KAKATIYA INSTITUTE OF TECHNOLOGY & SCIENCE: WARANGAL -15
DEPARTMENT OF MECHANICAL ENGINEERING
Proposed Scheme of Instruction and Evaluation for TWO-YEAR Post Graduate Programme
M.TECH. (DESIGN ENGINEERING)
SEMESTER – I

Course Code	Course	Hours of Instruction per week			Credits	Scheme of Evaluation				
						CIE			ESE	Total Marks
		L	T	P		TA	MSE	TOTAL	Max Marks	
P14DE101	Optimization Techniques in Engineering Design	3	1	-	4	15	25	40	60	100
P14DE102	Stress Analysis	3	1	-	4	15	25	40	60	100
P14DE103	Mechanical Vibrations	3	1	-	4	15	25	40	60	100
P14DE104	Computer Aided Engineering Design	3	1	-	4	15	25	40	60	100
P14DE105	ELECTIVE – I	3	1	-	4	15	25	40	60	100
P14DE106	ELECTIVE – II	3	1	-	4	15	25	40	60	100
P14DE107	Mechanical Vibrations Lab	-		3	2	40	-	40	60	100
P14DE108	CAD Lab	-		3	2	40	-	40	60	100
P14DE109	Seminar	-		-	2	100	-	100	-	100
		24		**6**	**30**	**270**	**150**	**420**	480	**900**

Elective-I:	P14DE105A: Principles of Product Design	**Elective-II:**	P14DE106A: Design of Heat Transfer Equipment
	P14DE105B: Design for manufacture & Assembly		P14DE106B: Computational Fluid Dynamics
	P14DE105C: Rapid prototyping Techniques		P14DE106C: HVAC Systems &Applications
	P14DE105D: Design of Experiments		P14DE106D: Advanced Fluid Mechanics

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SEMESTER – II

Course Code	Course	Hours of Instruction per week			Credits	Scheme of Evaluation				
						CIE			ESE	Total Marks
		L	T	P		TA	MSE	TOTAL	Max Marks	
P14DE201	Finite Element Analysis	3	1	-	4	15	25	40	60	100
P14DE202	Composite Materials	3	1	-	4	15	25	40	60	100
P14DE203	Advanced Design of Machine Components	3	1	-	4	15	25	40	60	100
P14DE204	Automation & Robotics	3	1	-	4	15	25	40	60	100
P14DE205	Elective-III	3	1	-	4	15	25	40	60	100
P14DE206	Elective – IV	3	1	-	4	15	25	40	60	100
P14DE207	FEM Lab	-		3	2	40	-	40	60	100
P14DE208	Automation & Robotics Lab	-		3	2	40	-	40	60	100
P14DE209	Comprehensive Viva-Voce	-		-	2	-	-	-	100	100
		24		**6**	**30**	**170**	**150**	**320**	**580**	**900**

Elective-III:	P14DE205 A: Fault Diagnosis of Machines	**Elective-IV:**	P14DE206A: Advance Materials Science
	P14DE205 B: Fatigue, Fracture & Failure Analysis		P14DE206B: MEMS & Nano Technology
	P14DE205C: Vibrations of Continuous systems& Noise Control		P14DE206C: Smart Structures
	P14DE205D : Design of Pressure Vessels and Piping		P14DE206D: Industrial Tribology

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SEMESTER – III

Course Code	Name of the Course	Duration	Credits	Scheme of Evaluation				
				CIE			ESE	Total marks
				TA	MSE	TOTAL		
P14DE301	Industrial Training	8 Weeks	4	100	-	100	-	100
P14DE302	Dissertation	16 Weeks	8	100	-	100	-	100
		TOTAL	**12**	**200**	**-**	**200**	**-**	**200**

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SEMESTER – IV

Course Code	Name of the Course	Duration	Credits	Scheme of Evaluation				
				CIE			ESE	Total marks
				TA	MSE	TOTAL		
P14DE401	Dissertation	24 Weeks	12	40	-	40	60	100
		TOTAL	**12**	**40**	**-**	**40**	**60**	**100**

OPTIMIZATION TECHNIQUES IN ENGINEERING DESIGN

Course Code: **P14DE101**
Class: M.Tech. I Semester **Branch**: Mech. Engg (Design Engg)

Teaching Scheme:

L	T	P	C
3	1	-	4

Examination Scheme:

Continuous Internal Evaluation:	**40 marks**
End Semester Exam:	**60 marks**

Course Learning Objectives (Cos):
This course will develop students 'knowledge in/on...

- *mathematical methods and applications in engineering disciplines.*
- *methods of optimization to solve a linear programming problem by various methods.*
- *techniques of solving a Non- linear programming problem with / without constraints.*
- *different advanced optimization techniques.*

UNIT-I

1. Introduction: Classification of optimization problems, mathematical models in engineering optimization. Concepts in linear optimization: General simplex method, revised simplex method, duality, decomposition principle, integer programming, branch and bound technique and the Gomory algorithm, post optimality analysis.

UNIT-II

2. Non linear programming without constraints: Local and global maxima, minima, Hessian matrix, Fibonacci method, Golden section method, random search method, steepest descent method and conjugate gradient method.

UNIT-III

3. Non linear programming with constraints: Lagrange multipliers, Kuhn-Tucker conditions, quadratic programming. Wolfe's and Beale's method, sequential linear programming approach, penalty methods. Interior and exterior penalty function method.

UNIT-IV

4. Advanced optimization techniques: Concepts of multi-objective optimization, genetic algorithms and simulated annealing.

Textbooks:

1. S.S.Rao, *Optimization-Theory and Applications, ,* Wiley Eastern, New Delhi, 1978
2. J.C.Pant, Introduction to Optimization, Jain Brothers, New Delhi, 1983
3. Kanthi Swaroop, et.at., *Operations Research,* S. Chand & Co., New Delhi,
4. Kalyanmoy Deb, *Optimization for Engineering Design Algorithms and Examples,* Prentice Hall of India, New Delhi, 1995
5. Kalyanmoy Deb, *Mulitobjective Optimization –An evolutionary Algorithmic Approcach,* John Wiley & Sons, New York.

Reference Books:

1. J.S. Arora, Introduction to optimum design, McGraw Hill, New York, 1989.
2. R.L. Fox, Optimization Methods for Engineering Design, Addison Wesley, New York, 1971.
3. D.E. Goldberg, Genetic Algorithms in Search, Optimization and Machine, Barnen, Addison Wesley, New York, 1989.

Course Learning Outcomes (COs):

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

- *solve the given linear programming problem by simplex/revised simplex method*
- *solve an integer programming problem using various techniques*
- *solve a non-linear programming problem by random search methods as well as steepest-descent method and conjugate gradient method, Kuhn-Tucker conditions*
- *understand the concept of Multi-objective optimization and use of genetic algorithms and simulated annealing*

STRESS ANALYSIS

Course Code: **P14DE102**
Class: M.Tech. I Semester **Branch**: Mech. Engg (Design Engg)

Teaching Scheme:

L	T	P	C
3	1	-	4

Examination Scheme:

Continuous Internal Evaluation:	**40 marks**
End Semester Exam:	**60 marks**

Course Learning Objectives (LOs):

This course will develop students 'knowledge in/on...

- *identification of the likely locations of highest stress of a loaded beam, shaft, or tension member and determination of principal stresses and strains and apply Mohr's circle*
- *evaluation of stresses at a point on an object subject to arbitrary loading*
- *governing differential equations of thick cylinders under uniform pressure.*
- *stress analysis using Energy Principles and Variation Methods.*

UNIT-I

1. **Analysis of Stress& Strain:** Definition and notation of stress, Differential equations of equilibrium, specification of stress at a point, Principal stresses and the Mohr Diagram, three-dimensional stress at a point, Boundary conditions in terms of given surface forces. Strain components, Specification of strain at a point, Compatibility equations, three-dimensional strains, Mohr's circle for strains, Measurement of strains bonded strain gages.

UNIT-II

2. **Stress-Strain Relations and the General Equations of Elasticity:** Idealization of Engineering Materials, Generalized Hooke's law, Elastic symmetry, Generalized Hooke's law in terms of Engineering elastic constants, Strain energy, Saint-Venant's principle.

UNIT-III

3. **Plane-Stress and Plane-Strain Problems:** The governing differential equations, Thick cylinder under uniform pressure, shrink and force fits. The effect of small circular holes in strained plates, Stress concentration **Thermal Stresses:** Thermoelastic stress-strain relations,

UNIT-IV

4. Energy Principles and Variational Methods: Principle of Potential energy, Principle of complementary energy. Rayleigh-Ritz method, Galerkin method. Reciprocal Theorem and Castigliano's Theorems.

Textbook:

1. C.T. Wang, *Applied Elasticity,* McGraw-Hill, New York, 1953.

Reference Books:

1. A.C.Ugural and S.K. Fenster, *Advanced Strength and Applied Elasticity, 3/e* PTR Prentice Hall, Englewood Cliffs, New Jersey, 1995.
2. G.E.Dieter, *Mechanical Metallurgy,* McGraw-Hill Book Company, Singapore, 1988.
3. S.P.Timoshenko and J.N.Goodier, *Theory of Elasticity,* 3/e, McGraw-Hill, New York, 1985.

Course Learning Outcomes (COs):

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

- *explain the behavior of a material under various kinds of static loadings, i.e., axial loading, bending moment, torsional loading and transverse loading etc.*
- *analyze the problems related to mechanics of materials and find the stress and deformation of the components under static loadings and cyclic loads.*
- *analyze the governing differential equations of thick cylinders under various parameters.*
- *perform the stress analysis based on various Energy Principles and Variational Methods.*

MECHANICAL VIBRATIONS

Course Code: **P14DE103**
Class: M.Tech. I Semester **Branch**: Mech. Engg (Design Engg)

Teaching Scheme:

L	T	P	C
3	1	-	4

Examination Scheme:

Continuous Internal Evaluation:	**40 marks**
End Semester Exam:	**60 marks**

Course Learning Objectives (LOs):

This course will develop students 'knowledge in/on...

- *importance of vibrations in mechanical design of machine parts that operate in vibratory conditions*
- *linear vibratory models of dynamic systems with changing complexities (SDOF, MDOF)*
- *free and forced (harmonic, periodic, non-periodic) vibration analysis of single and multi-degree of freedom linear systems*
- *measurement of vibration by various experimental methods*

UNIT-I

1. **Fundamental of Vibration:** Review of Single degree freedom systems – Response to arbitrary periodic Executions – Duhamel's Integral – Impulse Response function – Virtual work – Lagrange's equation – Single degree freedom forced vibration with elastically coupled viscous dampers – System Identification from frequency response – Transient Vibration – Laplace transformation formulation.

UNIT-II

2. **Two Degree Freedom System:** Free vibration of spring-coupled system – mass coupled system – Bending vibration of two-degree freedom system – Forced vibration – Vibration Absorber – Vibration isolation.

