep rupture corrosion.
3.	Design of simple vessels of different configuration. General proportions and lay-out. Vents, tapping and flanges.
4.	Design of tall vertical vessels and supports
5.	Elementary heat exchanger design.

Term work

3. Assignment
4. Seminar

Reference Books

1. "Pressure vessels design and practice", By: SomnathChattopadhyay. Publication: CRC Press. Ed: 2005
2. "Overview of pressure vessel design", By: Vincent A. Carucci. Publication: ASMEInternational
3. "Process equipment design", By: Brownell and Young. Publication: Wiley Eastern Limited. Ed:1959, sixth reprint Sept 1991.
4. "Review of code for pressure vessels, IS 2825 as compared to ASME/BS/ADMerkblatter", By: N K Roy. Publication: Journal for Process Equipment & Piping Technology. Vol 1, No 1, June 1994
5. "A special report : Worldwide pressure vessel codes". Publication: Hydrocarbon
6. Processing, Dec 1978.
7. ASME Section VIII Div-1, 2 & 3 Ed. 2010 Addenda 2011a.
8. "Theory & Design of Pressure Vessels", By: John F Harvey, 15th Edition, Van Nostrand Reinhold Company Ltd.
9. "Pressure Vessel Design Handbook" By H. Bedner
10. Pressure Vessel Design Manual – Dennis Moss

Programme Name	**:**	**M. Tech. (Mechanical) Machine Design SEMESTER – II**
Course Code	**:**	**ME5123S**
Course Title	**:**	**Elective III –Design of Material Handling Equipments**
Course Outcomes		Students should be able to – 1. Design sub systems of Electrically operated overhead travel Crane. 2. Design various components of single stage radial flow centrifugal pump for given specification. 3. Design various components External Gear Pump for given conditions. 4. Design sub-systems of flat belt conveyor for field application.

Sr.No.	Contents
1.	**Material Handling systems**: Classification, Criteria for selection. Types of cranes and their Layouts. Design of Electrically operated overhead travel Crane: Snatch block Assembly, Hoisting Mechanism, Traveling Mechanism – Trolley and Bridge. Design of Bridge Girder: Box type, Truss type.
2.	**Design of Radial Flow Centrifugal pump** - Motor selection, Suction and delivery pipe, Impeller, Impeller shaft with bearing, Casing Geometry.
3.	**Gear Pump**: Classification, Working Principle, Construction. Design of External Gear Pump: Motor selection, Gears, Gear shaft, Bearings, Cover and casing. Bolts, Pipe selection.
4.	**Conveyors**: Classification, Merits and Demerits. Design of Belt Conveyor: Belt, Roller Assembly, Drum & Drum Shaft, Bearings. Motor selection. Take-up arrangements.
5.	**Material Handling systems**: Classification, Criteria for selection. Types of cranes and their Layouts. Design of EOT Crane: Snatch block Assembly, Hoisting Mechanism, Traveling Mechanism – Trolley and Bridge. Design of Bridge Girder: Box type, Truss type.

REFERENCES

1. Pumps: Theory, Design and Applications,G K Sahu, 1st Ed, New age Publication 2000
2. Conveying Machines, Spivakosky&Dyachkov, Mir PublicationMoscow, 1985
3. Indian Standards: - IS: 807, IS: 3443, IS: 3777, IS: 3815, IS: 3973
4. Vicker's Manual
5. Recommended Data Books- PSG, K. Mahadevan
6. Material handling equipments, Alexandrov, MIR Publication. Moscow
7. Machine Design Exercises, S.N. Trikha, Khanna Publications, Delhi
8. Material handling equipments, N. Rudenko , Peace Publication

Programme Name	**:**	**M. Tech. (Mechanical) Machine Design**	**SEMESTER –II**
Course Code	**:**	**ME5127T**	
Course Title	**:**	**ADVANCE MACHINE DESIGN**	
Course Outcomes		Students should be able to – 1. Apply re-engineering practices. 2. Employ reverse engineering process 3. Carry out design of experiments & Taguchi method 4. Demonstrate robust design principles	

DETAILED SYLLABUS :

