Maratha Vidya Prasarak Samaj's

Karmaveer Adv. Baburao Ganpatrao Thakare College of Engineering

An Autonomous Institute affiliated to Savitribai Phule Pune University, Pune

Udoji Maratha Boarding Campus, Gangapur Road, Nashik - 422 013, Maharashtra, India

Syllabus

First Year M. Tech. (2024 Pattern)

As per NEP 2020

Post-Graduate Program in Mechanical Engineering (Design Engineering)

Academic Year 2024-25

(Copy for Student Circulation Only)

First Year M. Tech. Curriculum Structure (2024 Pattern)
Mechanical Engineering (Design Engineering)
Semester - I

Course Code	Course Type	Course Name	Teaching Scheme (Hrs/Week)			Evaluation Scheme and Marks						Credits			
			TH	PR	TU	CCE	ESE	TW	PR	OR	TOT	TH	PR	TU	TOT
201101	**PCC-1**	Optimization Techniques	3	-	-	50	50	-	-	-	**100**	3	-	-	**3**
201102	**PCC-2**	Advanced Material Science	3	2	-	50	50	25	-	-	**125**	3	1	-	**4**
201103	**PCC-3**	Advanced Solid Mechanics	3	2	-	50	50	25	-	25	**150**	3	1	-	**4**
201104	**MLC**	Research Methodology & IPR@	4	-	-	50	50	-	-	-	**100**	4	-	-	**4**
201105X	**PEC-I**	Elective-I*	4	-	-	50	50	-	-	-	**100**	4	-	-	**4**
201106	**VSEC-1**	Software Skills	-	2	-	-	-	25	-	-	**25**	-	1	-	**1**
Total			**17**	**06**	**-**	**250**	**250**	**75**	**-**	**25**	**600**	**17**	**03**	**-**	**20**

Abbreviations: **TH:** Theory **PR:** Practical **TU:** Tutorial **CCE:** Continuous Concrete Evaluation
ESE: End-Semester Examination **TW:** Term Work **OR:** Oral **TOT:** Total

@ common to all branches

First Year M. Tech. Curriculum Structure (2024 Pattern)
Mechanical Engineering (Design Engineering)
Semester - II

Course Code	Course Type	Course Name	Teaching Scheme (Hrs/Week)			Evaluation Scheme and Marks						Credits			
			TH	PR	TU	CCE	ESE	TW	PR	OR	TOT	TH	PR	TU	TOT
201201	**PCC-4**	Advanced Mechanical Vibrations	4	2	-	50	50	25	-	25	**150**	4	1	-	**5**
201202	**PCC-5**	Finite Element Analysis	3	2	-	50	50	25	-	-	**125**	3	1	-	**4**
201203	**PCC-6**	Kinematic Analysis and Synthesis	4	-	-	50	50	-	-	-	**100**	4	-	-	**4**
201204X	**PEC-II**	Elective-II**	4	-	-	50	50	-	-	-	**100**	4	-	-	**4**
201205	**ELC-I**	Seminar	-	4	-	-	-	50	-	50	**100**	-	2	-	**2**
201206	**VSEC-2**	Research Proposal Writing	-	2	-	-	-	25	-	-	**25**	-	1	-	**1**
Total			**15**	**10**	**-**	**200**	**200**	**125**	**-**	**75**	**600**	**15**	**05**	**-**	**20**

Abbreviations: **TH:** Theory **PR:** Practical **TU:** Tutorial **CCE:** Continuous Concrete Evaluation
ESE: End-Semester Examination **TW:** Term Work **OR:** Oral **TOT:** Total

Second Year M. Tech. Curriculum Structure (2024 Pattern)
Mechanical Engineering (Design Engineering)
Semester - III

Course Code	Course Type	Course Name	Teaching Scheme (Hrs/Week)			Evaluation Scheme and Marks						Credits			
			TH	PR	TU	CCE	ESE	TW	PR	OR	TOT	TH	PR	TU	TOT
201301	**SBC-I**	Dissertation Phase -I	-	20	-	-	-	100	-	100	**200**	-	10	-	**10**
201302	**ELC-II**	Research Seminar	-	8	-	-	-	50	-	50	**100**	-	4	-	**4**
201303	**SLC**	MOOC Courses	-	4	-	-	-	50	-	-	**50**	-	2	-	**2**
201304	**OJT/INT**	Internship	-	8	-	-	-	100	-	50	**150**	-	4	-	**4**
Total			**-**	**40**	**-**	**-**	**-**	**300**	**-**	**200**	**500**	**-**	**20**	**-**	**20**

Abbreviations: **TH:** Theory **PR:** Practical **TU:** Tutorial **CCE:** Continuous Concrete Evaluation
ESE: End-Semester Examination **TW:** Term Work **OR:** Oral **TOT:** Total

Second Year M. Tech. Curriculum Structure (2024 Pattern)
Mechanical Engineering (Design Engineering)
Semester - IV

Course Code	Course Type	Course Name	Teaching Scheme (Hrs/Week)			Evaluation Scheme and Marks						Credits			
			TH	PR	TU	CCE	ESE	TW	PR	OR	TOT	TH	PR	TU	TOT
201401	**SBC-II**	Dissertation Phase -II	-	40	-	-	-	200	-	100	**300**	-	20	-	**20**
Total			**-**	**40**	**-**	**-**	**-**	**200**	**-**	**100**	**300**	**-**	**20**	**-**	**20**

Abbreviations: **TH:** Theory **PR:** Practical **TU:** Tutorial **CCE:** Continuous Concrete Evaluation
ESE: End-Semester Examination **TW:** Term Work **OR:** Oral **TOT:** Total

Program Elective Course - I and II

Course Code	* Elective -I	Course Code	** Elective -II
201105A	Process Equipment Design	**201204A**	Advanced Composite Structure
201105B	Design of Material Handling Equipment	**201204B**	Design of Piping System
201105C	Industrial Tribology	**201204C**	Condition Monitoring
201105D	Energy Audit and Management	**201204D**	Robotics

Course Code	Skill Development Course – I	Course Code	Skill Development Course – II
201106	Software Skills	**201206**	Research Proposal Writing

List of Abbreviations Used with Percentage of Credits

Abbreviations	Course Type	Number of Courses	Credits	% of Credits
PCC	Program Core Course	06	21	25.0
PEC	Program Elective Course	02	08	10.0
PLC	Program Laboratory Course	04	04	5.0
ELC	Experiential Learning Course	02	06	7.5
MLC	Mandatory Learning Course	01	04	5.0
VSEC	Vocational and Skill Enhancement Course	02	02	2.5
SBC	Skill Based Course	02	30	37.5
OJT/INT	On Job Training / Internship	01	04	5.0
SLC	Self-Learning Course	01	06	7.5
Total		**20**	**80**	**100%**

- **Summary of Credits and Total Marks:**

Semester	Credits	Marks
I	20	600
II	20	600
III	20	500
IV	20	300
Total	**80**	**2000**

• Definition of Credit :

The Post Graduate (P.G.) programmes will have credit system. The details of credit will be as follow.

1 Credit = 1 hour/week for lecture
= 2 hours/week for practical
= 1 hour/week for tutorial

Semester - I

Course Code: 201101	Course Name: Optimization Techniques	
Teaching Scheme	**Credit**	**Evaluation Scheme**
Theory : 3 Hours/Week	**3**	**CCE :** 50 Marks **ESE :** 50 Marks

Prerequisite Courses:

- Mathematics, Machine Design.

Course Objectives:

- To educate students on how to use optimization techniques to solve complex engineering problems.
- To develop the ability of students to create mathematical models for engineering problems.
- To develop analytical proficiency in solving linear optimization problems.
- To make the student conversant with modern optimization techniques.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Apply knowledge of optimization techniques to solve real-life mechanical engineering problems.

CO2: Identify and formulate optimization problems using the right technologies and approaches for solutions.

CO3: Use classical optimization techniques in the field of engineering.

CO4: Describe the fundamental knowledge of Linear Programming.

CO5: Apply concept of modern optimization techniques in problem solving.

Course Contents

UNIT-I: Introduction to Optimization **08 Hours**

Introduction to optimization, classification of optimization problems, formulation of optimization problem, engineering applications of optimization.

UNIT-II: Introduction to Mathematical Modeling **08 Hours**

Introduction to mathematical modeling, types of modeling. Objective function; constraints and constraint surface; mathematical modeling characteristics and limitations, formulation of design problems.

UNIT-III: Classical Optimization Techniques 08 Hours

Single variable optimization, multi variable optimization with no constraint, equality constraint, in-equality constraint.

UNIT-IV: Linear Programming 08 Hours

Standard form of linear programming, geometry of linear programming, simplex algorithm, two phases of the simplex method, primal-dual simplex method, sensitivity or post optimality analysis, applications in engineering.

UNIT-V: Modern Methods of Optimization 08 Hours

Genetic algorithms, simulated annealing, particle swarm optimization, ant colony optimization, teaching learning based optimization, introduction to Artificial Neural Network (ANN).