UNIT-III

3. **Multi-Degree Freedom System:** Normal mode of vibration – Flexibility Matrix and Stiffness matrix – Eigen values and eigen vectors – orthogonal properties – Modal matrix – Modal Analysis – Forced Vibration by matrix inversion – Model damping in forced vibration – Numerical methods for fundamental frequencies.

UNIT-IV

4. **Experimental methods in Vibration Analysis:** Vibration instruments– Vibration exciters Measuring Devices – Analysis – Vibration Tests – Free and Forced Vibration tests. Examples of Vibration tests – Industrial, case studies.

Textbook:

1. Rao, S.S., *Mechanical Vibrations*, Addison Wesley Longman, 1995.

Reference Books:

1. William T. Thomson and Marie Dillon Dahleh, *Theory of Vibration with Applications, 5/e,* Pearson Education, Singapore, 2003.
2. Meirovich, L. *Elements of Vibration Analysis*, McGraw-Hill, New York, 1986,
3. S. Graham Kelly, *Fundamentals of Mechanical Vibrations, 2/e*, McGraw-Hill, Singapore, 2000.
4. Den Hartog, J.P., *Mechanical Vibrations*, Dover Publications, 1990.

Course Learning Outcomes (COs):

On completion of the subject, students will be able to…

- *explain the need and importance of vibration analysis in mechanical design of machine parts that operate in vibratory conditions*
- *analyze the mathematical model of a linear vibratory system to determine its response*
- *model linear mathematical models of real-life engineering systems*
- *determine vibratory responses of vibratory systems to harmonic, periodic excitation*

COMPUTER AIDED ENGINEERING DESIGN

Course Code: **P14DE104**
Class: M.Tech. I Semester **Branch**: Mech. Engg (Design Engg)

Teaching Scheme:

L	T	P	C
3	1	-	4

Examination Scheme:

Continuous Internal Evaluation:	**40 marks**
End Semester Exam:	**60 marks**

Course Learning Objectives (LOs):

This course will develop students 'knowledge in/on...

- *concepts of computer aided design; geometric modeling of curves*
- *parametric representation of curves*
- *synthetic surfaces, their characteristic and applications; 3D solid modeling techniques*
- *various data storage management systems and design applications*

UNIT – I

CAD TOOLS: Definition of CAD Tools, Types of system, CAD/CAM system evaluation criteria, brief treatment of input and output devices. Graphics standard, functional areas of CAD, Modeling and viewing, software documentation, efficient use of CAD software.

GEOMETRIC MODELLING: Types of mathematical representation of curves, wire frame models wire frame entities parametric representation of synthetic curves her mite cubic splines Bezier curves B-splines rational curves.

UNIT – II

SURFACE MODELING: Mathematical representation surfaces, Surface model, Surface entities surface representation, Parametric representation of surfaces, plane surface, rule surface, surface of revolution, Tabulated Cylinder.

UNIT – III

PARAMETRIC REPRESENTATION OF SYNTHETIC SURFACES –Hermite Bi-cubic surface, Bezier surface, B- Spline surface, COONs surface, Blending surface , Sculptured surface, Surface manipulation – Displaying, Segmentation, Trimming, Intersection, Transformations (both 2D and 3D).

GEOMETRICMODELLING-3D: Solid modeling, Solid Representation, Boundary Representation (B-rep), Constructive Solid Geometry (CSG).

UNIT – IV

CAD/CAM Data Exchange: Evaluation of data – exchange format, IGES data representations and structure, STEP Architecture, implementation, ACIS & DXF.

DESIGN APPLICATIONS: Mechanical tolerances, Mass property calculations, Finite Element Modeling and Analysis and Mechanical Assembly. Collaborative Engineering: Collaborative Design, Principles, Approaches, Tools, Design Systems.

Textbooks:

1. CAD/CAM Theory and Practice, Ibrahim Zeid, Mc Graw Hill international.
2. Mastering CAD/CAM, Ibrahim Zeid, Mc Graw Hill international.

3. CAD/CAM, P.N.Rao, Tata McGraw Hill.

Reference Books:

1. CAD CAM: Principles, Practice and Manufacturing Management, Chris Mc Mohan, Jimmie Browne, Pearson edu. (LPE)
2. Concurrent Engineering Fundamentals: Integrated Product Development, Prasad, Prentice Hall.
3. Successful Implementation of Concurrent Product and Process, Sammy G Sinha, Wiley, John and Sons Inc.

Course Learning Outcomes (COs):

On completion of this course, students will be able to…

- *explain the basic principles of computer aided design, geometric modeling of curves*
- *develop mathematical models to represent surfaces and learn characteristics of surfaces*
- *apply the parametric representation for synthetic surfaces and explain the concept of 3D solid modeling*
- *apply graphics standards & data base models in design*

PRINCIPLES OF PRODUCT DESIGN

Course Code: **P14DE105A**
Class: M.Tech. I Semester **Branch**: Mech. Engg (Design Engg)

Teaching Scheme:

L	T	P	C
3	1	-	4

Examination Scheme:

Continuous Internal Evaluation:	**40 marks**
End Semester Exam :	**60 marks**

Course Learning Objectives (LOs):
This course will develop students 'knowledge in/on...

- *design process, types and planning of design process*
- *design concept generation and evaluation*
- *development of engineering specifications*
- *importance and goals of performance evaluation*

UNIT-I

1. **Design Process**: Describing mechanical design problems and processes – Types of mechanical design problems, Languages of mechanical design, constraints, goals and design decisions, Designers and design teams. Planning of design process: overview of the design processes, organization techniques, developing design project plans, steps in planning, case studies

UNIT-II

2. **Design concept generation and evaluation:** Technique for functional decomposition, generating and developing concepts, evaluation based on feasibility judgment, technology – readiness assessment, Go/No Go screening, decision matrix.

UNIT-III

3. **Development of Engineering specifications**: Steps in development of engineering specification, identification of customer\s requirements, quality functional deployment (QFD),

UNIT-IV

4. **Product Evaluation**: Importance and goals of Performance evaluation, robust design, sensitivity analysis, cost estimation in design, design for reliability, environment and maintenance

Textbooks:

1. David G. Ullman, "The Mechanical Design Process", McGraw Hill, 1955.
2. George E. Dieter, "Engineering Design",

Refrence Books:

1. E.N.Baldwin and B.W. Niebel, , *Designing for Production,* Homewood, Illinois, 1975.

2. J.C.Jones, *Design Methods, Seeds of Human Futures,* John Wiley, New York, 1978.
3. J.G.Bralla, *Handbook of Product Design for Manufacture,* McGraw-Hill, New York, 1988.

Course Learning Outcomes (COs):

On completion of this course, students will be able to…

- *identify project constraints and solutions, problem decomposition, requirements elicitation, design trade-off analysis*
- *prepare documentation and presentations; making presentations; participating in team meetings, brainstorming session, code reviews and walkthroughs, or artifact reviews; customer or project sponsor interactions; use of discussion forums*
- *analyze Feasibility, environmental impact, support for different languages, and usability analysis for people with impairments*
- *use process methodologies, design methodologies, development tools*

DESIGN FOR MANUFACTURE & ASSEMBLY

Course Code: **P14DE105B**
Class: M.Tech. I Semester **Branch**: Mech. Engg (Design Engg)

Teaching Scheme:

L	T	P	C
3	1	-	4

Examination Scheme:

Continuous Internal Evaluation:	**40 marks**
End Semester Exam :	**60 marks**

Course Learning Objectives (LOs):
This course will develop students 'knowledge in/on...

- *key features of a production line process and how it can be made more effective*
- *material selection and compare various processes*
- *general considerations for a process and skills needed to make it work efficiently*
- *implementation techniques of manufacturability and product design*

UNIT-I

1. **INTROUDCTION TO DESIGN FOR MANUFACTURE (DFM):** Design Concepts considerations like part count, product weight, manufacturing costs assembly time etc., concurrent engineering – definition and concepts, improving competitiveness with concurrent engineering, implementation methodologies.

UNIT-II

2. **MATERIALS AND PROCESSES:** Material selection and its inter relationship with process selection, comparison of various processes for productivity and produce-ability machining process, casting processes, deformation processes.

UNIT-III

3. **GENERAL CONSIDERATIONS IN DFM:** Performance considerations, Manufacturability considerations, Testability consideration, Serviceability considerations, Computer aided engineering and testing.

UNIT-IV

4 **IMPLEMENTATION TECHNIQUES OF DFM:** Manufacturability evaluation methods, principles and rules for product design, Quantitative evaluation methods, Boothroyd and Dewhurst DFA method, Methodology for planning experiments in robust product and process design, Redesigning mature products for competitiveness. Designing for CNC manufacture knowledge based solutions for assembly problems, Linking manufacturing and product life cycles.

Textbooks:

1. John Cobert et. "Design for Manufacture – Strategirs, Principles and Techniques", Addison Wesley Pub.Co.,.

2. George E. Dieter, "Engineering Design – A material processing approach", McGraw International.

Reference Books:

1. John Turino, "Managing Concurrent Engineering "Von Nostrand Reinhold, New York.
2. Product Design for Manufacture and Assembly, Second Edition, Revised and Expanded (Manufacturing Engineering and Materials Processing), Third Edition, Geoffrey Boothroyd, Peter Dewhurst, Winston A. Knight, CRS Press

Course Learning Outcomes (COs):

On completion of this course, students will be able to…

- *identify how a production line can be run efficiently*
- *select the material and compare various processes for productivity.*
- *reflect upon the critical skills and evaluate their own performance by identifying general considerations for a process.*
- *apply the implementation techniques of manufacturability and product design*

RAPID PROTOTYPING TECHNIQUES

Course Code: P14DE105C
Class: M.Tech. I Semester **Branch**: Mech. Engg (Design Engg)

Teaching Scheme:

L	T	P	C
3	1	-	4

Examination Scheme:

Continuous Internal Evaluation:	**40 marks**
End Semester Exam :	**60 marks**

Course Learning Objectives (LOs):

This course will develop students 'knowledge in/on...

- *fundamentals of Rapid Prototyping and various classifications of RP processes.*
- *working principles & Applications of Solid-based, Powder Based Rapid Prototyping Systems & Fused Deposition Modeling.*
- *Rapid Tooling & various data formats.*
- *Rapid Prototyping applications.*

UNIT I

1. **Introduction**: Fundamentals of Rapid Prototyping, Advantages and Limitations of Rapid Prototyping, Commonly used Terms, Classification of RP process, Automated Processes, Process Chain.

2. **Liquid-based Rapid Prototyping Systems:** Stereo lithography Apparatus (SLA): Models and specifications, Process, working principle, photopolymers, photo polymerization, Layering technology, laser and laser scanning, Applications, Advantages and Disadvantages, Case studies.
   Solid ground curing (SGC): Models and specifications, Process, working principle, Applications, Advantages and Disadvantages, Case studies

UNIT II

3. **Solid-based Rapid Prototyping Systems:** Laminated Object Manufacturing (LOM): Models and specifications, Process, working principle, Applications, Advantages and Disadvantages, Case studies.
   Fused Deposition Modeling (FDM): Models and specifications, Process, working principle, Applications, Advantages and Disadvantages, Case studies.