Sr. No.	Contents
1	**Uncertainty, Statistical Tools and Techniques of handling Uncertainty.** The Mystique of Probability, Idea of a Random Variable ,`Hypothesis Testing': , Comparing Two Population, Cause-Effect Models and Regression ,"Cause" Factor, F-Statistic , The Mean Sum of Squares
2	**Design Process.** Re-engineering, Reverse Engineering of Design, Concurrent Engineering
3	**Design Of Experiment**. One-Factor Designed Experiment, ANOVA Helps Compare Variability , Factor Effects are Statistically Significant ,Sum of Squares and the F-Test
4	**Taguchi Method** Design Achieving Quality—Taguchi's Seven Points Optimized Design, Reduces R&D, Production, and Lifetime Cost. Taguchi's Definition of Quality ,Causes Performance ,Prevention by Quality Design Steps in Designing Performance into a Product Functional Design, Parametric Design, Additivity, the Response table,
5	**Signal to Noise Ratio** Selecting Factors for Taguchi Experiments Seek Robustness One Should Measure Performance by S/N Ratios, S/N Ratio in Optimization, OA as the Experiment Matrix, Axiomatic Approach to Design
6	**Orthogonal Arrays** Orthogonal Arrays , Control and Noise Factors: The Ishikawa Diagram , Optimized Design , Testing for Additivity, The Optimization Strategy , Taguchi's Two Steps to On-Target Performance with Minimum Variability

7	**Process/ Product Optimization.** Passive Network filter, Formal Statement of the Design Problem, Robust Design Formulation of the Problem, Data Analysis and Estimation of Effects , Effects of the Design Parameters, The Process for Manufacturing Optical Filters , Control Parameters and the OA Performance Measurements and the S/N Ratio Minimizing log10 (s2), Variability of Thickness.
8	**Robust Design** Re-Statement of the Multiple Objective Design Optimization , Target Performance Requirements as Explicit Constraints ,Constraints Present in the Filter Design , Seeking Pareto-Optimal Design, Monte Carlo Evaluation of S/N Ratios, Necessary Mathematical Tools, Developing a Multiple Regression Model, Rationale of the Constrained Robust Design Approach, Application of the Constrained Approach to Real, Discussion of the Constrained Design Optimization
9	**Loss function and Design Tolerances.** Loss to Society is More Than Defective Goods, Determining Manufacturing Tolerances , Loss Functions for Mass-Produced Items

TERM WORK

1 Assignments based on above topics

2 Case studies

3 Seminars

REFERENCES

1 Tapan P. Bagchi; Taguchi Method Explained, PHI, New Delhi, 1st ed, 1993

2 Suh Nam P.; the Principles of Design, Oxford university Press, NY, 1st ed, 1990

3 Hammer Michel, Champy J. ; Re-engineering the Corporation, Nicholas Brealey publishing , London.

Programme Name	**:**	**M. Tech. (Mechanical) Machine Design**	**SEMESTER –II**
Course Code	**:**	**ME5127P**	
Course Title	**:**	**ADVANCE MACHINE DESIGN LAB**	
Course Outcomes		Students should be able to – 1. Design experiment for process/Product optimisation. 2. Apply Taguchi method for optimisation. 3. Perform S/N analysis for optimisation.	

DETAILED PRACTICALS :

Contents

1 Process/ Product Optimization **- Case studies**

2 Design Of Experiment in Vibration of Bearing

3 Taguchi Method For optimization of parameters

4 Signal to Noise Ratio for optimization

5 Design Of Experiment in Fault Diagnosis Of machine

Programme Name	**:**	**M. Tech. (Mechanical) Machine Design**				**SEMESTER –II**	
Course Code	**:**	**ME5046T**					
Course Title	**:**	**Computational Fluid Dynamics**					
L	**T**	**P**	**Credits**	**TA**	**IST**	**ESE**	**Total**
3	-	-	3	20	20	60	100
OUTCOMES		The student should be able to – 1. Analyze methodologies used in CFD. 2. Apply finite volume method to heat transfer and fluid flow problems. 3. Develop computer codes for simulation of heat transfer and fluid flow problems.					

