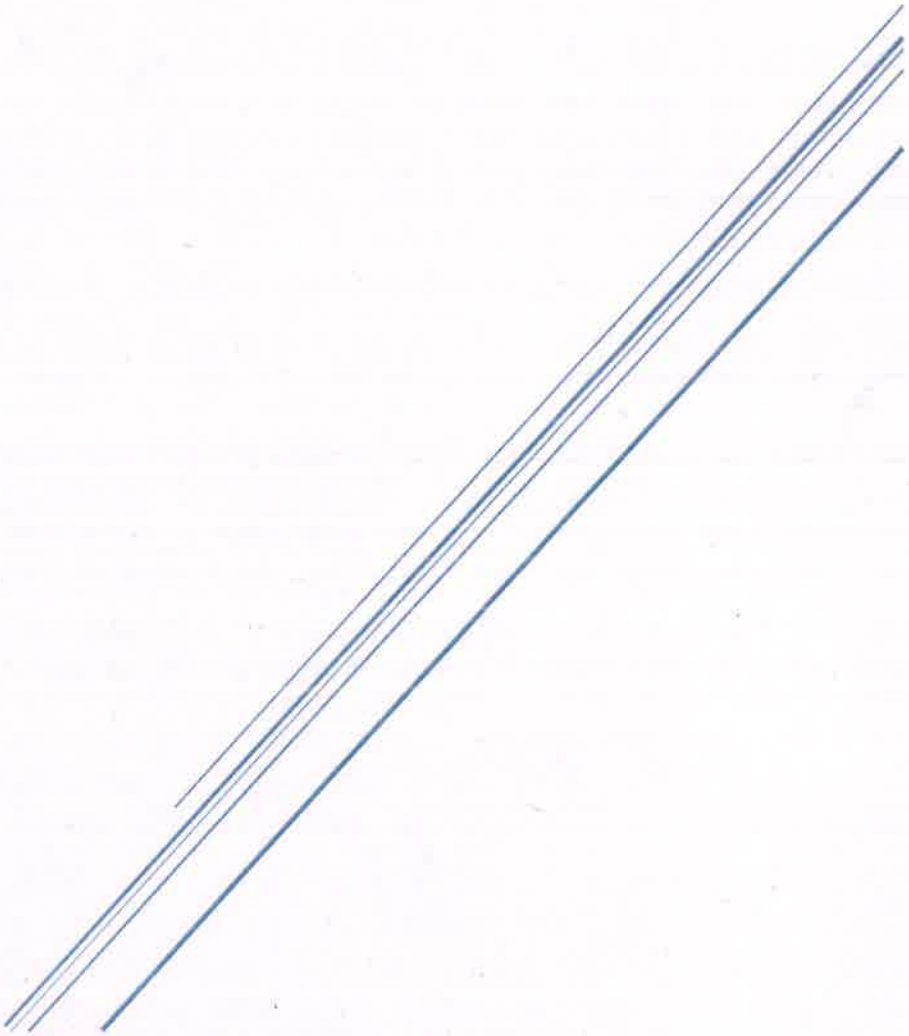
M.E. (Engineering Design)

REVISED CURRICULUM AND DETAILED SYLLABI UNDER REGULATION 2023



Leadership & Excellence
Sri Eshwar College of Engineering
An Autonomous Institution
Affiliated to Anna University, Chennai

DEPARTMENT OF MECHANICAL ENGINEERING

7.9.7 REVISED CURRICULUM AND DETAILED SYLLABI UNDER REGULATION 2023

M.E E.D - Curriculum

Outcome-Based Education (OBE) with Choice-Based Credit System (CBCS).

Regulation 2023

Semester I

Sl. No.	Course Code	Course Name	Category	Periods/wk L	T	P	J	TC	C
Theory Courses									
-	-	Induction Program	-	-	-	-	-	-	-
1	P23ED401	Computer Applications in Design	PC	3	0	0	0	3	3
2	P23RM101	Research Methodology and IPR	PC	3	0	0	0	3	3
3	P23ED402	Advanced Mechanics of Materials	PC	3	1	0	0	4	4
4	P23ED403	Mechanisms Design and Simulation	PC	3	0	0	0	3	3
5	P23ED5XX	Professional Elective - I	PE	3	0	0	0	3	3
6	P23ED5XX	Professional Elective - II	PE	3	0	0	0	3	3
Practical Courses									
7	P23ED451	Product Design and Development Laboratory	PC	0	0	4	0	2	2
8	P23ED452	Advanced Analysis and Simulation Laboratory	PC	0	0	4	0	2	2
Mandatory Course									
9	P23AC5XX	Audit Course I	MC	2	0	0	0	NC	NC
Total				**20**	**1**	**8**	**0**	**23**	**23**