4. **Powder Based Rapid Prototyping Systems**: Selective laser sintering (SLS): Models and specifications, Process, working principle, Applications, Advantages and Disadvantages, Three dimensional Printing (3DP): Models and specifications, Process, working principle, Applications, Advantages and Disadvantages, Case studies.

UNIT III

5. **Rapid Tooling**: Introduction to Rapid Tooling (RT), Conventional Tooling Vs. RT, Need for RT. Rapid Tooling Classification: Indirect Rapid Tooling Methods, Direct Rapid Tooling.

6. **Rapid Prototyping Data Formats**: STL Format, STL File Problems, Consequence of Building Valid and Invalid Tessellated Models, STL file Repairs: Generic Solution, Other Translators, Newly Proposed Formats, Features of various RP softwares.

UNIT IV

7. **RP Applications:** Application – Material Relationship, Application in Design , Application in Engineering, Analysis and Planning, Aerospace Industry, Automotive Industry, Jewelry Industry, Coin Industry, RP Medical and Bioengineering Applications: Planning and simulation of complex surgery, Customized Implants & Prosthesis, Design and Production of Medical Devices, Forensic Science and Anthropology, Visualization of Biomolecules.

Textbook:

1. Rapid prototyping: Principles and Applications - Chua C.K., Leong K.F. and LIM C.S, World Scientific publications.

Reference Books:

1. Rapid Manufacturing – D.T. Pham and S.S. Dimov, Springer.
2. Whalers Report 2000 – Terry Wohlers, Wohlers Associates, 2000Rapid Prototyping & Manufacturing – Paul F.Jacobs, ASME Press.

Course Learning Outcomes (COs):

On completion of this course, students will be able to…

- *explain the fundamentals of Rapid Prototyping and various classifications of RP processes*
- *explain working principles & Applications of Solid-based Rapid Prototyping Systems, FDM& Powder Based Rapid Prototyping Systems*
- *analyze Rapid Tooling & various data formats*
- *apply the principles of Rapid Prototyping for various applications*

DESIGN OF EXPERIMENTS

Course Code: **P14DE105D**
Class: M.Tech. I Semester **Branch**: Mech. Engg (Design Engg)

Teaching Scheme:

L	T	P	C
3	1	-	4

Examination Scheme:

Continuous Internal Evaluation:	**40 marks**
End Semester Exam :	**60 marks**

Course Learning Objectives (LOs):

This course will develop students 'knowledge in/on...

- *various types of experiments that are frequently employed in industries for experimental studies*
- *planning, designing and conducting experiments efficiently and effectively*
- *analysis and interpretation of the experimental data obtained through designed experiments*
- *comparison of classical designs, orthogonal arrays and response surface methods*

UNIT – I

Introduction to research methodology, The economics of reducing variation, quality characteristics and objective functions, Taguchi quality loss function, DOE process – steps and description, Typical test strategies, Better test strategies- full factorial experiments, fractional factorial experiments, standard orthogonal arrays and linear graphs.

UNIT – II

Construction of orthogonal arrays and modification of linear graphs. Introduction to nalysis of variance (ANOVA) – analogy with Fourier analysis, No way ANOVA, one way ANOVA, two way ANOVA, three way ANOVA, signal to noise (S/N) ratio, sum of squares, degrees of freedom, F-test, p-value, pooling, percent contribution, interpretation, examples on ANOVA.

UNIT – III

Control factors and their levels and noise factors. Two level experiments (2K design), blocking and confounding, three level experiments (3K design), mixed level experiments, multiple level experiments, polynomial effects, confirmation experiments, additive models, Latin squares and related designs, case studies.

UNIT – IV

Response surface methodology (RSM) – First order model, second order model, stationary point, central composite design (CCD), Box-Behnken design, Face centered cubic design (FCCD), surface plots. Fitting regression models, model building, adequacy checking of models and case studies.

Textbooks:

1. M. S. Phadake, *Quality Engineering and Robust Design*, Prentice Hall, Englewood Cliffs, New Jersy, 1989.

2. D. C. Montgomery, *Design and analysis of experiment*, Wiley, 5th edition, India, 2005.

Reference Book:

1. P.J. Ross, *Taguchi Techniques for quality engineering*, Tata Mc-Graw Hill, 2nd edition, 2005.

Course Learning Outcomes (COs):

On completion of this course, students will be able to…

- *explain the various types of designs of experiments*
- *selection of the proper design of experiments that suits the application*
- *select control factors, their levels, noise factors and objective functions*
- *learn adjustments and modifications in standard design of experiments*

DESIGN OF HEAT TRANSFER EQUIPMENT

Course Code: **P14DE106A**
Class: M.Tech. I Semester **Branch**: Mech. Engg (Design Engg)

Teaching Scheme:

L	T	P	C
3	1	-	4

Examination Scheme:

Continuous Internal Evaluation:	**40 marks**
End Semester Exam :	**60 marks**

Course Learning Objectives (LOs):
This course will develop students 'knowledge in/on...

- *major types of available heat-exchange equipment, with emphasis on shell-and-tube heat exchangers*
- *how to estimate overall heat transfer coefficients for a shell-and-tube heat exchanger*
- *how to compute pressure drops on both sides of a shell-and-tube heat exchanger*
- *mechanical design of the most appropriate shell-and-tube heat exchanger to meet desired duty and pressure drops*

UNIT I

1. **Design of Heat Exchangers:** Principle, Classification – Applications - Principle of Heat Exchangers. Concept of Overall Heat Transfer Coefficient - Derivation of the concerned equations, Fouling, Factors effecting fouling.
2. **Concept of Logarithmic Mean Temperature Difference**: Derivation for expression for the LMTD, Special Cases, LMTD for a single-pass cross-flow heat exchanger, AMTD, Relation between AMTD and LMTD.

UNIT II

3. **Concept of Effectiveness**: Effectiveness-Number of Transfer Units, Expressions for effectiveness of single-pass parallel-flow and counter-flow heat exchangers, Heat capacity ratio, Chart solutions of Kays and London pertaining to Effectiveness-NTU approach.
4. **Design of Condensers**: Types, Overall Heat Transfer coefficients – temperature distribution and heat flow in a condenser – pressure drop in a condenser – extended fin surfaces – consideration of fouling factor – LMTD – Correction Factor.

UNIT III

5. **Design of Evaporators**: Types - Temperature distribution and heat flow in an evaporator - pressure drop – factors to be considered in the design of heat transfer equipment – types of heat consideration of fouling factor.
6. **Design of Compressors**: Types – equivalent shaft work – volumetric efficiency – factors effecting total volumetric efficiency compound compression with inter cooling –rotary compressors.

UNIT IV

7. **Design of Cooling Tower and Spray Ponds**: Classification – performance of cooling towers – analysis of counter flow cooling towers – enthalpy – temperature diagram of air and water. Cooling ponds – types –cross flow cooling towers – procedure for calculation of outlet conditions

Textbooks:

1. Sadik Kakac and Yaman Yener: Heat Conduction, Hemisphere, 2nd Edition 2001.
2. Kays, W. M. and Crawford, M. E., Convective Heat and Mass Transfer, Tata McGraw Hill, 4th Edition, 2012.

Reference Book:

1. Siegel, R. and Howell, J. R., Thermal Radiation Heat Transfer, Taylor and Francis, 4th Edition, 2002.

Course Learning Outcomes (COs):

On completion of this course, students will be able to…

- *explain the major types of available heat-exchange equipment, with emphasis on shell-and- tube heat exchangers*
- *know how to estimate overall heat transfer coefficients, including the effect of fouling*
- *perform mechanical design of the most appropriate shell-and-tube heat exchanger to meet desired duty and pressure drops*
- *design and analyze the performance of Colling tower and spray ponds*

COMPUTATIONAL FLUID DYNAMICS

Course Code: **P14DE106B**
Class: M.Tech. I Semester **Branch**: Mech. Engg (Design Engg)

Teaching Scheme:

L	T	P	C
3	1	-	4

Examination Scheme:

Continuous Internal Evaluation:	**40 marks**
End Semester Exam :	**60 marks**

Course Learning Objectives (LOs):
This course will develop students 'knowledge in/on...

- *major theories, approaches and methodologies used in CFD*
- *governing equations of fluid flow*
- *actual implementation of CFD methods*
- *applying CFD analysis to real engineering applications*

UNIT-I

1. **Introduction to CFD:** Definition, applications, advantages, limitations and future scope of CFD.

2. **CFD Solution Procedure:** Creation of geometry; meshing; specification of fluid properties; specification of boundary conditions; numerical solution – initialization, solution control, convergence.

UNIT-II

3. **Governing Equations:** Substantial derivative; divergence; continuity equation for - finite control volume fixed in space and moving with the fluid, infinitesimally small element fixed in space and element moving with the flow; momentum equation; energy equation; Navier-Stokes equations; Euler's equations; types of physical boundaries and corresponding conditions;

UNIT-III

4. **Turbulence:** Definition of turbulence; its source; its impact on solution methodology, k-ε two equation model, limitations of turbulence models.

5. **Classification of PDEs** – Hyperbolic, parabolic and elliptic equations; mathematical behavior of PDEs.

UNIT-IV

6. **Discretization:** Introduction to finite difference; finite difference equations, explicit and implicit formulations; consistency; error and stability analysis - von Neumann approach; convergence; Finite difference and Finite volume approach, Direct Numerical Approach.

Textbook:

1. Computational Fluid Dynamics: The Basics with Applications, John D. Anderson, Jr., McGraw-Hill.

Reference Books:

1. Computational Fluid Dynamics: Klaus A. Hoffmann, Steve T. Chiang, Engineering Education System; 4th edition
2. Numerical Heat Transfer and Fluid Flow: Suhas Patankar, Hemisphere Publishing Corporation.

Course Learning Outcomes (COs):

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

- *explain various approaches and methodologies used in CFD*
- *understand the significance of the boundary conditions to various applications*
- *analyze different mathematical models and computational methods for flow simulations*
- *perform flow computations using current best practice for model and method selection, and assessment of the quality of results obtained*

HVAC SYSTEMS & APPLICATIONS

Course Code:
Class: M. Tech. I Semester **Branch**: Mech. Engg (Design Engg)

Teaching Scheme:

L	T	P	C
3	1	-	4

Examination Scheme:

Continuous Internal Evaluation:	**40 marks**
End Semester Exam :	**60 marks**

Course Learning Objectives (LOs):
This course will develop students 'knowledge in/on...