Learning Resources:

Text Books:

1. Introduction to optimum design, J.S. Arora, McGraw Hill, 198.
2. Design of thermal systems, W.F. Stoecker, McGraw Hill, 1989.
3. Optimization for engineering design - algorithms and examples, K.Deb,Prentice Hall, 1995.
4. R. K. Sundaram, A first course in optimization theory, 1996, Cambridge University Press, Cambridge.
5. R. Fletcher, Practical methods of optimization, 2nd Edition, Wiley, 2000, New York.

Reference Books:

1. Kreyszig, E. “Advanced Engineering Mathematics”, John Wiley & Sons, 7th Edition, 1993.
2. Chandrika Prasad. “Mathematics for Engineers”, Prasad Mudranalaya, 12th Edition, 1981.
3. Chandrika Prasad “Advanced Mathematics for Engineers”, Prasad Mudranalaya, 7th Edition, 1972
4. Speigel, M.R. “Advanced Mathematics For Engineers and Scientists”, McGraw Hill., 1992.

Course Code: 201102		Course Name: Advanced Material Science
Teaching Scheme	**Credit**	**Evaluation Scheme**
Theory : 3 Hours/Week **Practical :** 2 Hours/Week	**3** **1**	**CCE : 50 Marks** **ESE : 50 Marks** **TW : 25 Marks**

Prerequisite Courses:

- Material Science, Engineering Chemistry, Mathematics.

Course Objectives:

- Understand the mechanical properties of advanced engineering materials.
- Apply stress-strain analysis to assess material behavior.
- Conduct and interpret tensile and bending tests.
- Analyze plastic deformation using experimental and hardening models.
- Evaluate elastic-plastic equilibrium and residual stresses in materials.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Understand the mechanical behaviour and material properties of advanced engineering materials.

CO2: Apply principles of stress-strain analysis to evaluate material behavior under various conditions.

CO3: Conduct and analyze tensile and bending tests to assess material behavior under various loading conditions.

CO4: Analyze plastic deformation behavior using experimental methods and advanced hardening models under various loading and temperature conditions.

CO5: Evaluate elastic-plastic equilibrium and residual stresses in materials under variable loading conditions.

Course Contents

UNIT-I: Advanced Engineering Materials **08 Hours**

Study of dual-phase alloys, High-Strength Low-Alloy (HSLA) steels, and lightweight non-ferrous alloys focusing on their stress-strain responses under both quasi-static and high strain rate loading conditions, analysis of composites, including their orthotropic characteristics design aspects and performance evaluation, study of polymers and plastics, covering their mechanical properties, various applications, and behaviour under different conditions, Exploration of smart and nano-materials highlighting their types, applications, distinctive properties, and impact on contemporary

engineering practices.

UNIT-II: Material's Response Analysis 08 Hours

Exploration of elasticity, covering both isotropic and anisotropic types, and incorporating thermal expansion effects, analysis of shear stress and yield behavior, including octahedral shear stress, yield criteria, and yield surfaces and curves, use of Mohr's circle for graphical representation and transformation of stress and strain.

UNIT-III: Material Testing 08 Hours

Performing uni-axial and biaxial tension tests to generate full-range and true stress-strain curves, applying corrections such as Bridgman correction, and assessing effects like temperature rise and the Bauschinger effect, conducting combined loading experiments, including tests for bending and torsion as well as three-point bending, analyzing and evaluating the phenomena of elastic recovery.

UNIT-IV: Plastic Behavior of Materials 08 Hours

Experimental investigation of plastic deformations under both simple and complex loading conditions; Analysis of strain hardening and power law approximations, including isotropic, kinematic, and combined hardening models; Study of the theory of plastic flow, along with the strain-rate and temperature dependence of flow stress; Exploration of deformation theory of plasticity, thermo-plasticity, and the behaviour of metals with initial deformations.

UNIT-V: Governing Elastic-Plastic Equilibrium 08 Hours

Fundamental equations governing elastic-plastic behavior, Analysis of residual stresses and strains within materials, examination of interactions between plastic and rigid bodies, study of bending and torsion in elastic-plastic bodies, including their response to variable loading conditions, application of shakedown theorems to evaluate material stability and safety.

Learning Resources:

Text Books:

1. Engineering Materials 1: An Introduction to Properties, Applications and Design by Michael F. Ashby and David R.H. Jones.
2. Mechanical Metallurgy by George E. Dieter.
3. Mechanics of Composite Materials by Robert M. Jones.
4. Composite Materials: Science and Engineering by Krishan K. Chawla.
5. Introduction to Polymer Science and Chemistry: A Problem-Solving Approach by Robert W. Lyons and Paul A. Leary.
6. Engineering Plastics: An Introduction to Engineering Plastics by Charles A. Harper.
7. Smart Materials and Structures by M. A. Male and M. H. A. Hargreaves.

8. Introduction to Nano-materials and Nanotechnology by Joseph J. D. and Thomas J. Over.
9. Heat Treatment, Selection, and Application of Tool Steels by William E. Bryson.
10. Principles of Heat Treatment by J. A. Charles and J. W. Burch.
11. Mechanics of Materials by Ferdinand P. Beer, E. Russell Johnston Jr., John T. De Wolf, and David F. Mazurek.

Reference Books:

1. Fundamentals of Materials Science and Engg, William D. Callister, Jr., John Wiley & Sons.
2. Mechanical Metallurgy, George E. Dieter, McGraw Hill Book Company, 1988.
3. Theory of Plasticity, J. Chakrabarty, Elsevier, 2006.
4. Foundations of Theory of Plasticity, L. M. Kachanov, Dover Publications, 2004.
5. Theory of Plasticity and Metal Forming Processes, Sadhu Singh, Khanna Publishers.
6. Mechanical Behavior of Materials, W.F.Hosford, Cambridge University Press, 2005
7. Plasticity for Structural Engineers, W.F. Chen, Da-Jian Han, Springer.

Weblink for MOOC / NPTEL Links:

1. Materials Science and Engineering by IIT Madras – https://onlinecourses.nptel.ac.in/noc23_mm17
2. Mechanical Behavior of Materials by IIT Madras – https://onlinecourses.nptel.ac.in/noc23_me53
3. Composite Materials by IIT Kharagpur – https://onlinecourses.nptel.ac.in/noc23_mm18
4. Introduction to Polymer Science by IIT Madras – https://onlinecourses.nptel.ac.in/noc23_ce41
5. Nanomaterials by IIT Madras – https://onlinecourses.nptel.ac.in/noc23_mm16
6. Heat Treatment of Metals by IIT Madras – https://onlinecourses.nptel.ac.in/noc23_mm15
7. Mechanics of Materials by IIT Kharagpur – https://onlinecourses.nptel.ac.in/noc23_me52
8. Rheology of Fluids by IIT Madras – https://onlinecourses.nptel.ac.in/noc23_me56

List of Practicals:

1. Elasto-plastic analysis of a tensile test specimen using FEM software.
2. Determination of full range stress strain curve for mild steel and aluminum specimen as per ASTM -E8M.
3. Determination of friction and wear of dry sliding contacts using friction and wear test rig.
4. To study the toughness or energy absorbing properties of various composite materialsunder two types of impact tests.

Course Code: 201103	Course Name: Advanced Solid Mechanics	
Teaching Scheme	**Credit**	**Evaluation Scheme**
Theory : 3 Hours/Week **Practical :** 2 Hours/Week	**3** **1**	**CCE :** 50 Marks **ESE :** 50 Marks **TW :** 25 Marks **OR :** 25 Marks

Prerequisite Courses:

- Mechanics, Strength of Materials.

Course Objectives:

- To develop understanding of the foundations of stress and strain
- To develop understands of the displacement field, Hooke's constitutive law.
- To develop skills in analyzing stress problems through the application of the basic laws and equations.

Course Outcomes:

After successful completion of the course, the learner will be able to:

CO1: Apply knowledge of theory of elasticity to solve problems of practical interest with a variety of loading situations.

CO2: Apply the knowledge of torsion to solve complex problems of circular, noncircular, conical shafts and thin walled members.

CO3: Apply basic field equations to torsion, bending and two dimensional problems, energy methods and plastic hinges.

CO4: Apply the knowledge of contact stresses for determining stresses for two bodies in contact subjected to load normal and tangent to contact area.

CO5: Evaluate stresses using various analysis techniques.

Course Content:

UNIT-I: Theory of Elasticity **08 Hours**

Compatibility equations in two and three dimensions, free body diagram of complicated structures and stress calculations, stress functions in rectangular and cylindrical coordinate systems, evaluation of stresses in flat rectangular plates with different clamp and load conditions evaluation of the stresses in the flat and circular plate with center hole(s) using stress function.

UNIT-II: Theory of Torsion **08 Hours**

Torsion of prismatic bars of solid section and thin walled section. Analogies for torsion, membrane analogy, fluid flow analogy and electrical analogy. Torsion of conical shaft, bar of variable

diameter, thin walled members of open cross section in which some sections are prevented from warping, torsion of non-circular shaft.