Semester II

Sl. No.	Course Code	Course Name	Category	Periods/wk L	T	P	J	TC	C
Theory Courses									
1	P23ED404	Integrated Mechanical Design	PC	3	0	0	0	3	3
2	P23ED405	Vibration Analysis and Control	PC	3	0	0	0	3	3
3	P23ED406	Finite Element Methods in Mechanical Design	PC	3	1	0	0	4	4

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Sl. No.	Course Code	Course Name	Category	Periods/wk				TC	C
				L	T	P	J		
4	P23ED407	Integrated Product Development	PC	3	0	0	0	3	3
5	P23ED5XX	Professional Elective - III	PE	3	0	0	0	3	3
6	P23ED5XX	Professional Elective - IV	PE	3	0	0	0	3	3
Practical Course									
7	P23ED453	Vibration Laboratory	PC	0	0	2	0	2	2
8	P23ED601	Design Project	PW	0	0	0	4	2	2
Mandatory Course									
9	P23AC5XX	Audit Course II	MC	2	0	0	0	NC	NC
Total				**20**	**1**	**2**	**4**	**23**	**23**

Semester III

Sl. No.	Course Code	Course Name	Category	Periods/wk				TC	C
				L	T	P	J		
Theory Courses									
1	P23ED5XX	Professional Elective - V	PE	3	0	0	0	3	3
2	P23ED5XX	Professional Elective - VI	PE	3	0	0	0	3	3
3	P23OE5XX	Open Elective*	OE	3	0	0	0	3	3
Practical Courses									
4	P23ED602	Project Work - Phase I	PW	0	0	0	12	6	6
Total				**9**	**0**	**0**	**12**	**15**	**15**

Semester IV

Sl. No.	Course Code	Course Name	Category	Periods/wk				TC	C
				L	T	P	J		
Project Work									
1	P23ED603	Project Work - Phase II	PW	0	0	0	24	12	12
Total				**0**	**0**	**0**	**24**	**12**	**12**

L→Lecture; T→Tutorial; P→Practical; J→Project; TC→Total Classes/wk; C→Credit

CREDIT SUMMARY*

Sl. No.	Course Category	Credits per Semester				Credits	Credit %
		I	II	III	IV		
1	PC	17	15	-	-	32	43.8
2	PE	6	6	6	-	18	24.7
3	OE	-	-	3	-	3	4.1
4	PW	-	2	6	12	20	27.4
Total		**23**	**23**	**15**	**12**	**73**	**100%**

Total Number of Credits: 73.

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7.3 Professional Elective Courses:

Sl. No.	Course Code	Course Name	Category	Periods/ Week				TC	C
				L	T	P	J		
SEMESTER I - PROFESSIONAL ELECTIVE - I									
1	P23ED501	Mechanics of Composite Materials	PE	3	0	0	0	3	3
2	P23ED502	Design for Sustainability	PE	3	0	0	0	3	3
3	P23ED503	Bio Materials	PE	3	0	0	0	3	3
4	P23ED504	Additive Manufacturing and Tooling	PE	3	0	0	0	3	3
5	P23ED505	Applied Probability and Statistics for Design Engineers	PE	3	0	0	0	3	3
SEMESTER I - PROFESSIONAL ELECTIVE - II									
1	P23ED506	Mechanical Measurements and Analysis	PE	3	0	0	0	3	3
2	P23ED507	Industrial Robotics and Expert systems	PE	3	0	0	0	3	3
3	P23ED508	Quality Concepts in Design	PE	3	0	0	0	3	3
4	P23ED509	Wearable Technologies	PE	3	0	0	0	3	3
5	P23ED510	Industrial Internet of Things	PE	3	0	0	0	3	3
SEMESTER II - PROFESSIONAL ELECTIVE - III									
1	P23ED511	Engineering Fracture Mechanics	PE	3	0	0	0	3	3
2	P23ED512	Design of Hydraulic and Pneumatic Systems	PE	3	0	0	0	3	3
3	P23ED513	Advanced Metal Forming Techniques	PE	3	0	0	0	3	3
4	P23ED514	Tribology in Design	PE	3	0	0	0	3	3
5	P23ED515	Artificial Intelligence and Machine Learning	PE	3	0	0	0	3	3
SEMESTER II - PROFESSIONAL ELECTIVE - IV									
1	P23ED516	Surface Engineering	PE	3	0	0	0	3	3
2	P23ED517	Supply Chain Management	PE	3	0	0	0	3	3
3	P23ED518	Product Lifecycle Management	PE	3	0	0	0	3	3
4	P23ED519	Optimization Techniques in Design	PE	3	0	0	0	3	3
5	P23ED520	Mechanical Behaviour of Materials	PE	3	0	0	0	3	3
SEMESTER III - PROFESSIONAL ELECTIVE - V									
1	P23ED521	Advanced Finite Element Analysis	PE	3	0	0	0	3	3
2	P23ED522	Design for X	PE	3	0	0	0	3	3
3	P23ED523	Advanced Machine tool Design	PE	3	0	0	0	3	3
4	P23ED524	Vehicle Dynamics	PE	3	0	0	0	3	3
5	P23ED525	Bearing design and Rotor Dynamics	PE	3	0	0	0	3	3