- *principles of thermodynamics, heat transfer and fluid mechanics as applied to heating, ventilating and air-conditioning (HVAC) systems*
- *summer air conditioning and human comfort*
- *design (HVAC) and estimation on cooling loads*
- *realistic HVAC problems through examples and assignments*

UNIT I

1. **Introduction -** Purpose, applications, definition and components of air conditioning - Need and methods of ventilation - Course outline.
2. **Psychrometry -** Evolution of air properties and psychrometric chart - Basic processes such as sensible heating/cooling, humidification/dehumidification and their combinations, steam and adiabatic humidification, adiabatic mixing - Bypass factor and Sensible heat ratio.
3. **AC Equipments -** Air washer, adiabatic, heated and cooled - Cooling tower, enthalpy potential, types, tower efficiency.

UNIT II

4. **Summer and Winter AC** - Simple summer AC process, Room sensible heat factor, Coil sensible heat factor, ADP - Precision AC - Winter AC.
5. **Human Comfort** - Heat transfer from body - Concept of human comfort - Thermal response - comfort factors.

UNIT III

6. **Cooling Load Estimation -** Design conditions, outdoor, indoor - External load, wall, roof, glass - Internal load, occupancy, lighting, equipments - Ventilation, air quantity, loads - Load estimation methods

UNIT IV

7. **Ventilation -** Need, threshold limits of contaminants, estimation of ventilation rates, decay equation, air flow round buildings. Methods of Ventilation.
8. **Ventilation System Design:** Exhaust ducts, Filters, Blowers, Hoods, Chimney.

Textbooks:

1. Heating, Ventilating and Air Conditioning, Analysis and Design, by F.C. McQuiston & J.D. Parker, 2nd ed., John Wiley & Sons, Inc., .

2. Refrigeration and Air conditioning: Arora, C.P., Tata McGraw-Hill Education.

Reference Books:

1. Refrigeration and Air conditioning: Arora S C, Domkundwar S, Pearson Education Canada.
2. Refrigeration and Air Conditioning: Stoecker, W. F., and Jones, J. W., McGraw Hill.
3. Refrigeration and Air Conditioning: Manohar Prasad, New Age International Publishers.

Course Learning Outcomes:

On completion of this course, students will be able to…

- *apply the principles of thermodynamics to mixtures of water vapor and dry air to establish psychrometric properties*
- *analyze the combine basic HVAC processes into various building mechanical systems used in current practice. To understand and be able to evaluate the performance of heat pumps and modes of operation such as defrosting*
- *estimate building heating and cooling loads with basic heat transfer principles*
- *practice ASHRAE recommended building codes to the design ventilation methods for HVAC systems*

ADVANCED FLUID MECHANICS

Course Code: P14DE106D
Class: M.Tech. I Semester **Branch**: Mech. Engg (Design Engg)

Teaching Scheme:

L	T	P	C
3	1	-	4

Examination Scheme:

Continuous Internal Evaluation:	**40 marks**
End Semester Exam:	**60 marks**

Course Learning Objectives (LOs):
This course will develop students 'knowledge in/on...

- *differential equations of fluid mechanics and the impact of assumptions made in the analysis*
- *potential flow equations applied to basic flows*
- *compressible flow equations*
- *compressible fluid flow and its characteristics*

UNIT I

1. Basic Concepts and Fundamentals**,** Definition and properties of Fluids, Velocity and stress field, Fluid statics, Fluid Kinematics.
2. Governing Equations of Fluid Motion, Reynolds transport theorem, Integral and differential forms of governing equations: mass, momentum and energy conservation equations, Navier-Stokes equations, Euler's equation, Bernoulli's Equation.

UNIT II

3. Exact solutions of Navier-Stokes Equations: Couette flows, Poiseuille flows, Fully developed flows in non-circular cross-sections, Unsteady flows, Creeping flows.
4. Laminar Boundary Layers: Boundary layer equations, Boundary layer thickness, on a flat plate, Integral form of boundary layer equations, Approximate Methods.

UNIT III

5. Turbulent Flow**:** General equations of turbulent flow, Turbulent boundary layer equation, Flat plate turbulent boundary layer, Turbulent pipe flow, Prandtl mixing hypothesis, Turbulence modeling, Free turbulent flows

UNIT IV

6. Compressible Flows: Speed of sound and Mach number, Basic equations for one dimensional flows, Isentropic relations, Normal-shock wave, Quasi-one dimensional flows, Compressible viscous flows, Compressible boundary layers

Textbook:

1. Fundamentals of Fluid Mechanics; Bruce R. Munson, Alric P. Rothmayer, Theodore H. Okiishi: John Wiley & Sons, 7th Edition

Reference Books:

1. Fluid Mechanics; A. Mohanty, PHI Learning Pvt. Ltd., 2nd Edition.
2. Theory Appl Fluid Mechanics; K. Subramanyan, Tata Mcgraw-Hill Publishing Company Limited, 1993

Course Learning Outcomes (COs):

On completion of this course, students will be able to…

- *understand the limitations and advantages of various experimental techniques for fluid mechanics, and have a sound understanding of the physics underpinning these techniques*
- *apply contemporary data analysis techniques in the area of fluid mechanics, especially relating to boundary layers*
- *analyze the fundamentals of turbulent fluid flow in flat plate and conducts*
- *analyze the fundamentals of compressible fluid flow with Mach number and its characteristics*

MECHANICAL VIBRATIONS LAB

Course Code: **P14DE107**
Class: M.Tech. I Semester **Branch**: Mech. Engg (Design Engg)

Teaching Scheme:

L	T	P	C
-	-	3	2

Examination Scheme:

Continuous Internal Evaluation:	**40 marks**
End Semester Exam :	**60 marks**

Course Learning Objectives (LOs):
This course will develop students 'knowledge in/on...

- *concept of radius of gyration on bi-filar suspension*
- *engineering systems involving vibration.*
- *importance of dunkerley's rule for beams and damped torsional oscillations, damping coefficient*
- *programming concepts for vibratory models using c++/matlab*

LIST OF EXPERIMENTS
PART –A

1. Determination of Radius of Gyration of giver Bar by using Bi-fillar suspension.
2. Study of undamped free vibrations of equivalent spring mass system
3. Study of Forced vibrations of equivalent spring mass system
4. Study of free vibrations of two rotor shaft system.
5. Study of damped Torsional oscillations.
6. Verification of Dunkerlay's rule.

PART –B

7. To Plot the resulting motion of a mass subjected to two harmonic motions & identify the Beat Frequency.
8. To Plot the time variations of the displacement, velocity & acceleration of the mass in a given spring mass system.
9. To find & plot the free vibration response of a viscously damped system.
10. To find & plot the steady state response of a viscously damped system under harmonic force.
11. To plot the impulse response of a single degree of freedom structure due to a single impact.
12. To plot the impulse response of a double degree of freedom structure due to a single impact.

Exercises from Part B will be solved using MATLAB or C++ during regular class work in each week.

Textbook:

1. Rao, S.S., *Mechanical Vibrations*, Addison Wesley Longman, 1995.

Reference Books:

1. William T. Thomson and Marie Dillon Dahleh, *Theory of Vibration with Applications*, *5/e,* Pearson Education, Singapore, 2003.
2. Meirovich, L. *Elements of Vibration Analysis*, McGraw-Hill, New York, 1986,
3. S. Graham Kelly, *Fundamentals of Mechanical Vibrations, 2/e*, McGraw-Hill, Singapore, 2000.
4. Den Hartog, J.P., *Mechanical Vibrations*, Dover Publications, 1990.

Course Learning Outcomes (COs):

On completion of this course, students will be able to…

- *observe the experimental and theoretical methods of finding radius of gyration*
- *determine the natural frequency and period of simple vibrating mechanical systems*
- *find the natural frequencies of beam at various conditions and then check the dunkeley's rule and determine critical damping factor, logarithmic decrement and damping ratio for torsional oscillations*
- *write the programs for vibratory models using the c++/matlab*

C A D LABORATORY

Course Code: **P14DE108**
Class: M.Tech. I Semester **Branch**: Mech. Engg (Design Engg)

Teaching Scheme:

L	T	P	C
-	-	3	2

Examination Scheme:

Continuous Internal Evaluation:	**40 marks**
End Semester Exam :	**60 marks**

Course Learning Objectives (LOs):
This course will develop students 'knowledge in/on...

- *software packages for drafting and modeling*
- *2D modeling with dimensions from pictorial views using AutoCAD*
- *modeling of universal coupling, knuckle joint, flange coupling, screw jack, etc., using AutoCAD*
- *writing programs using algorithms to generate lines, curves and circles*

LIST OF EXPERIMENTS

PART –A

2-D and 3-D Modelling using AutoCAD, ProE/CATIA

1. 2-D drawing generatin.
2. Layout as per standard.
3. Simple 3 D geometry creation.
4. Complex 3 D generation with Boolean operations.
5. Viewports-Named viewports.
6. Project Work.

PART-B

1. Implementation of Bresenham's Line Algortihm using C / C++
2. Implementation of Bresenham's Circel Algorithm using C / C++
3. Cubic Spline generation using C / C++

Reference Books:

1. AutoCAD 2000, BPB Publications.
2. Learners Manual AutoCAD.

Course Learning Outcomes (COs):

On completion of this laboratory course, students will be able to…

- *operate a CAD Workstation; Understand and apply basic AutoCAD commands*
- *organize & manage AutoCAD related files for 2D and 3D drawings; Create 2D and 3D models using AutoCAD*
- *use modification techniques to edit and modify drawings for presentation and accuracy*
- *develop programs using C/ C++, to generate lines, curves and circles*

SEMINAR

Course Code: **P14DE109**
Class: M.Tech. I Semester **Branch**: Mech. Engg (Design Engg)

Teaching Scheme:

L	T	P	C
-	-	3	2

Examination Scheme:

Continuous Internal Evaluation:	**100 marks**
End Semester Exam :	**-**

Course Learning Objectives (LOs):

This course will develop students 'knowledge in/on...

- *literature review and report writing*
- *presentation skills and speaking with logical sequence & confidence*
- *latest and current trends in technologies*
- *critical thinking*

- There shall be only Continuous Internal Evaluation (CIE) for Seminar, which includes Report Submission & Presentation
- A teacher will be allotted to a student for guiding in
  (i) selection of topic
  (ii) report writing
  (iii) presentation (PPT) before the DPGRC

Course Learning Outcomes (COs):

On completion of this course, the students will be able to...

- *analyze the technical content and prepare a well-documented report*
- *make effective seminar presentation by exhibiting the presentation skills with confidence in a logical sequence*
- *explain the current and upcoming technologies*
- *propose and defend opinions and technical ideas with conviction (not as mere recipient of ideas)*

ADVANCED FINITE ELEMENT ANALYSIS

Course Code: **P14DE201**
Class: M.Tech. II Semester **Branch**: Mech. Engg (Design Engg)

Teaching Scheme:

L	T	P	C
3	1	-	4

Examination Scheme:

Continuous Internal Evaluation:	**40 marks**
End Semester Exam :	**60 marks**

Course Learning Objectives (LOs):
This course will develop students 'knowledge in/on...