Sr. No.	Content
1	**Introduction:** Definition and overview of CFD, need, Advantages of CFD, Numerical vs Analytical vs Experimental, Applications of CFD, CFD methodology, grid independence, Verification and validation
2	**Governing equations of mass, momentum and energy :** Derivation, Discussion of physical meanings and presentation of forms particularly suitable to CFD, Boundary Conditions – Dirichlet, Neuman, Robbins, initial conditions, mathematical behavior of partial differential equations – Elliptic, parabolic & hyperbolic equations, impact on CFD
3	**Discretisation methods** – Introduction to Finite Difference Method, Finite Volume Method, Finite Element Method. Concepts of Convergence, consistency, stability. **Finite Difference method** – Introduction to finite differences, difference equation, Solution of discretised equations, Direct methods and iterative methods, Tri Diagonal Matrix Algorithm, iterative convergence
4	**Finite volume method for diffusion problems (Conduction)**: Steady state one dimensional heat conduction with or without heat generation, dealing with Dirichlet, Neumann, and Robins type boundary conditions, Multi-solid heat conduction, Non-linear Heat Conduction, Unsteady heat conduction- Explicit, Crank-Nicolson , implicit schemes, two dimensional steady and unsteady heat conduction. Gauss-

	Seidal point by point and line by line TDMA methods.
5	**Finite volume method for Advection-diffusion problems (Convection-conduction)**: One dimensional convection-diffusion problem - Advection schemes- Central, first order upwind, hybrid, power law, Second order upwind, QUICK etc., Properties of advection schemes – Conservativeness, boundedness, transportiveness, False diffusion, Extension to two dimensional steady and unsteady advection – diffusion
6	**Solution algorithms for pressure velocity coupling in steady flows:** Staggered grids, SIMPLE, SIMPLER, SIMPLEC, PISO algorithms, unsteady flows
7	**Turbulence modeling :**Turbulence, its effect on governing equations,Reynolds averaged Navier-Stokes equations, introduction to turbulence modeling - DNS, LES, . k-ε , k-ω, RSM models
8	**Introduction to Grid Generation**: Structured and Unstructured Grids, General transformations of the equations, body fitted coordinate systems, Algebraic and Elliptic Methods, multi block structured grids, adaptive grids

Referances

1. S V Patankar, Numerical Heat Transfer and Fluid Flow, Special Indian Edition, Hemisphere, 1980.
2. H K Versteeg and W. Malalasekera, An Introduction to Computational Fluid Dynamics-The Finite Volume Method, Second Indian Edition, Pearson Education, 2008
3. John. D. Anderson, Jr., Computational Fluid Dynamics - The basics with applications, McGraw-Hill International edition, 1995
4. A.W. Date, Introduction to Computational Fluid Dynamics, Cambridge, 2005.
5. Ferziger and Peric, Computational Methods for Fluid Dynamics, 3rd Edition, Springer, 2008

Programme Name	**:**	**M. Tech. (Mechanical) Machine Design**	**SEMESTER –II**
Course Code	**:**	**5046P**	
Course Title	**:**	**Computational Fluid Dynamics Lab**	
Course Outcomes		The student should be able to – 1. Develop computer codes for simulation of heat transfer and fluid flow problems. 2. Implement of CFD process by using CFD software. 3. Evaluate data obtained from the numerical solution	

To develop computer codes for

1. Steady state one dimensional heat conduction with or without heat generation, different boundary conditions, Multi-solid heat conduction, Non-linear Heat Conduction, Unsteady heat conduction, two dimensional steady and unsteady heat conduction.
2. One dimensional convection-diffusion problem to implement various advection schemes like - Central, first order upwind, hybrid, power law, Second order upwind, QUICK etc., two dimensional steady and unsteady convection – diffusion
3. To implement pressure velocity couplings like SIMPLE etc.

Exposure to CFD software for solving simple problems like

1. Laminar Pipe Flow
2. Turbulent pipe flow
3. Flow over a flat plate
4. Flow over an aerofoil
5. Laminar Convection
6. Turbulent Convection
7. Channel flow with backward facing step
8. Lid driven cavity