UNIT-III: Stresses in Beams 08 Hours

Concept of shear centre in symmetrical and unsymmetrical bending, stress and deflections in beams subjected to unsymmetrical bending, shear centre for thin wall beam cross section, open section with one axis of symmetry, general open section, and closed section. Curved beams (Winkler-Bach formula), combined bending and torsion, equivalent bending moment, equivalent torque, combined bending, torque and internal pressure. Moving loads on beams.

UNIT-IV: Contact Stresses 08 Hours

Geometry of contact surfaces, method of computing contact stresses and deflection of bodies in point contact, Stress for two bodies inline contact with load normal to contact area and load normal and tangent to contact area, gear contacts, contacts between cam and follower, ball bearing contacts.

UNIT-V: Experimental Stress Analysis 08 Hours

Dimensional analysis, analysis techniques, strain gauges, types of strain gauges, materials, configuration, instrumentation, characteristics of strain gauge measurement, theory of photo-elasticity, elements of polariscope, simple and circular polariscope, fringes in dark and white field, isoclinic and isochromatic fringe patterns, evaluation of stresses from these fringe patterns.

Learning Resources:

Text Books:

1. T. G. Sitharam and L. Govindraju, Applied Elasticity, Interline Publishers, Bangalore.
2. Singh, Sadhu. Experimental Stress Analysis: A Text Book for Engineering Students. Khanna publishers, 1982.
3. Advanced Mechanics of Materials– Cook and Young, Prentice Hall.
4. Advanced Mechanics of Solids, L S Shrinath, Tata McGraw Hill.

Reference Books:

1. Advanced Strength and Applied Stress Analysis–Richard G. Budynas, McGraw Hill.
2. Advanced Mechanics of Materials–Boresi, Schmidt, Sidebottom, Willey.
3. Theory of Elasticity–Timoshenko and Goodier, McGraw Hill.
4. Advanced Strength of Materials–Den Hartog.
5. Experimental Stress Analysis–Dally & Riley.
6. Mechanics of Materials E J Hern, Buttorwoth.

7. Strength of Materials, Singer Andrue Pytel, Pearson.
8. Dally, James W., and William F. Riley. Experimental stress analysis. (1965).

Web link for MOOC / NPTEL Links:

1. www.youtube.com/playlist?list=PLbRMhDVUMngcbhsZgRWuYCi2kKQwQ0Av1
2. www.youtube.com/watch?v=_2d8YsXwm7M
3. www.nptel.ac.in/courses/112107146

List of Practicals: (First 2 experiments are compulsory, any 3 experiments from remaining)

1. Measurement of strain in cantilever beam using strain gauge
2. Contact stress analysis using FEM software
3. Study of polariscope and calibration of disc, beam and tension model
4. Assignment on Fixing of gauges on surfaces
5. Assignment on theory of elasticity problems
6. Case study on stress analysis due to structural loading using any simulation platform
7. Case study on stress analysis due to dynamic loading using any simulation platform
8. Determination of shear center for thin walled beam cross-section

Course Code: 201104	Course Name: Research Methodology & IPR	
Teaching Scheme	**Credit**	**Evaluation Scheme**
Theory : 4 Hours/Week	**4**	**CCE : 50 Marks** **ESE : 50 Marks**

Prerequisite Courses:

- Students should complete undergraduate courses in engineering/technology.

Course Objectives:

- To provide an overview of the research problem and describe the functions of literature survey in research.
- To explain the statistical and probability analysis.
- To explain the art of writing research reports and papers.
- To understand the patenting process and its commercial aspects.
- To explain patent rights and new developments in IPR.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Understand research problem formulation, approaches of investigation of solutions for research problems and literature survey.

CO2: Apply the principles of statistics and probability analysis in research.

CO3: Acquire skills in research proposal/paper writing.

CO4: Discover the importance of IPR.

CO5: Understand patent rights and new developments in IPR.

Course Content:

UNIT-I: Research Problem and Literature Survey 11 Hours

Research Problem: Meaning of research problem, sources of research problem, characteristics of a good research problem, and errors in selecting a research problem, scope and objectives of research problem. Approaches of investigation of solutions for research problems, data collection, benchmarking, analysis, interpretation.

Literature survey: Effective literature studies approaches, analysis, Plagiarism, its importance and software's, research ethics, research gap, writing objectives of research studies.

UNIT-II: Statistics and Probability Analysis 10 Hours

Statistical Analysis: Introduction, Sources of error and uncertainty, One-Dimensional Statistics:

combining errors and uncertainties, t-test, ANOVA statistics.

Probability Analysis: Classical and empirical probability, axioms of probability, conditional probability, Bayes' rule, law of total probability and law of total expectation.

UNIT-III: Technical Writing 11 Hours

Characteristics of effective technical writing, developing a Research proposal, format of the research proposal, financial heads of the research project, research paper writing, abstracting and indexing of journals, impact factor, h index, research paper submission and review process, writing responses to reviewer's comments, Publications.

UNIT-IV: Intellectual Property 10 Hours

Patents, designs, trade and copyright, the process of filing patents, designs, trade and copyright, examination, examination report, writing responses to the examination report, patent grant, commercialization, patenting under PCT and its advantages, case studies.

UNIT-V: Patent Rights and New Developments in IPR 10 Hours

Scope of patent rights, Licensing and transfer of technology, patent information and databases, geographical Indications. Administration of patent system, new developments in IPR, IPR of biological systems, computer software etc.

Learning Resources:

1. Research Methodology: Methods and Trends, by Dr. C. R. Kothari.
2. Research Methodology: An Introduction by Wayne Goddard and Stuart Melville.
3. Research Methodology: A Step by Step Guide for Beginners, by Ranjit Kumar, 2nd Edition.
4. Halbert, Resisting Intellectual Property, Taylor & Francis Ltd.
5. Mayall, Industrial Design, McGraw Hill.
6. Niebel, Product Design, McGraw Hill.
7. T. Ramappa, Intellectual Property Rights under WTO, S. Chand.
8. Paul L. Meyer, Introductory probability and statistical applications, Addison-Wesley Publishing Company, 1970.

Web link for MOOC / NPTEL Links:

1. www.ipindia.gov.in
2. www.nptel.ac.in/courses/121106007

Course Code: 201105A	Course Name: Process Equipment Design	
Teaching Scheme	**Credit**	**Evaluation Scheme**
Theory : 4 Hours/Week	**4**	**CCE :** 50 Marks **ESE :** 50 Marks

Prerequisite Courses:

- Engineering Thermodynamics, Heat Transfer.

Course Objectives:

- To acquire knowledge of process equipment design;
- To create awareness about design criteria;
- To optimize the design parameters and then cost estimation;
- To introduce various design standards;
- To aware learner about mechanical design of heat exchangers like condensers, evaporators, reboilers, crystallizers and distillation columns.

Course Outcomes:

On completion of the course, learner will be able to:

CO1: Understand the process of equipment design.

CO2: Explain the different design criteria.

CO3: Optimize the design parameters and able to estimate cost.

CO4: Analyze the different design codes and standards.

CO5: Apply the process of equipment design to industrial equipment.

Course Contents

UNIT-I: Introduction to Process Design **11 Hours**

Basic concepts in process design, block diagrams for flow of processes, material flow balance, design pressures and temperatures, design stresses.

UNIT-II: Design Criteria **11 Hours**

Factor of safety, minimum shell thickness and corrosion allowance, weld joint efficiency, design loading, stress concentration and thermal stresses, failure criteria.

UNIT-III: Optimization and Estimation **10 Hours**

Optimization techniques such as Lagrange's multiplier and golden section method, cost and profitability estimation.

UNIT-IV: Design Standards 10 Hours

Introduction to design codes like IS-2825, ASME-SECT, EIGHT-DIV-II TEMA. API-650, BS-1500 and 1515.

UNIT-V: Equipment Design 10 Hours

Mechanical design of heat exchangers like condenser, evaporator, reboiler, crystallizer, and distillation column.

Learning Resources:

Reference Books:

1. Process Equipment Design by Lloyd E. Brownell and Edwin H. Young, Wiley Inter-Science.
2. Process Equipment Design by M.V. Joshi, Mc-Millan.
3. Equipment Design: Mechanical Aspects by ShabinaKhanam. IIT Roorkee.
4. Process Heat Transfer: Principles and Applications by Robert W. Serth. Elsevier.
5. Handbook of Chemical Process Equipment Design by Nicholas P. Cheremisinoff. Butterworth-Heinemann.

Weblink for MOOC / NPTEL Links:

1. www.onlinecourses.nptel.ac.in/noc21_ch18/preview
2. www.digitalskills.iitmpravartak.org.in/course_details.php?courseID=224
3. www.archive.nptel.ac.in/courses/103/107/103107143/
4. www.archive.nptel.ac.in/courses/103/105/103105210/

Course Code: 201105B	Course Name: Design of Material Handling Equipment	
Teaching Scheme	**Credit**	**Evaluation Scheme**
Theory : 4 Hours/Week	**4**	**CCE :** 50 Marks **ESE :** 50 Marks

Prerequisite Courses:

- Engineering Mechanics, Strength of Material, Design of Machine elements.