- *variational and weighted residual methods and for elasticity problems: apply finite element formulation for solving real time 1-D bar element problems.*
- *Truss element-shape functions and stiffness matrix, load vectors and numerical: beam and frame elements-shape functions, and stiffness matrix, load vectors and numerical problems.*
- *concepts of CST elements applied for plane stress & strain problems: analysis of 2-D heat transfer problems of conduction and convection.*
- *dynamic analysis of systems and iso-parametric concept*

UNIT-I

1. **Formulation Techniques:** Methodology, Engineering problems and governing differential equations, finite elements, Variational methods-potential energy method, Raleigh Ritz method, strong and weak forms, Galerkin and weighted residual methods, calculus of variations, Essential and natural boundary conditions.

2. **One-dimensional finite element methods:** Bar elements, temperature effects. Element matrices, assembling of global stiffness matrix, Application of boundary conditions, Elimination and penalty approaches, solution for displacements, reaction, stresses, temperature effects, Quadratic Element, Heat transfer problems: One-dimensional, conduction and convection problems. Examples: one dimensional fin,

UNIT – II

3. **Trusses:** Element matrices, assembling of global stiffness matrix, solution for displacements, reaction, stresses, temperature effects.

4. **Beams and Frames:** Element matrices, assembling of global stiffness matrix, solution for displacements, reaction, stresses.

UNIT – III

5. **Two dimensional problems:** CST, LST, four noded and eight nodded rectangular elements, Lagrange basis for triangles and rectangles, serendipity interpolation functions. Axisymmetric Problems: Axisymmetric formulations, Element matrices, boundary conditions. Heat Transfer problems: Conduction and convection, examples: two-dimensional fin.

6. **Isoparametric formulation:** Concepts, sub parametric, super parametric elements, numerical integration.

UNIT – IV

7. **Finite elements in Structural Dynamics:** Dynamic equations, eigen value problems, and their solution methods, simple problems.

8. **Convergence:** Requirements for convergence, h-refinement and p-refinement, complete and incomplete interpolation functions, pascal's triangle.

Textbooks:

1. Harold C. Martin, *Introduction to Matrix Methods of Structural Analysis*, McGraw Hill, New York, 1966.
2. Robert D. Cook, David S. Malkus, Michel E. Plesha, Robert J. Witt, *Concepts and Applications of Finite Element Analysis*, 4/e, John Wiley & Sons, Singapore, 2003.

Reference Books:

1. P. Seshu, *TEXTBOOK of Finite Element Analysis,* Prentice Hall of India, New Delhi, 2003.
2. S. Rajasekaran, *Finite Element Analysis in Engineering Design,* S. Chand & Co., New Delhi, 2003.
3. Finite element methods by Chandrubatla & Belagondu.
4. J.N. Reddy, Finite element method in Heat transfer and fluid dynamics, CRC press
5. Zienckiwicz O.C. & R. L. Taylor, Finite Element Method, McGraw-Hill
6. J. N. Oden, Finite Element of Nonlinear continua, McGraw-Hill, New York
7. K. J. Bathe, Finite element procedures, Prentice-Hall

Course Learning Outcomes (COs):

On completion of this course, students will be able to…

- *apply variational and weighted residual methods and for elasticity problems: apply finite element formulation for solving real time 1-D bar element problems*
- *solve real time trusses to find the displacement and reactions and stresses: formulate and solve different types of beam and frame problems*
- *apply the concepts of CST elements for using plane stress & strain problems: analyze 2-Dheat transfer problems of conduction and convection*
- *analyze dynamic behavior of system and apply iso-parametric concept*

COMPOSITE MATERIALS

Course Code: **P14DE202**
Class: M.Tech. II Semester **Branch**: Mech. Engg (Design Engg)

Teaching Scheme:

L	T	P	C
3	1	-	4

Examination Scheme:

Continuous Internal Evaluation:	**40 marks**
End Semester Exam :	**60 marks**

Course Learning Objectives (LOs):

This course will develop students 'knowledge in/on...

- *recent developments in composites, including metal, ceramic and polymer matrix composites and the characteristics of fibers*
- *macro and Micromechanical behavior of lamina and laminates*
- *maximum Stress and Strain Criteria for Tsai-Hill's and Tsai-Wu Failure Criterion*
- *laminate Constitutive Equations and the failure prediction ofmstrength of a laminated composite.*

UNIT-I

1. Introduction to Composite Materials Constituents, Material forms Processing, Applications Definition –Need – General Characteristics, Applications. Fibers – Glass, Carbon, Ceramic and Aramid fibers. Matrices – Polymer, Graphite, Ceramic and Metal Matrices – Characteristics of fibers and matrices.

UNIT-II

2. Macromechanical and Micromechanical behavior of a lamina, Lamina Constitutive Equations:Lamina Assumptions – Macroscopic Viewpoint. Generalized Hooke's Law. Reduction to Homogeneous Orthotropic Lamina – Isotropic limit case, Orthotropic Stiffness matrix (Qij), Typical Commercial material properties, Rule of Mixtures. Generally Orthotropic Lamina – Transformation Matrix, Transformed Stiffness.

3. Basic Assumptions of Laminated anisotropic plates. Laminate Constitutive Equations – Coupling Interactions, Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates, Laminate Structural Moduli, Evaluation of Lamina Properties from Laminate Tests, Quasi-Isotropic Laminates. Determination of Lamina stresses within Laminates.

UNIT-III

4. Introduction - Maximum Stress and Strain Criteria. Von-Misses Yield criterion for Isotropic Materials, Generalized Hill's Criterion for Anisotropic materials, Tsai-Hill's Failure Criterion for Composites, Tensor Polynomial (Tsai-Wu) Failure criterion, Prediction of laminate Failure

5. Equilibrium Equations of Motion. Energy Formulations, Static Bending Analysis, Buckling Analysis. Free Vibrations – Natural Frequencies

UNIT-IV

6. Modification of Hooke's Law due to thermal properties - Modification of Laminate Constitutive Equations. Orthotropic Lamina - special Laminate Configurations – Unidirectional, Off-axis, Symmetric Balanced Laminates - Zero C.T.E laminates, Thermally Quasi-Isotropic Laminates

7. Delamination, Matrix Cracking, and Durability, Interlaminar stresses, Edge effects, Fatigue and fracture, Environmental effects, Introduction to design of composite structures.

Textbook:

1. Jones, R.M., "Mechanics of Composite Materials", McGraw-Hill, Kogakusha Ltd., Tokyo.

Reference Books:

1. Agarwal, B.D., and Broutman, L.J., "Analysis and Performance of Fibre Composites", John Wiley and sons. Inc., New York.
2. Hyer, M.W., "Stress Analysis of Fiber – Reinforced Composite Materials", McGraw-Hill.
3. Mechanics of Composite Materials, Autar K. Kaw, 2nd ed., CRC Press.
4. Engineering Mechanics of Composite Materials, I. M. Daniel, O. Ishai, Oxford University Press.

Course Learning Outcomes (COs):

On completion of this course, students will be able to…

- *explain the concepts of composite materials and Develop and processing of metal- matrix, ceramic -matrix and polymer-matrix composites*
- *analyze macro and micro mechanical behavior of a lamina*
- *analyze the Maximum Stress and Strain Criteria for Tsai-Hill's and Tsai-Wu Failure*
- *modify Laminate Constitutive Equations and predict the failure strength of a laminated composite*

ADVANCED DESIGN OF MACHINE COMPONENTS

Course Code: **P14DE203**
Class: M.Tech. II Semester **Branch**: Mech. Engg (Design Engg)

Teaching Scheme:

L	T	P	C
3	1	-	4

Examination Scheme:

Continuous Internal Evaluation:	**40 marks**
End Semester Exam :	**60 marks**

Course Learning Objectives (LOs):
This course will develop students 'knowledge in/on...

- *stresses and strain calculations in machine elements and structures subjected to various loads.*
- *tolerance analysis and specify appropriate tolerances for machine design applications.*
- *multidimensional static failure criteria in the analysis and design of mechanical components.*
- *multidimensional fatigue failure criteria in the analysis and design of mechanical components.*

UNIT - I

Introduction to Advances in Mechanical Engineering Design. Review of materials & processes for design of machine elements.

UNIT - II

Static strength failure analysis -theories of failure, High cycle and low cycle fatigue design of shafting and gears, design of rolling contact bearings.

UNIT - III

Design for creep. Combined creep and fatigue failure prevention. Design to prevent buckling and instability, Design of sliding bearings and mechanical seals, Study of lubrication systems.

UNIT - IV

Design for corrosion, wear, Design of Brakes, Clutches, springs. Aesthetic and ergonomic consideration in design of products**,** Shape, features , materials and finishes, Relation between man, machine and environmental factors.

Textbook:

1. Norton L. R., "Machine Design – An Integrated Approach" Pearson Education, 2005.

Reference Books:

1. Fundamentals of Machine Component Design Robert C. Juvinall, Kurt M. Marshek, John Wiley & Sons
2. Maitra G.M., "Hand Book of Gear Design", Tata McGraw Hill, 1985.
3. Joseph E. Shigley, Charles R. Mischke, Richard G. Budynas, "Mechanical Engineering Design", McGraw Hill, 2004.
4. P.S.G. Tech., "Design Data Book", Coimbatore, 2003.

Course Learning Outcomes (COs):

On completion of this course, students will be able to…

- *analyze and design structural joints*
- *analyze and design power transmission shafts carrying various elements with geometrical features*
- *analyze and design mechanical springs*
- *apply standards, safety, reliability, importance of dimensional parameters and Tribological aspects in mechanical design*

AUTOMATION AND ROBOTICS

Course Code: **P14DE204**
Class: M.Tech. II Semester **Branch**: Mech. Engg (Design Engg)

Teaching Scheme:

L	T	P	C
3	1	-	4

Examination Scheme:

Continuous Internal Evaluation:	**40 marks**
End Semester Exam :	**60 marks**

Course Learning Objectives (LOs):
This course will develop students 'knowledge in/on...

- *automation principles, strategies, flow lines and material handling and storage system.*
- *basic elements of control system and NC &CNC, AS/RS automated inspection.*
- *basics of robotics and robot arm kinematics.*
- *control of robot manipulators and vision and sensing*

UNIT - I

1. Manufacturing Automation: Introduction, Types of automations, automation strategies. Automated flow lines and automated assembly systems. Automated Material Handling and Storage system: Conveyors, AGVs, AS/RS and identification & data collections systems.

UNIT - II

2. Automated Manufacturing Systems: Introduction to NC, CNC & DNC and Adaptive control. Programmable Logic Controllers: logic control and sequencing elements. Automated Inspection Systems: CMM, Machine Vision, flexible inspection systems.

UNIT - III

3. Basic concepts in robotics: classification of robotics, Drives and control system for robotics, Robot work cell design and applications**.** Robot arm kinematics: Direct kinematics, transformation matrices for rotations, combined rotations, Denavit -Hartenberg representation.