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Sl. No.	Course Code	Course Name	Category	Periods/ Week				TC	C
				L	T	P	J		
SEMESTER III - PROFESSIONAL ELECTIVE - VI									
1	P23ED526	Computational Fluid Dynamics	PE	3	0	0	0	3	3
2	P23ED527	Design of Hybrid and Electric Vehicles	PE	3	0	0	0	3	3
3	P23ED528	Industry 4.0	PE	3	0	0	0	3	3
4	P23ED529	Solid Freeform Manufacturing	PE	3	0	0	0	3	3
5	P23ED530	Creativity and Innovation	PE	3	0	0	0	3	3

7.4 Open Electives (OEs):

Sl. No.	Course Code	Course Name	Category	Periods/week				TC	C
				L	T	P	J		
1	P23OE501	Business Analytics	OE	3	0	0	0	3	3
2	P23OE502	Industrial Safety	OE	3	0	0	0	3	3
3	P23OE503	Operations Research	OE	3	0	0	0	3	3
4	P23OE504	Cost Management of Engineering Projects	OE	3	0	0	0	3	3
5	P23OE505	Composite Materials	OE	3	0	0	0	3	3
6	P23OE506	Waste to Energy	OE	3	0	0	0	3	3

7.5 Audit Courses :

Sl. No.	Course Code	Course Name	Category	Periods/ Week				TC	C
				L	T	P	J		
1	P23AC501	English for Research Paper Writing	AC	2	0	0	0	NC	NC
2	P23AC502	Disaster Management	AC	2	0	0	0	NC	NC
3	P23AC503	Sanskrit for Technical Knowledge	AC	2	0	0	0	NC	NC
4	P23AC504	Value Education	AC	2	0	0	0	NC	NC
5	P23AC505	Constitution of India	AC	2	0	0	0	NC	NC
6	P23AC506	Pedagogy Studies	AC	2	0	0	0	NC	NC
7	P23AC507	Stress Management by Yoga	AC	2	0	0	0	NC	NC
8	P23AC508	Personality Development throughLife Enlightenment Skills.	AC	2	0	0	0	NC	NC

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SYLLABI

SEMESTER I

P23ED401	Computer Applications in Design	L	T	P	J	C
		3	0	2	0	3

1. Course Description:

This course offers a comprehensive overview of essential computer applications and tools used in various design disciplines, including graphic, industrial, and architectural design. Students will gain hands-on experience with industry-standard software such as Adobe Creative Suite and AutoCAD, focusing on digital design fundamentals, 3D modeling, and interactive design. Emphasizing practical skills, the course covers topics like typography, color theory, and user experience principles while exploring effective collaboration and workflow management. By completing projects and assignments, students will develop a strong portfolio that showcases their technical proficiency and creativity, preparing them for successful careers in the design field.

2. Course Objectives:

By the end of this course, students will be able to:

1. To impart the parametric fundamentals to create and manipulate geometric models using
   NURBS and solids.
2. To impart the parametric fundamentals to create and manipulate geometric models using curves, surfaces and solids.
3. To Create and manipulate 3D models using CAD software, focusing on accuracy and visualization techniques.
4. To provide clear understanding of CAD systems for 3D modelling and viewing.
5. To create strong skills of assembly modelling and prepare the student to be an effective user of a standards in CAD system.

3. Syllabus: **45 Periods**

Unit-I: Geometric Transformations **9 Periods**

Homogeneous representation; Translation, Scaling, Reflection, Rotation, Shearing in 2D and 3D; Orthographic and perspective projections. Window to View-port transformation

Unit-II: Curves a nd Surfaces Modeling **9 Periods**

Introduction to curves - Analytical curves: line, circle and conics – synthetic curves: Hermite cubic spline- Bezier curve and B-Spline curve – curve manipulations.
Introduction to surfaces - Analytical surfaces: Plane surface, ruled surface, surface of revolution and tabulated cylinder – synthetic surfaces: Hermite bicubic surface- Bezier surface and B-Spline surface- surface manipulations.

Unit-III: Nurbs and Solid Modeling **9 Periods**

NURBS - Basics - curves, lines, arcs, circle and bi linear surface. Regularized Boolean set operations - primitive instancing - sweep representations - boundary representations – constructive solid Geometry - comparison of representations - user interface for solid modeling - ASM, Primitive instancing, Cell Decomposition and Octree encoding.