Course Objectives:

- To understand the knowledge of materials management for logistics and supply chain operations.
- To acquaint students with material handling management functions - planning, purchase, controlling, storing, dispatching and standardizing.
- To understand lifting materials in load chain and material handling systems
- To acquired knowledge of bulk material handling systems
- To get the knowledge of Automation in the material handling system.

Course Outcomes:

On completion of the course, learner will be able to:

CO1: Understand basics of material handling systems.

CO2: Understand principles of material handling systems.

CO3: Select the material handling equipment.

CO4: Study the bulk material handling systems.

CO5: Understand Automation in material handling.

Course Contents

UNIT-I: Materials Handling Equipment **11 Hours**

Material handling system: Principles and features of material handling system, importance, terminology, objectives and benefits of better material handling, selection of material handling equipment, factors affecting for selection. Definition of unit load, advantages and disadvantages, load unitization process and handling methods, pallets, skids and containers, alternative methods of handling, packaging for materials handling.

UNIT-II: Design of Hoists **11 Hours**

Basic equipment types, classification of handling equipment, definition of unit load, advantages and disadvantages, load unitization process and handling methods, pallets, skids and containers, alternative methods of handling, packaging for materials handling.

UNIT-III: Load lifting Attachments **10 Hours**

Load chains and types of ropes used in material handling system, forged, standard and Ramshorn hooks, crane grabs and clamps, grab buckets; electromagnet, design consideration for conveyor belts; drums, sheaves, sprockets.

UNIT-IV: Bulk Material Handling Systems **10 Hours**

Objectives of storage, bulk material handling, gravity flow of solids through slides and chutes, storage in bins and hoppers, screw conveyor, vibratory conveyor, pneumatic and hydraulic conveyor: classification, types, principles of operation.

UNIT-V: Automation in Warehouse and Safety **10 Hours**

Storage and warehouse planning and design; computerized warehouse planning; Need, Factors and Indicators for consideration in warehouse automation, Control of hoisting & conveying machinery, material handling in direct-line, production and automated lines, safety and design; safety regulations and discipline.

Learning Resources:

Text Books:

1. N. Rudenko, Material Handling Equipment, Peace Publishers.
2. James M. Apple, Material Handling System Design, John-Wiley and Sons.
3. John R. Immer, Material Handling McGraw Hill.
4. Colin Hardi, Material Handling in Machine Shops. Machinery Publication Co. Ltd.
5. M.P.Nexandrn, Material Handling Equipment, MIR Publication.
6. C. R. Cock and J. Mason, Bulk Solid Handling, Leonard Hill Publication Co. Ltd.
7. Spivakovsy, A.O. and Dyachkov, V.K., Conveying Machines, Volumes I and II, MIR Publishers.
8. Kulwiac R. A., Material Handling Hand Book, John Wiley Publication.

Reference Books:

1. Conveyor Equipment Manufacturer's Association, Belt conveyors for bulk materials, 6th edition, The New CEMA Book
2. Rudenko N., Materials handling equipment for industry, Elnvee Publishers, 1970
3. Ishwar G Mulani and Mrs. Madhu I Mulani, Engineering Science and application design

for belt conveyor, Madhu I. Mulani, 2002.
4. Spivakovsy A.O. and Dyachkov V.K., Conveying Machines, Volumes I and II, MIR Publishers, 1985.
5. Alexandrov, M., Materials Handling Equipments, MIR Publishers, 1981.
6. Boltzharol, A., Materials Handling Handbook, The Ronald press company 1958.

e-Books:

1. Bulk solids handling: equipment selection and operation by Dr. D. McGlinchey
2. Materials Handling Equipment by Michael G. Kay.

Course Code: 201105C	Course Name: Industrial Tribology	
Teaching Scheme	**Credit**	**Evaluation Scheme**
Theory : 4 Hours/Week	**4**	**CCE :** 50 Marks **ESE :** 50 Marks

Prerequisite Courses:

- Engineering Mathematics, Engineering Mechanics, Material Science, Strength of Materials, Fluid Mechanics, Dynamics of Machines, Machine Design.

Course Objectives:

- To provide necessary concepts, knowledge and skills in Engineering Tribology with design aspect.
- The impart knowledge on friction and methods to minimize wear of engineering components.
- To provide hands on training with design of bearing, friction, wear test rig for lab purpose.

Course Outcomes:

On completion of the course, learner will be able to:

CO1: Apply theories of friction and wear to various practical situations by analyzing the physics of the process.

CO2: Select materials and lubricants to suggest a tribological solution to a particular situation.

CO3: Design a hydrodynamic bearing and measure the performance parameters using various bearing charts.

CO4: Analyze the behavior of bearing in different lubrication regimes.

CO5: Decide on the condition monitoring techniques based on performance of tribological components.

Course Contents

UNIT-I: Introduction of Tribology **11 Hours**

Definition and Scope of tribology, Nature of metallic surface, surface geometry, measurement of surface topography, quantifying surface roughness, contact between surfaces Friction, the laws of friction, measurement of friction, origin of friction, theories of friction adhesion- theory, extension of the adhesion theory.

UNIT-II: Wear Measurement **11 Hours**

Types of wear, adhesive wear, Archard's law, abrasive wear, erosion wear, factors affecting corrosive wear, wear map, various wear testing methods - pin on disc, pin on drum, slurry wear, air jet and water jet erosion as per ASTM standards.

UNIT-III: Surface Treatments **10 Hours**

Surface treatments with or without change of composition, surface coating- welding, flame, spraying, plasma spraying, electroplating and electroless coating, chemical vapour deposition (CVD) and physical vapour deposition (PVD), super hard coatings.

UNIT-IV: Design of Hydrodynamic Bearings **10 Hours**

Mechanism of pressure development, classification, idealized journal bearing, oil film thickness, pressure distribution, load carrying capacity. Failure Case Studies. Elasto-hydrodynamic lubrication Pressure-viscosity term in Reynold's equation, hertz theory, Ertel-Grubin equation, lubrication of spheres.

UNIT-V: Antifriction Bearings **10 Hours**

Ball and roller bearings, geometry of ball bearings, radial load distribution, stresses and deformations, lubrication of ball bearings. Failure case studies. **Condition Monitoring of Equipment's:** condition monitoring techniques, lubricant, corrosion, temperature & surface roughness monitoring. Failure case studies. Nano /micro tribology, green tribology.

Learning Resources:

Text Books:

1. Principles of Lubrication, Camaron, Longman's Green Co. Ltd.
2. Tribology in Machine Design, T. A. Stolarski.
3. Tribology in Industries – S.K. Shrivastava -S. Chand & Company Ltd., New Delhi, 2001.
4. Bearing Design in Machinery, Engineering Tribology and Lubrication - A. Harnoy- Marcel Dekker Inc., 2003.

Reference Books:

1. Engineering Tribology- Prasanta Sahoo - Prentice Hall of India Pvt. Ltd., New Delhi, 2005.
2. Fundamentals of Tribology – S.K. Basu, S.N. Sengupta, B.B. Ahuja – PHI Learning Pvt.Ltd., 2010.
3. Tribology Handbook M.J. Neele.
4. Engineering Tribology – G.W. Stachowiak, A.W. Batchelor – Elsevier India Pvt. Ltd., New Delhi.
5. Introduction to Tribology of Bearings – B.C. Majumdar – S. Chand & Company Ltd., New Delhi.
6. Rolling Bearing Analysis – T.A. Harris – John Wiley & Sons, Inc., New York 4. Engineering Tribology – J. Williams - Cambridge University Press, 2004.

7. Fundamental of Friction and Wear of Metals – ASM
8. The Design of Aerostatic Bearings – J. W. Powell
9. Theory Hydrodynamic Lubrication, Pinkush and Sterrolicht.

e-Books:

1. https://nptel.ac.in/courses/112102015
2. https://archive.nptel.ac.in/courses/112/102/112102014/
3. https://nitsri.ac.in/Department/Mechanical%20Engineering/NPTEL____Mechanical_Engineering_-_Tribology.pdf
4. https://onlinecourses.nptel.ac.in/noc24_me75/preview

Course Code: 201105D	Course Name: Energy Audit and Management	
Teaching Scheme	**Credit**	**Evaluation Scheme**
Theory : 4 Hours/Week	**4**	**CCE :** 50 Marks **ESE :** 50 Marks

Prerequisite Courses:

- Heat transfer, Applied Thermodynamics.

Course Objectives:

- To impart the knowledge to the students about energy conservation, energy audit and energy management.
- To inculcate the systematic knowledge and skill in assessing the energy efficiency, energy auditing and energy management.
- To carry out an energy audit of institute/industry/organization.

Course Outcomes:

On completion of the course, learner will be able to:

CO1: Explain the energy audit and role of energy management.

CO2: Explain the role of financial management.

CO3: Explain the role of project management.

CO4: Analyze the energy conservation performance of thermal utilities.

CO5: Analyze the energy conservation performance of electrical systems.