UNIT - IV

4. Control of robot manipulators: control of robot arm, computed torque technique, feedback control, resolved motion control. Robot vision and sensing: Different types of sensors, proximity, touch, force and torque sensors, low level and high level vision, vision systems

Textbooks:

1. K.S. Fu, R.C. Gonzalez, C.S.G. Lee, *Robotics*, McGraw Hill, 1987.
2. M.P.Groover, "Automation, Production Systems and Computer Integrated Manfucaturing", PHI, New Delhi.

Reference Books:

1. Y.Koren, *Robotics for Engineers,* McGraw Hill, 1985.
2. J.J. Craig, *Robotics,* Addison-Wesley, 1986.

Course Learning Outcomes (COs):

On completion of this course, students will be able to…

- *explain Principle of automation, material handling and storage system*
- *exemplify basic element of control and NC Systems*
- *implement advanced algebraic tools like D-H representation for the description of motion of robot*
- *describe control of robot manipulators and vision and sensors*

FAULT DIAGNOSIS OF MACHINES

Course Code: **P14DE205A**
Class: M.Tech. II Semester **Branch**: Mech. Engg (Design Engg)

Teaching Scheme:

L	T	P	C
3	1	-	4

Examination Scheme:

Continuous Internal Evaluation:	**40 marks**
End Semester Exam :	**60 marks**

Course Learning Objectives (LOs):
This course will develop students 'knowledge in/on...

- *preventive maintenance program*
- *instrumentation for recording and analysis in vibrations*
- *detailed diagnostic monitoring*
- *various data processing and vibration analysis methods for performance monitoring of machines*

UNIT-I

1 **Introduction**: System failure, component failure, failure decisions, failure classifications, types of failure, failure investigations, causes of failure, Various methods of maintenance

2 **Condition Monitoring**: Need and importance of condition monitoring, common monitoring techniques, online/off-line monitoring, commonly measured operating characteristics, condition monitoring as used in industry.

UNIT-II

3 **Transducers and Instrumentation for Recording and Analysis**: Vibration transducers, Displacement transducers, velocity pickups, accelerometers, Temperature transducers, Vibration meters, FFT analyzers, Time domain instruments, Tracking analyzers, Magnetic tape recorders, amplifiers.

UNIT-III

4 **Analyzing Machine Condition**: General characteristics-Process measurements, vibration. Typical vibration sources, symptoms of other common machinery problems. Development and use of acceptance limits-guide lines and limits based on physical constraints, Vibration severity criteria, changing machinery condition-time trends, statistical limits, detailed diagnostic monitoring.

UNIT-IV

5 **Data Processing & Vibration Analysis**: Fourier analysis, frequency analysis techniques, vibration signature, vibration monitoring equipment, system monitors and vibration limit detectors. Primary and secondary performance parameters, performance monitoring systems.

Textbooks:

1. Collacott, R.A., *Mechanical Fault Diagnosis and Condition Monitoring,* Chapman and Hall, London, 1977.
2. John S.Mitchell: *Introduction to Machinery Analysis and Monitoring,* 2/e, Pennwell Books, Oklahama.

Refrence Books:

1. Trever M. Hunt, *Condition Monitoring of mechanical & Hydraulic Plant* A concise introduction and guide, Chapman & Hall, Madras
2. Philip Wild, *Industrial Sensors and applications for Condition Monitoring*, Mechanical Engineering Publications Ltd., London
3. Joseph Mathew, *Common Vibration Monitoring Techniques – handbook of Condition Monitoring*, Chapman & Hall, 1998

Course Learning Outcomes (COs):

On completion of this course, students will be able to…

- *explain preventive maintenance*
- *analyze Machine Condition*
- *perform Vibration Analysis*
- *apply various data processing and vibration analysis methods for performance monitoring of machines*

FATIGUE, FRACTURE AND FAILURE ANALYSIS

Course Code: **P14DE205B**
Class: M.Tech. II Semester **Branch**: Mech. Engg (Design Engg)

Teaching Scheme:

L	T	P	C
3	1	-	4

Examination Scheme:

Continuous Internal Evaluation:	**40 marks**
End Semester Exam :	**60 marks**

Course Learning Objectives (LOs):
This course will develop students 'knowledge in/on...

- *Provide an understanding of the mechanics and micro-mechanisms of elastic and plastic deformation.*
- *Provide practical examples of the application of fracture mechanics to design and life prediction methods and reporting.*
- *Appraise Linear elastic fracture mechanics.*
- *Acquire knowledge on Investigation and analysis of failures*

UNIT-I

1. Introduction to fatigue and fracture mechanics, ductile and brittle fractures. Mechanism of fatigue crack initiation and propagation, fatigue data representation,

UNIT-II

2. Factors influencing fatigue strength, life prediction, prevention of fatigue failures, corrosion fatigue.

UNIT-III

3. Linear elastic fracture mechanics, determination of fracture toughness, elastic plastic fracture mechanics, sub-critical growth in reactive environment.

UNIT-IV

4. Fatigue and fracture safe designs. Investigation and analysis of failures, case studies in fatigue and fracture mechanics.

Textbook:

1 S.T. Rolfe and J.M. Barsom, *Fracture and Fatigue Control in Structure*, Prentice Hall, 1977.

Reference Books:

1. D.Broek, Elementary Engineering Fracture Mechanics, Noordhoff, 1975.
2. S,Kocanda: Fatigue failure of Metals, Synthofford Noordhoff, 1978.

3. N.E. Fros, et al. Metal fatigue, Clarendon Press, 1974.
4. American Society for Metals, Case histories in failure analysis, ASM, 1979.

Course Learning Outcomes (COs):

On completion of this course, students will be able to…

- *analyze the mechanics and micro-mechanisms of elastic and plastic deformation*
- *apply practical examples of fracture mechanics to design and life prediction methods*
- *appraise Linear elastic fracture mechanics*
- *apply knowledge on Investigation and analysis of failures*

VIBRATIONS OF CONTINUOUS SYSTEMS& NOISE CONTROL

Course Code: **P14DE205C**
Class: M.Tech. II Semester **Branch**: Mech. Engg (Design Engg)

Teaching Scheme:

L	T	P	C
3	1	-	4

Examination Scheme:

Continuous Internal Evaluation:	**40 marks**
End Semester Exam :	**60 marks**

Course Learning Objectives (LOs):
This course will develop students 'knowledge in/on...

- *continuous Systems*
- *comparison of different Mode Summation Procedures for Continuous Systems*
- *Sound Level & Response*
- *engineering noise and control*

UNIT-I

1. **Continuous Systems:** Introduction, Vibration of strings, longitudinal vibrations of bars, torsional vibration of rods, transverse vibration of beams, suspension bridge as continuous system, Euler equation for beams, system with repeated identical sections.

UNIT-II

2. **Mode Summation Procedures for Continuous Systems:** Mode Summation method, Normal Modes of constrained structures, Mode acceleration method, Component-Mode Synthesis.

UNIT-III

3. **Sound Level &Response:** Introduction, Subjective response to sound, frequency dependent human response to sound, sound-pressure dependent human response, Decibel Scale, Sound Power, Sound Intensity and Sound Pressure Level, sound spectra, various sound fields, octave band analysis, Loudness, Weighting Networks and Equivalent Sound level .

UNIT-IV

4. Major Sources of Noise, Noise Standards and Limits, Noise Survey Techniques, Measurement Technique for Vehicular Noise, Noise due to Construction Equipments and Domestic Appliances, Industrial Noise sources, Industrial Noise Control-Strategies, Noise Control at the Source, Noise Control along the path, Acoustic Barriers, Noise Control at the receiver.

Textbooks:

1. Mechanical Vibrations and Noise Engineering, A.G.Ambekar, Eastern Economy Edition, Prentice -Hall India.

2. Theory of Vibration with applications, William T. Thomson, Marie Dillon Dahleh, Chandramouli Padmanabhan; Pearson Education.

Reference Books:

1. Peter Hagedorn and Anirvan DasGupta: Vibrations and Waves in Continuous Mechanical Systems, Wiley, 2007
2. Leonard Meirovitch: Analytical Methods in Vibrations, The Macmillan Co., 1967
3. S.S. Rao: Vibration of Continuous Systems, Wiley, 2007

Course Learning Outcomes (COs):

On completion of this course, students will be able to…

- *explain Continuous Systems*
- *compare different Mode Summation Procedures for Continuous Systems*
- *explain Sound Level & Response*
- *explain about engineering noise and control*

DESIGN OF PRESSURE VESSELS AND PIPING

Course Code: **P14DE205D**
Class: M.Tech. II Semester **Branch**: Mech. Engg (Design Engg)

Teaching Scheme:

L	T	P	C
3	1	-	4

Examination Scheme:

Continuous Internal Evaluation:	**40 marks**
End Semester Exam :	**60 marks**

Course Learning Objectives (LOs):
This course will develop students 'knowledge in/on...

- *engineering problems involved in the design of pressure vessel.*
- *procedure to design pressure vessels.*
- *buckling and fracture analysis of pressure vessel under various load conditions*
- *piping, piping layout and designing of pipes*

UNIT-I

1. **Introduction:** Methods for determining stresses – Terminology and Ligament Efficiency – Applications.

2. **Stresses in Pressure Vessels:** Introduction – Stresses in a circular ring, cylinder – Membrane stress Analysis of Vessel Shell components – Cylindrical shells, torspherical Heads, conical heads – Thermal Stresses – Discontinuity stresses in pressure vessels.

UNIT-II

3. **Design of Vessels: Localized stresses and their significance** – stress concentration – at a variable Thickness transition section in a cylindrical vessel, about a circular hole, elliptical openings. Theory of Reinforcement – pressure vessel Design.

UNIT-III

4. **Supports for Vessels**: introduction, bracket or lug supports, leg supports, skirt supports, saddle supports.

5. **Buckling and Fracture Analysis in Vessels:** Buckling phenomenon – Elastic Buckling of circular ring and cylinders under external pressure – collapse of thick walled cylinders or tubes under external pressure.

UNIT-IV

6. **Buckling:** Effect of supports on Elastic Buckling of Cylinders – Buckling under combined External pressure and axial loading.

7. **Piping:** Introduction – Flow diagram – piping layout and piping stress Analysis.

Textbooks:

1. John F.Harvey, *Theory and Design of Pressure Vessels,* CBS Publishers and Distributors, 1987.

2. M.V. Joshi, *Process Equipment Design,* Macmillan India Ltd.

Reference Books:

1. Henry H.Bedner, *Pressure Vessels*, Design Hand Book, CBS Publishers and Distributors, 1987.
2. Stanley, M.Wales, *Chemical process equipment, selection and Design*, Butterworths series in Chemical Engineering, 1988.
3. 4.William J., Bees, *Approximate Methods in the Design and Analysis of Pressure vessels and Piping*, Pre ASME Pressure Vessels and Piping Conference, 1997.