Unit-IV: Visual Realism **9 Periods**

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Hidden – Line – Surface – solid removal algorithms shading – coloring. Introduction to parametric and variational geometry based software's and their principles creation of prismatic and lofted parts using these packages.
Unit-V: Assembly of Parts and Product Data Exchange **9 Periods**
Assembly modeling - interferences of positions and orientation - tolerances analysis – mass property calculations - mechanism simulation. Graphics and computing standards– Open GL Data Exchange standards – IGES, STEP etc–Communication standards.
Text Books:
1. David F. Rogers, James Alan Adams "Mathematical elements for computer graphics" second edition, Tata McGraw-Hill edition.2003 2. Donald Hearn and M. Pauline Baker "Computer Graphics", Prentice Hall, Inc., 1992.
Reference:
Reference Books: 1. Foley, Wan Dam, Feiner and Hughes – Computer graphics principles & practices, Pearson Education – 2003. 2. Ibrahim Zeid Mastering CAD/CAM – McGraw Hill, International Edition, 2007.
Journals: 1. International Journal of Computer Applications in Technology - Inderscience 2. Computer-Aided Design and Applications - Taylor and Francis
MOOC/NPTEL /SWAYAM Courses: 1. https://www.mooc-list.com/tags/computer-aided-design 2. https://onlinecourses.nptel.ac.in/noc21_ge11/preview 3. https://www.coursera.org/learn/3d-cad-fundamental 4. https://coursera.org/learn/introduction-to-3d-modeling

5. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED401.1	(Apply) Apply the basic principles of computer aided design and graphics in product design and development.
P23ED401.2	(Apply) Apply the surface and solid modeling techniques in product design
P23ED401.3	(Apply) Apply the curve generation and assembly modeling techniques in product design
P23ED401.4	(Apply) Apply top-down design principles to model a design
P23ED401.5	(Evaluate) Compare the use of curves and surfaces in CAD

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P23RM101	Research Methodology and IPR	L	T	P	J	C
		3	0	0	0	3

1. Course Description:

The course on Research Methodology and Intellectual Property Rights (IPR) typically aims to equip students with essential skills and knowledge necessary for conducting effective research and understanding the legal framework surrounding intellectual property.

2. Course Objectives:

1. Teach various research methods, including qualitative, quantitative, and mixed methods.
2. Develop skills in designing research studies and formulating research questions
3. Enhance critical thinking skills to evaluate existing research literature and methodologies.
4. Understand the fundamentals of intellectual property, including patents, copyrights, trademarks, and trade secrets
5. Improve academic writing skills, focusing on writing research proposals, papers, and reports

3. Syllabus: **45 Periods**

Unit-I: Research Problem **9 Periods**

Meaning of research problem: Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem; Scope and objectives of research problem: Defining a research problem, Problem formulation, Techniques involved in defining a problem; Approaches of investigation of solutions for research problem: data collection, analysis, interpretation, Necessary instrumentations.

Unit-II: Literature Study and Plagiarism **9 Periods**

Importance of literature survey; Assessment of quality journals and articles: Effective literature studies approaches, analysis. Plagiarism: Research ethics: Definition, Ethics and Ethical issues, Principles and Responsibilities, Data Protection.

Unit-III: Report Writing **9 Periods**

Meaning of Interpretation: Technique of Interpretation, Precaution in Interpretation; Significance of Report Writing: Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Mechanics of Writing a Research Report, Precautions for Writing Research Reports, Conclusions; Oral Presentation.

Unit-IV: Nature of Intellectual Property **9 Periods**

Patents: Designs, Trade and Copyright; Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property, Procedure for grants of patents, Patenting under PCT.

Unit-V: Patent Rights and New Developments in IPR **9 Periods**

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. Traditional knowledge Case Studies.

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Text Books:

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students" Juta & Company Ltd, 1996
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction" Juta and Company Ltd, 2004.

References:

Reference Books:

1. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"
2. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
3. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age", 2016.
4. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008
5.

Journals:

1. Intellectual property rights and growth
2. Intellectual property rights in innovation management research

MOOC/NPTEL /SWAYAM Courses:

1. Research methodology: https://archive.nptel.ac.in/courses/127/106/127106227/
2. Intellectual property rights and competition law https://archive.nptel.ac.in/courses/110/105/110105139/
3. Intellectual property https://archive.nptel.ac.in/courses/109/106/109106137/
4. Introduction on Intellectual property to Engineers and Technologists https://archive.nptel.ac.in/courses/109/105/109105112/
5. Economics of IPR https://archive.nptel.ac.in/courses/109/106/109106100/

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23RM101.1	**(Apply)** Apply techniques involved in defining a problem
P23RM101.2	**(Analyze)** Analyze research related information
P23RM101.3	**(Apply)** Apply research writing procedures
P23RM101.4	**(Apply)** Apply patent and grant procedures
P23RM101.5	**(Apply)** Apply new developments in IPR

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P23ED402	Advanced Mechanics of Materials	L	T	P	J	C
		3	0	0	0	3

1. Course Description:

This course provides an in-depth understanding of the mechanical behavior of materials under various loading conditions. Students will explore advanced concepts in elasticity, plasticity, torsion, and stress analysis. The course covers stress-strain relations, the analysis of stress and strain invariants, and the behavior of materials in different geometric configurations, such as beams, plates, and rotating members. Emphasis is placed on constitutive modeling for elastic solids, failure theories, and energy methods for solving structural problems.