Course Contents

UNIT-I: Energy Audit and Management **11 Hours**

Definition, energy audit- need, types of energy audit, energy management (audit) approach-understanding energy costs, bench marking, energy performance, matching energy use to requirement, maximizing system efficiencies, optimizing the input energy requirements, fuel and energy substitution, energy audit instruments.

UNIT-II: Financial Management **11 Hours**

Investment - need, appraisal and criteria, financial analysis techniques - simple payback period, return on investment, net present value, internal rate of return, cash flows, risk and sensitivity analysis, financing options, Energy performance contracting and role of Energy Service Companies (ESCOS).

UNIT-III: Project Management **10 Hours**

Definition and scope of project, technical design, financing, contracting, implementation and performance monitoring, implementation plan for top management, planning budget, procurement procedures, construction, measurement and verification.

UNIT-IV: Evaluation of Thermal Utilities **10 Hours**

Energy performance opportunities and assessment of boilers and furnaces (numerical on direct method), heat exchangers, cooling towers, DG sets, fans & blowers, pumps, compressors, compressed air systems and HVAC systems. Assessment of steam distribution losses, steam leakages, steam trapping, condensate and flash steam recovery system.

UNIT-V: Energy Efficient Technologies in Electrical Systems **10 Hours**

Maximum demand controllers, automatic power factor controllers, energy efficient motors, soft starters with energy saver, variable speed drives, energy efficient transformers, electronic ballast, occupancy sensors, energy efficient lighting controls.

Learning Resources:

Text Books:

1. Bureau of Energy Efficiency Study material for Energy Managers and Auditors Examination: Paper I to IV.

Reference Books:

1. Barney L. Capehart, Wayne C. Turner and William J. Kennedy, Guide to Energy Management, Seventh Edition, The Fairmont Press Inc., 2012.
2. Craig B. Smith, Energy Management Principles, Pergamon Press, 2015.
3. Hamies, Energy Auditing and Conservation; Methods, Measurements, Management and Case Study, Hemisphere Publishers, Washington, 1980.
4. Albert Thumann P.E. CEM, William J. Younger CEM, Handbook of Energy Audit, The Fairmont Press Inc., 7th Edition.
5. Wayne C. Turner, Energy Management Handbook, The Fairmont Press Inc., Georgia.

e-Books:

1. www.npcindia.gov.in
2. http://www.bee-india.nic.in
3. www.aipnpc.org (for entire course material along with case studies).

Course Code: 201106	Course Name: Software Skills	
Teaching Scheme	**Credit**	**Evaluation Scheme**
Practical : 2 Hours/Week	**1**	**TW : 25 Marks**

Prerequisite Courses:

- Solid Modelling and Drafting, Strength of Material, CAD/CAM and automation, Computer Aided Engineering, Computational Fluid Dynamics, Computational Multi Body Dynamics, Project Based Learning, Internship/Mini project.

Course Objectives:

- Understand Finite Element Analysis (FEA) Principles: Gain a fundamental understanding of the principles of Finite Element Analysis (FEA) and how Ansys software applies these principles in engineering simulations
- Perform Structural Analysis: Learn to perform linear and non-linear structural analyses, including static, dynamic, and modal analyses, to assess the mechanical behavior of materials and structures
- Apply Ansys to Real-World Engineering Problems: Engage in hands-on projects that require application of Ansys software to solve real-world engineering problems across various industries.

Course Outcomes:

On completion of the course, learner will be able to:

CO1: Demonstrate the principles of Finite Element Analysis (FEA) to solve intricate engineering problems, encompassing both static and dynamic structural analyses.

CO2: Execute structural analyses, both linear and non-linear, with the ability to perform static, dynamic, and modal analyses, and accurately interpret the outcomes.

CO3: Invent yourself to face the challenges of future technologies and their associated problems.

List of Practicals:

1. Modeling and analysis of any Mechanical system.
2. Design and Simulation (MBD) of a Mechanical system.
3. Mini project focusing on a practical application. Students are required to select a problem of their preference and validate the solution by comparing it with experimental data or a research paper.

Learning Resources:

Text Books:

1. Oliver, D. W., Kelliher, T. P., Keegan, Jr., J. G., (1997), "Engineering Complex Systems With Models and Objects," McGraw-Hill, ISBN: 978-0070481886
2. Bi, Zhuming (2018), "Finite Element Analysis Applications: A Systematic and Practical Approach, Academic Press, ISBN: 9780128099520
3. Space & Missile Systems Center, (2004), "SMC Systems Engineering Primer & Handbook:Concepts, Processes, and Techniques," SMC, U.S. Air Force.

Reference Books:

1. Rao, J.S., (2011), "Kinematics of Machinery Through Hyper Works," Springer, ISBN: 9789400711556.
2. Nikravesh, P.E., (2019), "Planar multibody dynamics: formulation, programming with MATLAB®, and applications," CRC Press, ISBN: 9781138096127.
3. Rao, J.S., (2017), "Simulation Based Engineering in Fluid Flow Design," Springer, ISBN:9783319463810.

Web link for MOOC / NPTEL Links:

1. https://archive.nptel.ac.in/courses/112/104/112104193/
2. https://archive.nptel.ac.in/courses/112/106/112106130/
3. https://archive.nptel.ac.in/courses/112/105/112105308/
4. https://archive.nptel.ac.in/courses/105/108/105108141/
5. https://archive.nptel.ac.in/courses/112/104/112104205/

Kinematic and Dynamic analysis of Serial Robot Manipulators:

1. https://youtu.be/zZXjkYHuKPk
2. https://youtu.be/7g6lkEBMUcU
3. https://youtu.be/DeWcz_KlqLM
4. https://youtu.be/01eC4Ibd5gk
5. https://youtu.be/JyTX1tqbPw8
6. https://youtu.be/DDJEl95AVj0
7. https://youtu.be/q41GsFM9BTA
8. https://youtu.be/4YyxrnPfmm4
9. https://youtu.be/rn4HVfPYq_U

Semester - II

Course Code:201201		Course Name: Advanced Mechanical Vibrations
Teaching Scheme	**Credit**	**Evaluation Scheme**
Theory : 4 Hours/Week **Practical :** 2 Hours/Week	**4** **1**	**CCE :** 50 Marks **ESE :** 50 Marks **TW :** 25 Marks **OR :** 25 Marks

Prerequisite Courses:

- Physics, Engineering Mathematics, Engineering Mechanics, Dynamics Machinery.

Course Objectives:

- To develop the mathematical model of Multi degree freedom System and formulate the equation of motion.
- To Analyse equation of motion of continuous systems and response to transient vibration system
- To study measure of vibration and analyse the measured data
- To study control of vibration.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Compute the free and forced vibration responses of multi degree of freedom systems.

CO2: Analyse equation of motion of continuous systems.

CO3: Analyse response to transient vibration system.

CO4: Measure and analyse vibration of machines.

CO5: Apply vibration control techniques.

Course Content:

UNIT-I: Multi Degree Freedom System **11 Hours**

Free vibration equation of motion, stiffness and flexibility influence coefficients, Lagrange's equations, Eigen values Eigen vector problems, modal analysis, forced vibrations of un-damped system, modal analysis, Holzer's Method, Transfer Matrix Method, Methods of Matrix iterations.

UNIT-II: Continuous System **11 Hours**

Transverse vibrations of string, longitudinal vibration of rods, torsional vibrations of shaft, lateral vibrations of simply supported and cantilever beams, equations of motion and boundary conditions, forced vibration of beams.

UNIT-III: Transient Vibrations 10 Hours

Laplace transformation, response to step input, response to an impulsive input, response to a pulse input-rectangular pulse and half sinusoidal pulse.

UNIT-IV: Vibration Measurement 10 Hours

FFT analyzer, vibration exciters, accelerometer, signal analysis, time domain and frequency domain analysis of signals, experimental modal analysis, machine conditioning and monitoring, fault diagnosis, vibration severity chart.

UNIT-V: Vibration Control 10 Hours

Balancing of rotating machine, in-situ balancing of rotors, control of natural frequency, vibration isolation and vibration absorbers, Passive, active and semi-active control, free layer and constrained layer damping.

Learning Resources:

Text Books:

1. Theory of Vibrations with Applications, W. T. Thomson, Pearson Education, Delhi
2. Mechanical Vibrations, S. S. Rao, Pearson Education, Delhi
3. Mechanical Vibrations, G K Groover, Nem Chand & Bros, Roorkee, India
4. Fundamentals of Vibration, Leonard Meirovitch, McGraw Hill International Edison.

Reference Books:

1. Principles of Vibration Control: Ashok Kumar Mallik, Affiliated East-West Press, New Delhi.
2. Mechanical Vibrations, A H Church, John Wiley & Sons Inc
3. L. Meirovich, Elements of Vibration Analysis, 2nd Ed. Tata McGraw Hill Book Company, 2007.

Web link for MOOC / NPTEL Links:

1. https://nptel.ac.in/courses/112107212

List of Practicals (Any Five):

1. Determination of Natural Frequencies & Modal analysis of beam using FFT Analyzer.
2. Vibration analysis of any mechanical component using FEA software.
3. A Case study on Fault Diagnosis of rotating machines.
4. Forced vibration analysis of system subjected to Harmonic excitation using FEA software.
5. To study the dynamic vibration absorber system and its characteristics for different excitation frequency and amplitude and masses.
6. Experimental analysis of unbalance fault using FFT Analyzer.