Course Learning Outcomes (COs):

On completion of this course, students will be able to…

- *understood the concepts of various types of pressure vessels and their applications*
- *design different types of pressure vessels*
- *be thorough with bucking and fracture analysis of pressure vessels and their components*
- *gain knowledge on the concepts of piping and stress analysis of piping*

ADVANCED MATERIALS SCINECE

Course Code: **P14DE206A**
Class: M.Tech. II Semester **Branch**: Mech. Engg (Design Engg)

Teaching Scheme:

L	T	P	C
3	1	-	4

Examination Scheme:

Continuous Internal Evaluation:	**40 marks**
End Semester Exam :	**60 marks**

Course Learning Objectives (LOs):
This course will develop students 'knowledge in/on...

- *fundamentals of dynamic multilevel microstructure*
- *structural modifications and mechanical behavior of materials*
- *processing and characterization of composites*
- *materials performance requirements and suitable surface treatment*

UNIT-I

1. **Introduction to Engineering Materials:** Types of materials, material engineering Structures of solids, crystalline materials, formation crystal structures, Determination of structure, Defects in materials, their classification and significance. Effects of defects on properties.
2. **Non-crystalline Solids:** Types and their structures, Importance of non-crystalline structure, Role of bonding on structures, Multi component phases and their structures. Effect of various factors on phase formation, phase diagrams and their significance. Non-equilibrium structures.

UNIT-II

3. **Structural Modifications:** Atomic movement in solid state, Transformation kinetics, tailoring of macrostructures, Typical heterogeneous transformations.
4. **Mechanical behavior of Materials:** Introduction, deformation processes. Fatigue, creep and Fracture and their behavior. Determination of properties of materials.

UNIT-III

5. **Composite Materials:** Introduction, Principle, classification, Materials for reinforcement and matrix, their characteristics, processing techniques for composites, Micro-mechanics of composites, Mechanical properties of composites, Applications of composites.

UNIT-IV

6. **Surface Engineering:** Surface cleaning and finishing, surface plantings, Conversion coating, shard facing, thermal spraying, diffusion processes, Special surface treatments, organic coatings, process selection
7. **Materials Selection:** Design process, selection factors, Materials for typical machine components, Selection case histories.

Textbooks:

1. V.S.R. Murthy, AK. Jena, K.P. Gupta and G.S.Murthy, *Structure and properties of Engineering Materials,* Tata McGraw-Hill Publishing Company, 2003.
2. Kenneth G. Budinski, Michael K. Budinski, *Engineering Materials properties and Selection, 7/e,* Prentice Hall of India, 2003.

Reference Books:

1. William D. Callister, Jr, *Materials, Science and Engineering: An Introduction, 6/e,* John Wiley & Sons, 2004.
2. Donald R. Askeland *A Science of Engineering Materials,* University of Missouri, Rolla.

Course Learning Outcomes (COs):

On completion of this course, students will be able to…

- *get the knowledge of the dynamic nature of all structure, including materials*
- *apply Knowledge of structural modifications and mechanical behavior of materials*
- *explain knowledge on processing and characterization of composites*
- *describe the materials performance requirements and suitable surface treatment*

MEMS AND NANOTECHNOLOGY

Course Code: **P14DE206B**
Class: M.Tech. II Semester **Branch**: Mech. Engg (Design Engg)

Teaching Scheme:

L	T	P	C
3	1	-	4

Examination Scheme:

Continuous Internal Evaluation:	**40 marks**
End Semester Exam :	**60 marks**

Course Learning Objectives (LOs):

This course will develop students 'knowledge in/on...

- *recent development of the science and technology of micro- and nano-systems*
- *operation principles and design of micro Systems*
- *different materials used for MEMS and microsystems*
- *microsystems design and Packaging and Nanotechnology*

UNIT-I

1. Overview of MEMS and Microsystems: Typical MEMS and Micro-system products. Evolution of Micro-fabrication, Microsystems and Miniaturization. Applications of Microsystems in Industrial products, applications in Telecommunications.

2. Working Principles of Microsystems: Micro-sensors, Micro-actuation, MEMS with Micro-actuators, Micro accelerators, Micro-fluidics.

UNIT-II

3. Engineering Science for Microsystems Design: Ions and Ionization, Doping of Semiconductors, the Diffusion process, Plasma physics, Electrochemistry, Quantum Physics. Micro-system Fabrication Processes: Photolithography, Ion implantation, Diffusion, Oxidation, Chemical vapor deposition, Physical vapor Deposition-Sputtering, Deposition by Epitaxy, Etching. Overview of Micro-manufacturing-Bulk micro-manufacturing, Surface micromachining, the LIGA process.

UNIT-III

4. Materials for MEMS and Microsystems: Substrates and Wafers, Active Substrate Materials, Silicon compounds, Silicon Piezo resistors, Gallium Arsenide, Quartz, Piezoelectric crystals, Polymers, Packaging Materials.

5. Scaling Laws in Miniaturization: Scaling in Geometry, Scaling in Rigid-Body Dynamics, Scaling in Electrostatic forces, Electromagnetic forces, Electricity, Fluid Mechanics, Heat Transfer.

UNIT-IV

6. Microsystems Design and Packaging: Design considerations, Process Design, Mechanical Design, Mechanical Design using FEM, Design of a Silicon Die for a micro-pressure sensor, Design of Micro-fludic Network systems. Essential packaging Technologies. Selection of packaging Materials, Signal Mapping and Transduction.

7. Nanotechnology, Nanomachines, Nanorobots, Nanotubes, Nanowires, Nanomechanical amplifiers, Nanotransisters, tera-storage devices, Molecular engineering, DNA computing, Nanomedicine, Smart pills, Nanofabrication of structures.

Textbook:

1. T-R. Hsu, *MEMS & Microsystems: Design and Manufacture,* Tata McGraw-Hill, New Delhi, 2002.

Reference Books:

1. M.E.lwenspoek and R. Wiegerink, *Mechanical Microsensors*, Springer-Verlag, 2001
2. G.T.A. Kovacs, *Micromachined Transducers Source Book,* McGraw-Hill, 1998.
3. S.D. Senturia, *Microsystem Design*, Kluwer, 2001.
4. *http;//www.wpi.edu/~chslt*
5. K. Eric Drexler, *Nanosystems: Molecular Machinery, Manufacturing, and Computation*, John Wiley, New York, 2002.
6. Charles P. Poole, Jr., Frank J. Owens, *Introduction to Nanotechnology*, John Wiley, 2002.

Course Learning Outcomes (COs):

On completion of this course, students will be able to…

- *explain the operation of micro devices, micro systems and their applications*
- *design the micro devices, micro systems using the MEMS fabrication process*
- *explain different materials used for MEMS and microsystems*
- *explain Microsystems Design and Packaging and Nanotechnology*

SMART STRUCTURES

Course Code: **P14DE206C**
Class: M.Tech. II Semester **Branch**: Mech. Engg (Design Engg)

Teaching Scheme:

L	T	P	C
3	1	-	4

Examination Scheme:

Continuous Internal Evaluation:	**40 marks**
End Semester Exam :	**60 marks**

Course Learning Objectives (LOs):
This course will develop students 'knowledge in/on...

- *working principle of advanced smart structures including failure mechanisms*
- *different Sensing Technologies used in smart structures*
- *different Actuator techniques used in smart structures*
- *different Signal processing and control of smart structures*

UNIT – I

1. **Smart structures and Materials:** Definitions, instrumented materials-basic considerations, functions and responses, structural responses, sensing systems, self-adiagnosis, signal processing considerations, Actuating systems and effectors, applications.

UNIT – II

2. **Sensing Technologies:** Specifications and terminology for sensors in smart structures, physical measurements-piezoelectric strain measurement, inductively read transducers-the LVDT, fiber optic sensing techniques.

UNIT – III

3. **Actuator techniques:** Mechanical impedance, conversion efficiencies and matching. Actuators and actuator materials, piezo electric and electro restrictive materials, magneto-restrictive materials, shape memory alloys, electro-rheological fluids, electromagnetic actuation.

UNIT – IV

4. **Signal processing and control of smart structures:** Sensors as geometrical processors, signal processing, control systems, the linear and the non-linear. Smart structures-Some applications: Smart composites, Mechanical analysis and self testing structures.

Textbook:

1. Culshaw B., *Smat Structures and Materials*, Artec House, Boston, 1996.

Reference Books:

1. Gandhi M.V., and Thompson, *Smart Structures and Materials,* Chapman & Hall, New York, 1992.
2. Banks, H.T., Smith, R.C. and Wang, Y., *Smart Material Structures: Modeling, Estimation and Control,* John Wiley & Sons, New York, 1996.

3. Srinivasan, A.V. and Michael Me Farland, D., *Smart Structures: Analysis and Design,* Cambridge University Press, Cambridge, 2001.

Course Learning Outcomes (COs):

On completion of this course, students will be able to…

- *explain the working principle of advanced smart structures including failure mechanisms*
- *implement different Sensing Technologies used in smart structures*
- *adopt different Actuator techniques used in smart structures*
- *illustrate different Signal processing and control of smart structures*

INDUSTRIAL TRIBOLOGY

Course Code: **P14DE206D**
Class: M.Tech. II Semester **Branch**: Mech. Engg (Design Engg)

Teaching Scheme:

L	T	P	C
3	1	-	4

Examination Scheme:

Continuous Internal Evaluation:	**40 marks**
End Semester Exam :	**60 marks**

Course Learning Objectives (LOs):
This course will develop students 'knowledge in/on...

- *basic theories of friction, wear and lubrication to predict the frictional behavior of commonly encountered sliding interfaces*
- *features of rough surface & liquid lubricants and mechanism of pressure development in oil film*
- *modeling of systems as hydrostatic, squeeze film and elasto-hydrodynamic lubrication as infinite and later finite structures.*
- *gas (air) lubricated and rolling contact type motions with deformation at contact as special systems*

UNIT-I

1. **INTRODUCTION:** Defining Tribology, Tribology in Design - Mechanical design of oil seals and gasket, Tribological design of oil seals and gasket, Tribology in Industry (Maintenance), Defining Lubrication, Basic Modes of Lubrication, Properties of Lubricants, Lubricant Additives, Defining Bearing Terminology - Sliding contact bearings ,Rolling contact bearings Comparison between Sliding and Rolling Contact Bearings

2. **FRICTION and WEAR:** Friction - Laws of friction - Friction classification - Causes of Friction, Theories of Dry Friction, Friction Measurement, Stick-Slip Motion and Friction Instabilities, Wear - Wear classification - Wear between solids – Wear between solid and liquid - Factors affecting wear – Measurement of wear, Theories of Wear, Approaches to Friction Control and Wear Prevention, Boundary Lubrication, Bearing Materials and Bearing Construction

UNIT-II

3. **LUBRICATION of BEARINGS:** Mechanics of Fluid Flow - Theory of hydrodynamic lubrication -Mechanism of pressure development in oil film. Two Dimensional Reynolds's Equation and its Limitations, Idealized Bearings, Infinitely Long Plane Fixed Sliders, Infinitely Long Plane Pivoted Sliders,Infinitely Long Journal Bearings, Infinitely Short Journal Bearings,Designing Journal Bearing - Sommerfeld number - Raimondiand Boyd method - Petroff's Solution - Parameters of bearing design - Unit pressure Temperature rise - Length to diameter ratio - Radial clearance - Minimum oil-film thickness