2. Course Objectives:

1. Enabling Students to solve problems related to equilibrium, compatibility, and boundary conditions in mechanical systems.
2. Students will be empowered to analyze the location of the shear center for various thin sections and solve for stresses and deflections in beams subjected to unsymmetrical loading conditions.
3. students will be equipped with the ability to calculate stresses and deflections in flat plates and curved members, including components such as chain links and crane hooks, under different loading and boundary conditions
4. students can analyse torsional stresses in non-circular sections, utilizing concepts such as St. Venant's theory, elastic membrane analogy, and Prandtl's stress function.
5. Students will know to compute radial and tangential stresses in rotating members and contact stresses in mechanical components, enabling them to design safe components subjected to high-speed and contact loading condition

3. Syllabus : **45 Periods**

Unit-I: Elasticity **9 Periods**

Stress-Strain relations and general equations of elasticity in Cartesian, Polar and curvilinear coordinates, differential equations of equilibrium-compatibility; boundary conditions; representation of three-dimensional stress of a tension generalized hook's law; St. Venant's principle; plane stress; Airy's stress function. Energy methods.

Unit-II: Shear Center and Unsymmetrical Bending **9 Periods**

Location of shear center for various thin sections;shear flows; Stresses and Deflections in beams subjected to unsymmetrical loading;kern of a section.

Unit-III: Stresses in Flat Plates and Curved Members **9 Periods**

Circumference and radial stresses; deflections; curved beam with restrained ends; closed ring subjected to concentrated load and uniform load; chain links and crane hooks. Solution of rectangular plates; pure bending of plates; deflection; uniformly distributed load; various end conditions

Unit-IV: Torsion of Non-Circular Sections **9 Periods**

Torsion of rectangular cross section; St.Venants theory; elastic membrane analogy; Prandtl's stress function; torsional stress in hollow thin walled tubes.

Unit-V: Stresses in Rotating Members and Contact Stresses **9 Periods**

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Radial and tangential stresses in solid disc and ring of uniform thickness and varying thickness; allowable speeds. Methods of computing contact stress; deflection of bodies in point and line contact applications

Text Books:

1. "Mechanics of Materials" by James M. Gere and Barry J. Goodno (9th edition, 2017, Cengage Learning)
2. "Advanced Mechanics of Materials" by Robert D. Cook and Warren C. Young (8th edition, 2018, Pearson Education)
3. "Mechanics of Solids and Structures" by I.H. Shames and J.L. Coombes (2nd edition, 2012, McGraw-Hill)

Reference :

Reference Books:

1. Advanced Strength and Applied Elasticity" by Ansel C. Ugural and Saul K. Fenster (5th edition, 2018, Pearson Education)
2. Arthur P. Boresi and Richard J. Schmidt, Advanced Mechanics of Materials, John Wiley & Sons, 2002.
3. Srinath L.S., Advanced Mechanics of Solids, Tata McGraw Hill, 1992.

Journals:

1. International Journal of Solids and Structures — Elsevier
2. Mechanics of Materials – Elsevier

MOOC/NPTEL /SWAYAM Courses:

1. Coursera - Mechanics of Materials (University of Michigan)
2. MIT OpenCourseWare - Mechanics of Materials
3. NPTEL - Advanced Mechanics of Materials (IIT Kharagpur)

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED402.1	**(Analyze)** Learn about the elastic and plastic behavior of material and analyze stress invariants, principal stresses, and their directions.
P23ED402.2	**(Analyze)** Determine strain invariants, principal strains, and their directions.
P23ED402.3	**(Analyze)** Develop constitutive relationships between stress and strain for linearly elastic solids.
P23ED402.4	**(Analyze)** Analyze theories of failure and design components for safe operation.
P23ED402.5	**(Analyze)** Examine the properties of ideally plastic solids and apply the concepts of energy methods in solving structural problems.

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P23ED403	Mechanisms Design and Simulation	L	T	P	J	C
		3	0	0	0	3

1. Course Description:

This course provides a comprehensive introduction to the principles, methods, and tools for designing and simulating mechanical mechanisms. It covers the fundamental concepts of mechanism design, including kinematic and dynamic analysis, and introduces students to modern simulation techniques used to validate designs before physical prototyping. Through a blend of theoretical concepts and hands-on experience with simulation software, students will gain the skills necessary to design, analyze, and optimize mechanical systems.