Course Code: 201202		Course Name: Finite Element Analysis
Teaching Scheme	**Credit**	**Evaluation Scheme**
Theory : 3 Hours/Week **Practical :** 2 Hours/Week	**3** **1**	**CCE :** 50 Marks **ESE :** 50 Marks **TW :** 25 Marks

Prerequisite Courses:

- Solid Mechanics, Numerical and Statistical Methods, Engineering Mathematics, Manufacturing Processes, Fluid Mechanics, Heat and Mass Transfer.

Course Objectives:

- Understand the basic concepts of Finite Element Method (FEM) and Characteristics of various elements required for analysis.
- Understand the approaches of FEM and to find displacement and stresses over the body and effect of temperature.
- Develop the knowledge and skills needed to effectively evaluate the results using Finite Element Analysis (FEA).
- Apply computational technique to solve complex solid mechanics problems and its loading states.
- Study the applications of CAE in the various domains of the Mechanical Engineering.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Understand the different techniques used to solve mechanical engineering problems.

CO2: Derive and use 1-D element stiffness matrices and load vectors from various methods to solve for displacements and stresses.

CO3: Derive and use 2-D element stiffness matrices and load vectors from various methods to solve for displacements and stresses.

CO4: Evaluate and solve non-linear and dynamic analysis problems by analyzing the results obtained from analytical and computational method.

CO5: Analyze and apply various numerical methods for different types of analysis.

Course Contents

UNIT-I: Fundamental Concepts of FEA **08 Hours**

Introduction: Solution methodologies to solve engineering problems, governing equations, mathematical modelling of field problems in engineering, brief history of FEM.

Discrete and Continuous Models: Advantages and disadvantages, weak formulation, variational methods of approximation – Rayleigh-Ritz methods, Galerkin method of weighted residuals.

UNIT-II: 1D Elements **08 Hours**

Types of 1D elements, displacement function, global and local coordinate systems, polynomial form of interpolation functions- linear, quadratic and cubic, properties of shape function, primary and secondary variables. Formulation of elemental stiffness matrix and load vector for bar (using elimination and penalty approach), truss and beam using any approach, formulation of load vector due to uniform temperature change.

UNIT-III: 2D Elements **08 Hours**

Two-Dimensional Stress Analysis: Plane Stress/Strain problems in 2D elasticity, constitutive relations, Constant Strain Triangle (CST), Liner Strain Rectangle (LSR), displacement function, Pascal‘s triangle, compatibility and completeness requirement, geometric isotropy, convergence requirements, strain filed, stress filed, formulation of element stiffness matrix and load vector for plane stress/strain problems.

UNIT-IV: Non-Linear and Dynamic Analysis **08 Hours**

Non-Linear Analysis: Introduction to non-linear problems, comparison of linear and non-linear analysis, types of non-linearities, stress-strain measures for non-linear analysis, analysis of geometric, material non-linearity, solution techniques for non-linear analysis, Newton - Raphson method, essential steps in non-linear analysis.

Dynamic Analysis: Introduction to dynamic analysis, comparison of static and dynamic analysis, time domain and frequency domain, types of loading, simple harmonic motion, free vibration, boundary conditions of free vibration and solution.

UNIT-V: Applications of FEM **08 Hours**

Computer Implementation: Pre-processor, processor, post-processor, automatic mesh generation techniques, mesh quality checks, h and p refinements, symmetry – mirror/plane, axial, cyclic and repetitive, node numbering scheme.

Durability Analysis: Durability, reliability and fatigue, FEA bases fatigue analysis viz: Stress-Life approach (S-N method) and Strain-Life approach (E-N method).

Crash Analysis: Introduction, explicit time integration schemes, implicit integration schemes.

Noise Vibration and Harshness (NVH) Analysis: NVH concepts, terminology, FEA for structural dynamics, FEA for acoustics.

Learning Resources:

Text Books:

1. Gokhale N. S., Deshpande S. S., Bedekar S. V. and Thite A. N., Practical Finite Element Analysis, Finite to Infinite, Pune.
2. S. S. Bhavikatti, Finite Element Analysis, New Age International Publishers.
3. Chandrupatla T. R. and Belegunda A. D., Introduction to Finite Elements in Engineering, Prentice Hall India.
4. G Lakshmi Narasaiah, Finite Element Analysis, BS Publications / BSP Books.
5. J. N. Reddy, An Introduction to the Finite Element Method, Mcgraw Hill Series in Mechanical.
6. P. Seshu, Text book of Finite Element Analysis, PHI Learning Private Limited, New Delhi.

Reference Books:

1. K. J. Bathe, Finite Element Procedure, Prentice-Hall of India (P) Ltd., New Delhi.
2. Cook R. D., Finite Element Modeling for Stress Analysis, John Wiley and Sons Inc.
3. G.R. Liu S. S. Quek, The Finite Element Method- A Practical Course, Butterworth Heinemann.
4. Fagan M. J., Finite Element Analysis Theory and Practice, Harlow Pearson/Prentice Hall.
5. S. Moaveni, Finite element analysis, theory and application with Ansys, Pearson, Third Edition.
6. David V. Hutton, Fundamental of Finite Element Analysis, Tata McGraw-Hill, 2017.
7. Mukhopadhyay M and Sheikh A. H., Matrix and Finite Element Analyses of Structures, Ane Books Pvt. Ltd.
8. Daryl L. Logan, A First Course in the Finite Element Method, Fourth Edition, Thomson Canada Limited.
9. O.C. Zienkiewicz, The Finite Element Method: Its Basis and Fundamentals, Sixth Edition, Elsevier Butterworth-Heinemann.

List of Practicals:

1. Stress and deflection analysis of short and long beams with different end conditions and cross-sections subjected to different loading conditions (i.e., point load – force & moment, distributed load etc.) using FEA software.
2. Stress and deflection analysis of thin and thick rectangular and circular plates/shells with different end conditions subjected to different loading conditions (i.e., point load – force and moment, distributed load etc.) using FEA software.
3. Model analysis of any mechanical component.
4. Coupled analysis of any mechanical components.
5. Case study on fatigue/crash/NVH analysis.

Course Code: 201203	Course Name: Kinematic Analysis and Synthesis	
Teaching Scheme	**Credit**	**Evaluation Scheme**
Theory : 4 Hours/Week	**4**	**CCE :** 50 Marks **ESE :** 50 Marks

Prerequisite Courses:

- Physics, Engineering Mathematics, Engineering Mechanics, Dynamics Machinery.

Course Objectives:

- To develop the understanding of the planar and complex mechanisms.
- To develop the understanding of synthesis of mechanisms using analytical and graphical methods.
- To develop skills in analyzing spatial mechanisms.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Develop analytical equations describing the relative position, velocity and acceleration of all moving links.

CO2: Analyze and animate the movement of planar and spherical four-bar linkages.

CO3: Formulate and solve four position synthesis problems for planar and spherical four-bar linkages by graphical method.

CO4: Formulate and solve four position synthesis problems for planar and spherical four-bar linkages by analytical method.

CO5: Select, configure and synthesize mechanical components into complete systems.

Course Content:

UNIT-I: Introduction to Kinematics and Complex Mechanisms 11 Hours

Review of concepts related to kinematic analysis of mechanisms, degree of freedom, Grashoff's and Grubler's criteria, transmission and deviation angles, mechanical advantage, review of graphical and analytical methods of velocity and acceleration analysis of simple mechanisms. Types of complex mechanisms, velocity-acceleration analysis of complex mechanisms by the normal acceleration method and auxiliary point method, introduction to Goodman's method.

UNIT-II: Curvature Theory 11 Hours

Fixed and moving centrodes, inflection circle, Euler-Savary equation, Bobillier constructions,

cubic of stationary curvature, Ball's point and applications in dwell mechanisms.

UNIT-III: Graphical Synthesis of Planar Mechanism 10 Hours

Types, number and dimensional synthesis, function generation, path generation and rigid body guidance problems, accuracy (precision) points, Chebychev spacing, types of errors, graphical synthesis for function generation and rigid body guidance with two and three accuracy points using Relative pole method and inversion method, center point and circle point curves, Bermester points, branch and order defects, synthesis for path generation.

UNIT-IV: Analytical Synthesis of Planar Mechanism 10 Hours

Freudenstein's equation, synthesis for four accuracy points, compatibility condition, introduction to complex numbers method of synthesis, the dyad, center point and circle point circles, ground pivot specifications, three accuracy point synthesis using dyad method, Robert Chebychev theorem, Cognate linkages.

UNIT-V: Kinematics of Spatial Mechanisms 10 Hours

Transformations describing planar finite displacements, planar finite transformations, identity transformation, rigid-body transformations, spatial transformations Denavit-Hartenberg parameters, matrix method of analysis of spatial mechanisms.