4. **HYDRODYNAMIC THRUST BEARING:** Introduction, Pressure Equation , Load , Center of Pressure , Friction - Flat plate thrust bearing - Tilting pad thrust bearing

UNIT-III

5. **HYDROSTATIC and SQUEEZE FILM LUBRICATION:** Hydrostatic Lubrication - Basic concept - Advantages and limitations - Viscous flow through rectangular slot – Load carrying capacity and flow requirement - Energy losses -Optimum design. Squeeze Film Lubrication - Basic concept - Squeeze action between circular and rectangular plates - Squeeze action under variable and alternating loads, Application to journal bearings, Piston Pin Lubrications
6. **ELASTO-HYDRODYNAMIC LUBRICATION:** Principles and Applications, Pressure viscosity term in Reynolds's equation, Hertz's Theory, Ertel-Grubin equation, Lubrication of spheres, Gear teeth bearings, Rolling element bearings

UNIT-IV

7. **GAS (AIR) LUBRICATED BEARINGS:** Introduction, Merits, Demerits and Applications, Tilting pad bearings, Magnetic recording discs with flying head, Hydrostatic bearings with air lubrication, Hydrodynamic bearings with air lubrication, Thrust bearings with air lubrication
8. **TRIBOLOGICAL ASPECTS of ROLLING MOTION:**The mechanics of tyre-road interactions, Road grip and rolling resistance, Tribological aspects of wheel on rail contact
9. **FINITE BEARINGS:** Hydrostatic bearings, Hydrodynamic bearings, Thrust oil bearings, Porous Bearings, Foil bearings, Heat in bearings

Textbooks:

1. Fundamentals of Tribology, Basu, SenGupta and Ahuja/PHI
2. Tribology in Industry, Sushil Kumar Srivatsava, - S. Chand &Co.

Reference Books:

1. Tribology, B.C. Majumdar, - Tata McGraw Hill Co Ltd.
2. Introduction to Tribology Halling , - Wykeham Publications Ltd.
3. Tribology H.G.Phakatkar and R.R.Ghorpade - Nirali Publications

Course Learning Outcomes (COs):

On completion of this course, students will be able to…

- *apply the basic theories of friction, wear and lubrication to predictions about the frictional behavior of commonly encountered sliding interfaces*
- *characterize features of rough surface and liquid lubricants as they pertain to interface Sliding and Mechanism of pressure development in oil film*
- *model systems as hydrostatic, squeeze film and elasto-hydrodynamic lubrication as infinite and later finite structures*
- *analyze gas (air) lubricated and rolling contact type motions with deformation at contact as special systems*

FEM LAB

Course Code: **P14DE207**
Class: M.Tech. II Semester **Branch**: Mech. Engg (Design Engg)

Teaching Scheme:

L	T	P	C
-	-	3	2

Examination Scheme:

Continuous Internal Evaluation:	**40 marks**
End Semester Exam :	**60 marks**

Course Learning Objectives (LOs):
This course will develop students 'knowledge in/on...

- *applying the knowledge of fem to construct finite element models using the library of finite elements available in the software; choosing suitable number of finite elements for the given domain to carry out analysis.*
- *using the appropriate type of boundary conditions for the given problem.*
- *solving the problem using commercially available software (solver).*
- *comparison of the results obtained using FEA with analytical or experimental techniques.*

List of Exercises

Part A:

Students will be allotted individual course projects that involve development of code using MATLAB. At the end of the Semester, each student will be required to present the results of the problem obtained from the code.

Part B:

1. Statically indeterminate reaction force analysis
2. Beam stresses and deflections
3. Thermally loaded support structure
4. Deflection of a hinged support
5. Residual stress problem
6. Combined bending and torsion
7. Bending of a solid beam(Plane elements)
8. Tie rod with lateral loading
9. Thermal structural contact of two bodies
10. Stresses in a long cylinder

Exercises from Part B will be solved using ANSYS package during regular class work in each week.

Reference Books:

1. **Chandrupatla, T.R. and Belegundu, A.D.,** *Introduction to finite Elements in Engineering, 2/e,* Pearson Education, New Delhi, 2003.
2. ANSYS 5.6, Verification Manual.
3. ANSYS Structural Analysis Guide.

Course Learning Outcomes (COs):

On completion of this course, students will be able to....

- *interpret the steps involved in solving a given analysis problem and understand the procedure for carrying out engineering analysis.*
- *use the software for doing the analysis and simulation.*
- *compare the results obtained with other methods of analysis.*
- *plan to carry out number of iterations by changing the parameters involved in FEA software.*

P14DE208 AUTOMATION & ROBOTICS LAB

Course Code: **P14DE208**
Class: M.Tech. II Semester **Branch**: Mech. Engg (Design Engg)

Teaching Scheme:

L	T	P	C
-	-	3	2

Examination Scheme:

Continuous Internal Evaluation:	**40 marks**
End Semester Exam :	**60 marks**

Course Learning Objectives (LOs):
This course will develop students 'knowledge in/on...

- *writing programs to operate various actuators in closed loop and open loop systems*
- *writing programs to integrate the input and output devices*
- *simulation of robot motion*
- *simulation of manufacturing and material handling systems*

LIST OF EXPERIMENTS

1. Controlling of AC Non Servo motors using LS controller
2. Controlling of DC Servo motors using LS controller
3. Integration of PLC and PMC.
4. Simulation of Robot Motion using Robo X software
5. Study of Automated machines.
6. Simulation of Manufacturing and Material handling systems.

Course Learning Outcomes (COs):
On completion of this course, students will be able to…

- *estimate the performance of AC Non servo synchronous motors and dc motors in both open and closed loop systems*
- *analyze the performance of integrated system (ac non servo synchronous motors and dc motors integrated with sensors*
- *apply Simulation of robot motion*
- *apply simulation of manufacturing and material handling systems*

COMPREHENSIVE VIVA -VOCE

Course Code: **P14DE209**
Class: M.Tech. II Semester **Branch**: Mech. Engg (Design Engg)

Teaching Scheme:

L	T	P	C
-	-	3	2

Examination Scheme:

Continuous Internal Evaluation:	**-**
End Semester Exam :	**100 marks**

There shall be only external oral examination for Comprehensive Viva-voce on a pre-notified date. The oral examination shall cover the entire content of courses covered in First and Second Semesters.

INDUSTRIAL TRAINING

Course Code: **P134DE301**
Class: M.Tech. III Semester **Branch**: Mech. Engg (Design Engg)
Duration: 8weeks

Teaching Scheme:

L	T	P	C
-	-	3	4

Examination Scheme:

Continuous Internal Evaluation:	**100 marks**
End Semester Exam :	**60 marks**

- M.Tech. Coordinator in consultation with the Training & Placement Section has to procure training slots, for the students before the last day of instruction of 2nd semester.
- The students shall confirm their training slots by the last day of 2nd semester
- The students after 8 weeks Industrial Training shall submit a certificate, a report in the prescribed format before the last date specified by the Department Post Graduate Review Committee (DPGRC). The DPGRC shall evaluate their submitted reports and oral presentations.

P14DE302 DISSERTATION

Course Code: **P134DE302**
Class: M.Tech. III Semester

Branch: Mech. Engg (Design Engg)
Duration: 16Weeks

Teaching Scheme:

L	T	P	C
-	-	3	8

Examination Scheme:

Continuous Internal Evaluation:	**100 marks**
End Semester Exam :	**-**

Course Learning Objectives (LOs):
This course will develop students 'knowledge in/on...

- *problem based and project based learning*
- *major project design in one of the selected areas of specialization with Substantial multi-disciplinary component*
- *analytical and research skills*
- *team work, leadership and interpersonal skills*

Continuous Internal Evaluation (CIE) for Dissertation:

- **Dissertation** shall be normally conducted in two stages, spread over two sequential semesters i.e. third and fourth semester.
- **Registration Seminar** shall be arranged within four weeks after completion of the Industrial Training and Seminar in the 3rd semester. The Registration Seminar shall include a brief report and presentation focusing the identified topic, literature review, time schedule indicating the main tasks, and expected outcome.

Progress Seminar-I: At the end of first stage (third semester), student shall be required to submit a preliminary report of work done for evaluation to the project coordinator and present the same before the DPGRC. The Continuous Internal Evaluation (CIE) for the third semester is as follows:

Assessment	Weightage
Dissertation Supervisor Assessment	50%
DPGRC Assessment	50%
Total Weightage:	**100%**

Course Learning Outcomes (COs):
On completion of this course, the students will be able to.....

- *demonstrate creativity in the design of components, systems or processes of their program of study*
- *design an innovative product by applying current knowledge and adopt to emerging applications of engineering & technology*
- *work cooperatively with others to achieve shared goal by motivating team-mates with a clear sense of direction, values and ethics,*
- *write concisely & convey meaning in a manner appropriate to different readers and verbally express ideas easily understood by others who are unfamiliar with the topic*

P14DE401 DISSERTATION & VIVA-VOCE

Course Code: **P14DE401**
Class: M.Tech. IV Semester

Branch: Mech. Engg (Design Engg)
Duration: 24 weeks

Teaching Scheme:

L	T	P	C
-	-	3	12

Examination Scheme:

Continuous Internal Evaluation:	**40 marks**
End Semester Exam :	**60 marks**

Course Learning Objectives (LOs):
This course will develop students 'knowledge in/on...

- *problem based and project based learning*
- *major project design in one of the selected areas of specialization with Substantial multi-disciplinary component*
- *analytical and research skills*
- *team work, leadership and interpersonal skills*

- **Progress Seminar-II** shall be arranged during the 6th week of IV semester.
- **Progress Seminar-III** shall be arranged during the 15th week of IV semester.
- **Synopsis Seminar** shall be arranged two weeks before the final thesis submission date. The student shall submit a synopsis report covering all the details of the works carried out duly signed by the Dissertation Supervisor.
- At the end of second stage (fourth semester), student shall be required to submit two bound copies, one being for the department and other for the Dissertation Supervisor. The Dissertation report shall be evaluated by the DPGRC and external examination shall be conducted on a pre-notified date. The Dissertation evaluation for the fourth semester is as follows:

Assessment	Weightage
Dissertation Supervisor Assessment	20%
DPGRC Assessment	20%
ESE (Presentation & Viva-voce)	60%
Total Weightage:	**100%**

Course Learning Outcomes (COs):
On completion of this course, the students will be able to.....

- *demonstrate creativity in the design of components, systems or processes of their program of study*
- *design an innovative product by applying current knowledge and adopt to emerging applications of engineering & technology*
- *work cooperatively with others to achieve shared goal by motivating team-mates with a clear sense of direction, values and ethics,*
- *write concisely & convey meaning in a manner appropriate to different readers and verbally express ideas easily understood by others who are unfamiliar with the topic*