2. Course Objectives:

1. Students will learn how to design and analyze different types of mechanical systems, including linkages, gears, cams, and other mechanisms, to see how they work and function together.
2. Students can develop ability to perform kinematic and dynamic analysis of mechanisms to study motion, velocities, accelerations, forces, and torques.
3. Students can able to apply simulation tools to virtually test and validate the behavior of designed mechanisms under different operating conditions.
4. Students able to apply optimization techniques to improve mechanism performance with respect to criteria such as efficiency, speed, and accuracy.

3. Syllabus: **45 Periods**

Unit-I: Introduction **9 Periods**

Review of fundamentals of kinematics: classifications of mechanisms; components of mechanisms; mobility analysis, formation of one D.O.F, multi loop kinematic chains, Network formula, Gross motion concepts; Basic kinematic structures of serial and parallel robot manipulators; Compliant mechanisms, Equivalent mechanisms.

Unit-II: Kinematic Analysis **9 Periods**

Position Analysis: Vector loop equations for four bar, slider crank, inverted slider crank, geared five bar and six bar linkages. Analytical methods for velocity and acceleration Analysis: Four bar linkage jerk analysis, plane complex mechanisms, auxiliary point method. Spatial RSSR mechanism: Denavit-Hartenberg Parameters, Forward and inverse kinematics of robot manipulators.

Unit-III: Path Curvature Theory, Coupler Curve **9 Periods**

Fixed and moving centrodes, inflection points and inflection circle: Euler Savary equation, graphical constructions, cubic of stationary curvature: Four bar coupler curve-cusp, crunodes, coupler driven six-bar mechanisms, straight line mechanisms

Unit-IV: Synthesis of Four Bar Mechanisms **9 Periods**

Type synthesis: Number synthesis, Associated Linkage Concept: Dimensional synthesis: function generation, path generation, motion generation. Graphical methods: Pole technique inversion technique, point position reduction-two, three and four position synthesis of four-bar mechanisms. Analytical methods: Freudenstein's Equation-Bloch's Synthesis.

Unit-V: Synthesis of Coupler Curve Based Mechanisms & Cam Mechanisms 9 Periods

Cognate Linkages: parallel motion Linkages, Design of six bar mechanisms, single dwell-double stroke; Geared five bar mechanism: multi-dwell. Cam Mechanisms: determination of optimum size of cams: Mechanism defects, Study and use of Mechanism using Simulation Software packages, Students should design and fabricate a mechanism model as term project.

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Text Books:
1. Amitabha Ghosh and Asok Kumar Mallik, "Theory of Mechanism and Machines", EWLP, Delhi,1999. 2. Kenneth J, Waldron, Gary L. Kinzel, "Kinematics, Dynamics and Design of Machinery", John Wiley-sons, 2016.
References:
Reference Books: 1. Robert L.Norton., "Design of Machinery",Tata McGraw Hill, 2012 2. Sandor G.N., and Erdman A.G., "Advanced Mechanism Design Analysis and Synthesis", Prentice Hall, 1984. 3. Uicker, J. J., Uicker Jr, J. J., Pennock, G. R., & Shigley, J. E.. Theory of machines and mechanisms. Cambridge University Press, 2023. 4. Meriam, James L., L. Glenn Kraige, and Jeff N. Bolton. *Engineering mechanics: dynamics*. John Wiley & Sons, 2020. **Journals:** 1. Journal of Mechanisms and Robotics- ASME 2. Mechanism and Machine Theory- Science Direct **MOOC/NPTEL /SWAYAM Courses:** 1. https://www.udemy.com/course/basics-of-mechanism-design-analysis-for-mechanical-design/?couponCode=ST11MT91624B 2. https://archive.nptel.ac.in/courses/112/108/112108211/

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED403.1	**(Apply)** Apply concepts of gross motion capability and develop multi loop kinematic chains and equivalent mechanisms
P23ED403.2	**(Apply)** Determine velocity and acceleration of complex mechanisms
P23ED403.3	**(Analyze)** Evaluate inflection points and draw the inflection circle.
P23ED403.4	**(Analyze)** Synthesise planar mechanisms
P23ED403.5	**(Analyze)** Design of six bar coupler driven mechanisms and cam mechanisms

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P23ED451	Product Design and Development Laboratory	L	T	P	J	C
		0	0	2	0	1

1. Course Description:

This course provides an introduction to computer-aided design (CAD). Emphasis is placed on CAD fundamentals; creating and modifying 2D and 3D models; feature manipulation; assembly modeling; and drafting techniques. Topics include sketching, solid and surface modeling, feature editing, assembly constraints, and documentation methods using industry-standard CAD software.

2. Course Objectives:

4. To equip students with the skills to create and interpret 2D drafting and 3D modeling representations, enabling accurate visualization and design communication.
4. To impart knowledge on how to prepare drawings for various mechanical components using any Commercially available 3D modeling software's.