Learning Resources:

Text Books:

1. Theory of Machines and Mechanisms, A. Ghosh and A.K.Mallik, Affiliated East- West Press.
2. Theory of Machines and Mechanisms, J. E. Shigleyand J. J. Uicker, 2nd Ed., McGraw-Hill.

Reference Books:

1. Kinematic Synthesis of Linkages, R. S. Hartenberg and J. Denavit, McGraw-Hill.
2. Mechanism Design - Analysis and Synthesis (Vol.1and 2), A. G. Erdman and G. N. Sandor, Prentice Hall of India.
3. Design of Machinery: An Introduction to the Synthesis and Analysis of Mechanisms and Machines, Robert L.Norton, Tata McGraw-Hill, 3rd Edition.
4. Kinematics and Linkage Design, A.S. Hall, Prentice Hall of India.

Web link for MOOC / NPTEL Links:

1. https://www.youtube.com/watch?v=xIRI2fDbn_Q
2. https://www.youtube.com/watch?v=yDEJxYGAoso

Course Code: 201204A		Course Name: Advanced Composite Structure
Teaching Scheme	**Credit**	**Evaluation Scheme**
Theory : 4 Hours/Week	**4**	**CCE :** 50 Marks **ESE :** 50 Marks

Prerequisite Courses:

- Design, Mechanics, Engineering Mathematics.

Course Objectives:

- To develop the understanding of the behavior, and applications of composite materials.
- To develop skills in testing composite materials, measuring their properties.
- To develop skills in analyzing composite structure.
- To achieve proficiency in designing composite structures.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Understand the types, behavior and applications of composite materials.

CO2: Apply the knowledge of mechanical behavior of lamina to evaluate the properties of composites.

CO3: Analyze the composite structures by different governing equations.

CO4: Analyze the material properties of composites by testing.

CO5: Design and optimize the composite structures.

Course Contents

UNIT-I: Introduction to Composite Materials **11 Hours**

Introduction, types – fibrous, laminate, particulate, combination, polymer matrix composites, metal matrix composites, mechanical behavior of composite material, applications.

UNIT-II: Mechanical Behavior of Lamina **11 Hours**

Anisotropy, Orthotropy, stiffness, engineering constants, uniaxial and biaxial strength of lamina, failure theories – maximum stress, maximum strain, Tsai-Hill, Hoffman, Tsai-Wu, computational procedure, applicability, mechanics approach to stiffness and strength.

UNIT-III: Analysis of Laminated Plates **10 Hours**

Design of composite structure bending, buckling and vibration of laminated plates - governing

equations, simply supported laminated plates – deflection under distributed transverse load, buckling under in-plane load, vibration.

UNIT-IV: Testing of Composite Materials 10 Hours

Characterization of constituent materials, physical characterization of composite material, determination of tensile, compressive and shear properties, determination of inter-laminar fracture toughness, bi-axial testing, characterization of composites with stress concentration.

UNIT-V: Design of Composite Structures 10 Hours

Structural design procedure, configuration selection, joints, design requirements, failure criteria, design analysis, optimization.

Learning Resources:

Text Books:

1. Introduction to Composite Materials by J. A. C. and M. B. H.
2. Mechanics of Composite Materials and Structure by E. K. and B. D.
3. Composite Materials: Testing and Design by J. M. and D. T.
4. Design and Analysis of Composite Structures by L. M. and C. S.

Reference Books:

1. Mechanics of Composite Materials, Robert M. Jones, Taylor & Francis.
2. Introduction to Composite Materials Design by Ever J. Barbero.
3. Engineering Mechanics of Composite Materials, Isaac M. Daniel and Ori Ishai, Oxford University Press.
4. Mechanics of Composite Materials by Robert M. Jones.
5. Mechanics of Composite Materials, Autar K. Kaw, CRC Press.
6. Fundamentals of Composite Material Mechanicsby Peter J. Svoboda.
7. Mechanics and Analysis of Composite Materials, Valery V. Vasiliev and Evgeny V. Morozov, Elsevier.
8. Composite Materials Testing and Design by G. G. A. C. and M. L. J.

MOOC / NPTEL / YouTube:

1. https://www.coursera.org/instructor/~9971288
2. https://www.coursera.org/learn/cam-design-manufacturing-mechanical-engineers
3. https://www.udemy.com/course/fundamentals-of-composite-materials/?couponCode=SKILLS4SALEA
4. http://www.ae.iitkgp.ac.in/ebooks/
5. https://nptel.ac.in/courses/101104010
6. https://www.youtube.com/watch?v=VMH6qbED7pg

Course Code: 201204B	Course Name: Design of Piping Systems	
Teaching Scheme	**Credit**	**Evaluation Scheme**
Theory : 4 Hours/Week	**4**	**CCE : 50 Marks** **ESE : 50 Marks**

Prerequisite Courses:

- Machine Design, Fluid Mechanics, Thermodynamics.

Course Objectives:

- Understand the principles and standards for piping system design.
- Apply advanced design techniques to ensure system reliability and efficiency.
- Analyze the impact of various factors on piping system performance.
- Develop skills in using industry-standard software for piping design and analysis.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Apply relevant codes, standards, and best practices to ensure safe and efficient piping system design.

CO2: Perform detailed stress analysis to address issues such as thermal expansion, pressure fluctuations, and dynamic loading.

CO3: Design efficient and maintainable piping layouts considering accessibility, safety and integration with other systems.

CO4: Apply relevant codes, standards, and best practices to ensure safe and efficient piping system design.

CO5: Proficiently use piping design and analysis software (e.g., AutoCAD P&ID, CAESAR II) to model, simulate, and evaluate piping systems.

Course Content:

UNIT-I: Introduction to Piping Systems, Materials and Components 11 Hours

Overview of piping systems in various industries (oil & gas, chemical, water treatment), design objectives and considerations, overview of relevant codes and standards (ASME B31.1, ASME B31.3, API, etc.), selection criteria for piping materials (metals, plastics, composites), pipe fittings, valves and supports, corrosion and material degradation.

UNIT-II: Fluid Flow and Thermodynamics 11 Hours

Basic fluid dynamics principles (flow regimes, pressure drop calculations), Heat transfer and thermal expansion, Fluid properties and their impact on design.

UNIT-III: Pipe Layout and Design 10 Hours

Piping layout principles and optimization, stress analysis techniques for piping systems (bending, thermal, and pressure stresses), design for fatigue and dynamic loading, design for maintenance and accessibility, design for fatigue and dynamic loading, integration with other systems (electrical, instrumentation).

UNIT-IV: Design Codes and Standards 10 Hours

Detailed study of relevant codes (ASME B31.1, ASME B31.3), compliance and safety considerations, case studies of code applications.

UNIT-V: Advancement in Piping Design, Software Tools & Simulation 10 Hours

Expansion joints and flexible connections, seismic and dynamic analysis, high-pressure and high-temperature piping systems, introduction to piping design software (AutoCAD P&ID, CAESAR II, pipe flow expert), simulation and analysis techniques, hands-on software practice.

Learning Resources:

Text Books:

1. Piping and Pipeline Engineering by George A. Antaki.
2. Industry standards and codes (ASME B31.1, ASME B31.3).

Reference Books:

1. Piping Handbook by Nicholas C. Yaw.
2. Process Piping Design Handbook by John J. McKetta Jr.

Web link for MOOC / NPTEL Links:

1. https://www.coursera.org/specializations/design-of-industrial-piping-systems
2. Designing Piping Systems : Pipe Fittings Flanges Valves | Udemy

Group Project:

1. Design and analysis of a piping system for a specific application.

Course Code: 201204C	Course Name: Condition Monitoring	
Teaching Scheme	**Credit**	**Evaluation Scheme**
Theory : 4 Hours/Week	**4**	**CCE :** 50 Marks **ESE :** 50 Marks

Prerequisite Courses:

- Dynamics of Machinery, Advanced mechanical vibration.

Course Objectives:

- Understand some basic concepts of condition monitoring.
- Understand the fault diagnosis using vibration analysis and oil analysis.
- Apply signal conditioning.
- Study condition monitoring of bearing, gears and electrical machines.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Understand condition monitoring and predictive maintenance techniques.

CO2: Select appropriate instruments for vibration analysis.

CO3: Apply vibration monitoring techniques to detect the faults.

CO4: Monitor condition of bearing, gear, pumps and electrical machines using vibration analysis.

CO5: Apply oil and particle analysis for condition-based maintenance.

Course Content:

UNIT-I: Condition Monitoring **11 Hours**

Introduction to condition monitoring. Predictive maintenance basics, maintenance philosophies, evolution of maintenance philosophies, plant machinery classification and recommendations, principles of predictive maintenance, predictive maintenance techniques, basic vibration theory, limits and standards of vibration.

UNIT-II: Signal Processing **11 Hours**

Data acquisition, collection of vibration signal – vibration transducers, characteristics and mountings, conversion of vibrations to electrical signal, Fast Fourier transform (FFT) analysis, time waveform analysis, phase signal analysis, spectral signal processes.

UNIT-III: Machinery Fault Diagnosis I **10 Hours**

Time and frequency domain analysis to identify unbalance, Eccentricity, bent shaft, misalignment,

mechanical looseness, resonance, crack, Rotor rubs, Belt drive faults.