3. Syllabus: **30 Periods**

List of Experiments

- CAD Introduction.
- Sketcher
- Solid modeling – Extrude, Revolve, Sweep and variational sweep, Loft
- Surface modeling – Extrude, Sweep, Trim and Mesh of curves, Freeform.
- Feature manipulation – Copy, Edit, Pattern, Suppress, History operations etc.
- Assembly - Constraints, Exploded Views, Interference check
- Drafting - Layouts, Standard & Sectional Views, Detailing & Plotting.

Exercises in modeling and drafting of mechanical components-assembly using parametric and feature based packages like PRO-E/SOLIDWORKS /CATIA/NX

Text Books:

1. Gopalakrishna K.R., "Machine Drawing", 22nd Edition, Subhas Stores Books Corner, Bangalore, 2013

References:

Reference Books:

1. Junnarkar, N.D., "Machine Drawing", 1st Edition, Pearson Education, 2004
2. P.S.G. Design Data Book
3. Luzadder,Warren.J., and Duff, Jon.M. "Fundamentals of Engineering Drawing", Prentice Hall India Pvt. Ltd., Eastern Economy Edition, Eleventh Edition,
4. Chang, T. C., Wysk, R.A., Wang, H. P, "Computer aided Manufacturing," Prentice Hall, Third Ed.

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4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED451.1	(Apply) Apply design principles to develop conceptual engineering design of any components
P23ED451.2	(Apply) Apply theoretical knowledge to design the mechanical components using modern software tools
P23ED451.3	(Apply) Apply the engineering knowledge to solve real life industrial problems
P23ED451.4	(Analyze) Analyze design problems in a systematic manner
P23ED451.5	(Create) Create the parts design with assembly

P23ED452	**Advanced Analysis and Simulation Laboratory**	**L**	**T**	**P**	**J**	**C**
		0	**0**	**4**	**0**	**2**

1. Course Description:

This course provides a comprehensive course exploring ANSYS basics and practical applications in stress analysis, thermal stress analysis, heat transfer analysis, mode frequency analysis, harmonic analysis, truss analysis and MATLAB basics to solve simple problems in vibration.

2. Course Objectives:

1. To analyze the various mechanical components in both static conditions
2. To impart the students with necessary computer aided analysis skills.
3. To analyze the various mechanical components in the dynamic conditions.
4. Simulation of mechanical components by visualization software's.
5. To impart the knowledge on program-based simulation for solving the problems.

3. Syllabus: **60 Periods**

List of Experiments

Simulation:

1. MATLAB basics, Dealing with matrices, Graphing-Functions of one variable and two variables
2. Use of Matlab to solve simple problems in vibration
3. Mechanism Simulation using Multibody Dynamic software.

Analysis:

1. Force and Stress analysis using link elements in Trusses, cables etc.
2. Stress and deflection analysis in beams with different support conditions.
3. Stress analysis of flat plates and simple shells.

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4. Stress analysis of axi – symmetric components. 5. Thermal stress and heat transfer analysis of plates. 6. Thermal stress analysis of cylindrical shells. 7. Vibration analysis of spring-mass systems. 8. Model analysis of Beams. 9. Harmonic, transient and spectrum analysis of simple systems.
References:
Reference Books: 1. The Mathworks, Inc, The student Edition of Matlab, student Edition, The MATLAB curriculum series, 1997 2. RudraPratap, Getting started with MATLAB, 1st Edition, Oxford University Press, 2010 **Video References:** 1. https://www.youtube.com/watch?v=-6yJS13KB8Y 2. https://www.youtube.com/watch?v=1dvEmK6To7M 3. https://www.youtube.com/watch?v=CgH3AUe6KMw

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED452.1	(Apply) Apply the fundamental knowledge on using various analytical tools like ANSYS, MATLAB, etc., for engineering applications.
P23ED452.2	(Analyze) Perform analysis of stress, truss/beam and dynamic analysis of mechanical members.
P23ED452.3	(Analyze) Simulate simple problems in vibrations and simple mechanisms using simulation software.
P23ED452.4	(Analyze) Perform two dimensional stress analysis in plate and asymmetric shells.
P23ED452.5	(Analyze) Analyze the temperature distribution in one dimensional heat transfer problems (walls and fins).

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P23ED404	Integrated Mechanical Design	L	T	P	J	C
		3	0	0	0	3

1. Course Description:

Integrated Mechanical Design focuses on advanced mechanical design principles, enabling students to integrate components into complex systems. It covers material selection, manufacturing processes, and design standards for mechanical components. Students will develop skills in analyzing and designing elements such as shafts, gears, brakes, and clutches using software tools, while considering dynamics and thermal aspects in system integration.

2. Course Objectives:

6. Students will comprehend integrated mechanical design principles and apply them to complex components and systems.
7. Students will select advanced materials, processes, and standards for mechanical components.
8. Students will analyze mechanical components like shafts, gears, brakes, and clutches using advanced analytical methods and software.
9. Students will evaluate and design complex mechanical systems, considering dynamics and thermal aspects.