UNIT-IV: Machinery Fault Diagnosis II 10 Hours

Fault diagnosis of rolling element bearings and journal bearing, faults related to gearbox, vane defects in pumps, fault in fans and blowers, faults in electrical machines.

UNIT-V: Oil and Particle Analysis 10 Hours

Condition-based maintenance and oil analysis, setting up an oil analysis program, oil analysis sampling methods, lubricant properties, contaminants in lubricants, particle analysis techniques-spectrometric analysis, infrared analysis, wear particle analysis, XRF (X-ray fluorescence) spectroscopy.

Learning Resources:

Text Books:

1. Theory of Vibration with Applications, Thomson, W. T., CBS Publishers and Distributors, New Delhi.
2. Introductory Course on Theory and Practice of Mechanical Vibrations, Gupta K., New Age International Ltd.
3. Practical Machinery Vibration Analysis and Predictive Maintenance, C. Scheffer, PareshGirdhar, Elsevier.
4. Vibratory Condition Monitoring of Machines, J. S. Rao, Narosa Publishing House, New Delhi.

Reference Books:

1. Shock and Vibration Handbook, Cyril M. Harris, Allan G. Piersol, McGraw-Hill Publishing Co.
2. V. Wowk, Machinery Vibration Measurement and Analysis, McGraw-Hill, Inc.,1991
3. R.B. Randall, Vibration-based Condition Monitoring, Wiley2021.

Web link for MOOC / NPTEL Links

1. https://nptel.ac.in/courses/112105232

Course Code: 201204D	Course Name: Robotics	
Teaching Scheme	**Credit**	**Evaluation Scheme**
Theory : 4 Hours/Week	**4**	**CCE :** 50 Marks **ESE :** 50 Marks

Prerequisite Courses:

- Engineering Mechanics, Theory of Machines, Mechatronics, Basics of Electrical and Electronics Engineering, Control system.

Course Objectives:

- To get acquainted with basic components of robotic systems.
- To study various gripper mechanisms and sensors and understand role of suitable control system.
- To understand statistics and kinematics of robots.
- To develop competency in obtaining desired motion of the robot.
- To study various programming methods in robotics.
- To understand need of modern techniques in robotics.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Identify different type of robot configuration with relevant terminology.

CO2: Select suitable sensors, actuators and drives for robotic systems.

CO3: Understand kinematics in robotic systems.

CO4: Design robot with desired motion with suitable trajectory planning.

CO5: Select appropriate robot programming for given application.

Course Content:

UNIT-I: Introduction of Robotics **11 Hours**

Introduction: Basic concepts, laws of robotics, robot anatomy, classification, structure of robots, point to point and continuous path robotic systems. Robot performance- resolution, accuracy, repeatability, dexterity, compliance, RCC device, applications.

Robot Grippers: Types of grippers, design of gripper, force analysis for various basic gripper systems.

UNIT-II: Sensor and Control System 11 Hours

Robotic Sensors: characteristics of sensing devices, classification, selection and applications of sensors. Types of sensors, need for sensors and vision system in the working and control of a robot. GPS, IMU, vision, PVDF tactile (construction, working and selection).

Drives and Control Systems : Types and selection of drives, actuators and transmission systems, types of controllers, closed loop control, second order linear systems and their control, control law of partitioning, trajectory-following control, modeling and control of a single joint, force control.

UNIT-III: Kinematics of Robotics 10 Hours

Kinematics: Transformation matrices and their arithmetic, link and joint description, Denavit - Hartenberg parameters, frame assignment to links, direct kinematics, kinematics redundancy, kinematics calibration, inverse kinematics of two joints, solvability, algebraic and geometrical methods.

Velocities and Static Forces in Manipulators: Motion of the manipulator links, Jacobians, singularities, static forces, Jacobian in force domain.

UNIT-IV: Dynamics of Robotics 10 Hours

Introduction to dynamics, trajectory generations, motion planning and control: joint and Cartesian space trajectory planning and generation, potential field method for motion planning manipulator mechanism design, force control and hybrid position / force control.

UNIT-V: Vision System and Robot Programming 10 Hours

Machine Vision System: Vision system devices, image acquisition, masking, sampling and quantization, image processing techniques, masking, sampling and quantization, noise reduction methods, edge detection, segmentation.

Robot Programming: Methods of robot programming, lead through programming, motion interpolation, branching capabilities, WAIT, SIGNAL and DELAY commands, subroutines, **Programming Languages:** Robot language structure, introduction to various types such as RAIL and VAL II.

Learning Resources:

Text Books:

1. S. R. Deb, Robotics Technology and Flexible Automation, Tata McGraw Hill.

Reference Books:

1. Groover M.P. Automation, production systems and computer integrated manufacturing -

Prentice Hall of India.

2. S. B. Niku, Introduction to Robotics, Analysis, Control, Applications, 2nd Edition, Wiley Publication.
3. John Craig, Introduction to Robotics, Mechanics and Control, 3rd Edition, Pearson Education.
4. Mathia, Robotics for Electronics Manufacturing, Cambridge Uni. Press, India.
5. A Ghosal, Robotics: Fundamental Concepts and Analysis, Oxford University Press.
6. R. K. Mittal and I. J. Nagrath, Robotics and Control, McGraw Hill Publication.

Course Code: 201205	Course Name: Seminar	
Teaching Scheme	**Credit**	**Evaluation Scheme**
Practical : 4 Hours/Week	**2**	**TW** : 50 Marks **OR** : 50 Marks

Course Objectives:

- To identify the latest topic in the field of design engineering.
- To carry out literature surveys and problem identification.
- Enhance presentation and report writing skills.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Identify the seminar topic in the field of design engineering by literature survey.

CO2: Understand how research papers are written and understand modeling, theory, concept, and simulation related to the topic of interest.

CO3: Effectively communicate the seminar topic through oral presentation.

CO4: Prepare a detailed seminar report.

Course Contents:

The topic of seminar will be based on current research in the field of design engineering and industrial case study approved by an authority. The student shall submit the duly certified seminar report in standard format, for satisfactory completion of the work by the concerned guide and head of the department.

Guidelines:

1. Individual student need to study recent topics in the field of design engineering under the guidance of allocated guide.
2. Students can choose topic related to design engineering, considering recent trends and its societal importance.
3. The extensive literature survey, mathematical modeling of particular method, experimentation and valuable conclusion is expected from seminar study.
4. Seminar report should be submitted as a compliance of term work.
5. Technical paper publication is expected as outcome of seminar.
6. Total duration: 24 contact hours and additional 24 hours should be spend by students on completion of related activities and requirements.

Guideline for Evaluation

Sr #	Components for Evaluation	Allotted Marks
1	Content coverage and understanding	20 Marks
2	Oral Presentation and Question Answer	20 Marks
3	Report writing and submission	10 Marks

Course Code: 201206	Course Name: Research Proposal Writing	
Teaching Scheme	**Credit**	**Evaluation Scheme**
Practical : 2 Hours/Week	**1**	**TW :** 25 Marks

Prerequisite Courses:

- Under-Grauate Project Work.

Course Objectives:

- To define research proposal and the project management lifecycle.
- To identify the parts of a research proposal and the basic principles of project management.
- To draft a project based research proposal.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Carry out critical literature review.

CO2: Prepare a project plan and budget.

CO3: Write and present a project based research proposal.

Course Content:

UNIT-I: Introduction **10 Hours**

Definition of project proposal, types of project proposal.

UNIT-II: Contents of Research Proposal **08 Hours**

Introduction, review of literature, aims and objectives, research design and method, ethical considerations, budget, appendices, citations.

UNIT-III: Budget and Project Planning **08 Hours**

Principles of financial planning and control, types of budgets (operational, capital, etc.), cost estimation techniques, detailed budget development, budget forecasting and adjustments, cost control and variance analysis, resource planning and scheduling, techniques for effective resource utilization.

Learning Resources:

Text Books:

1. Writing a Research Proposal: Practical Guide by John K. Smith and John W. Adams, Sage Publications.

2. Research Proposals: A Practical Guide by Patrick McGowan, Academic Press.

Reference Books:

1. The Research Proposal: A Guide for Research Students and Early Career Researchers by Peter L. Berger and Kathryn R. Smith Publisher: Rout ledge.
2. Writing a Research Proposal: Practical Guide by John K. Smith and John W. Adams Publisher: Sage Publications.

Web link for MOOC / NPTEL Links:

1. https://www.westminster.ac.uk/study/postgraduate/research-degrees/entry-requirements/how-to-write-your-research-proposal
2. https://masterclasses.nature.com/?gad_source=1&gclid=CjwKCAjwlbu2BhA3EiwA3yXyu0IwlWf0hLxZBaQ9uRsq96XMwXRL8CwnGdnEjxujf-Y_8aJAcdNmgxoC_2MQAvD_BwE#nmo

List of Practicals:

1. Write a research proposal to a national funding agency such as DST, MNRE and AICTE etc. for resolving a real World issues.