3. Syllabus **45 Periods**

Unit-I: Fundamentals and design of shafts **9 Periods**

Phases of design: Standardization and interchangeability of machine elements; Process and Function; Tolerances: Individual and group tolerances, Selection of fits for different design situations; Design for assembly and modular constructions; Concepts of integration: BIS, ISO, DIN, BS, ASTM Standards; Oblique stresses; Principal stresses; Maximum shear stress; Theories of Failure: Ductile vs. brittle component design; Analysis and Design of shafts for different applications; integrated design of shaft, bearing and casing; Design for rigidity;

Unit-II: Design of gears and gear boxes **9 Periods**

Principles of gear tooth action; Gear correction; Gear tooth failure modes; Stresses and loads; Component design of spur, helical, bevel and worm gears; Design for sub assembly; Integrated design of speed reducers and multi-speed gear boxes; application of software packages; Design of gears considering dynamic and static loading conditions;

Unit-III: Brakes & Clutches **9 Periods**

Dynamics and thermal aspects of brakes and clutches; Integrated design of brakes and clutches for machine tools, automobiles and mechanical handling equipment; Use of materials having higher wear and tear resistance;

Unit-IV: Integrated design **9 Periods**

Integrated Design of Machine Element: shaft, bearings, springs, motor, gears, belt, rope, chain, pulleys, Cam & Follower, flywheel; Design of systems: Elevators, Escalators, Gear Box, Valve gear Mechanisms, Machine Tools; Use of materials having higher wear and tear resistance;

Unit-V: Design Optimization and Advanced Integration Techniques **9 Periods**

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Advanced optimization techniques: Design for manufacturability, performance, and cost; Failure analysis: Reliability and safety in mechanical design; Integration of dynamic and thermal considerations into system-level design; Advanced mechanical systems: high-performance gearboxes, robotics systems;

Text Books:

1. Shigley, J.E. and Mischke, C.R., "Mechanical Design", McGraw-Hill, 10th Edition, 2015.
2. Norton, R.L., "Machine Design: An Integrated Approach", Prentice Hall, 5th Edition, 2011.
3. Juvinall, R.C. and Marshek, K.M., "Fundamentals of Machine Component Design", Wiley, 5th Edition, 2016.

Reference Books:

6. Alexandrov, M., Materials Handling Equipments, MIR Publishers, 1981.
7. Boltzharol, A., Materials Handling Handbook, The Ronald Press Company, 1958.
8. Maitra G.M., "Hand Book of Gear Design", Tata McGraw Hill, 1985.
9. Newcomb, T.P. and Spur, R.T., "Automobile Brakes and Braking Systems", Chapman and Hall, 2nd Edition, 1975.
10. Prasad. L. V., "Machine Design", Tata McGraw Hill, New Delhi, 1992.

Approved Data Books:

1. P.S.G. Tech., "Design Data Book", Kalaikathir Achchagam, Coimbatore, 2003.
2. Lingaiah. K. and Narayana Iyengar, "Machine Design Data Hand Book", Vol. 1 & 2, Suma Publishers, Bangalore,1983.

Journals:

1. Journal of Mechanical Design - American Society of Mechanical Engineers (ASME)
2. International Journal of Mechanical Sciences – Elsevier
3. Journal of Vibration and Control - Sage Publications

MOOC/NPTEL /SWAYAM Courses:

1. https://youtube.com/playlist?list=PL3D4EECEFAA99D9BE&feature=shared
2. https://archive.nptel.ac.in/courses/112/106/112106137/
3. https://www.udemy.com/course/mechanical-design-a-comprehensive-course/
4. Design of Machine Element I - https://archive.nptel.ac.in/courses/112/105/112105124/
5. Machine Design II - https://archive.nptel.ac.in/courses/112/106/112106137/

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4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED404.1	(Understand) Understand the principles of integrated mechanical design, and be able to apply them to the design of components, subassemblies and systems.
P23ED404.2	(Apply) Develop the skills to select and apply suitable materials, manufacturing processes and design standards for various mechanical components.
P23ED404.3	(Analyze) Analyze and design shafts, gears, brakes and clutches, using appropriate software tools.
P23ED404.4	(Analyze) Develop the ability to integrate multiple components into a system, considering the dynamics and thermal aspects of the design.
P23ED404.5	(Evaluate) Apply the principles of integrated mechanical design to design and analyze complex mechanical systems such as elevators, escalators, gearboxes, valve gear mechanisms and machine tools.

P23ED405	**Vibration Analysis and Control**	**L**	**T**	**P**	**J**	**C**
		3	**0**	**0**	**0**	**3**

1. Course Description:

This course on Vibration Analysis provides a comprehensive understanding of the fundamental principles and applications of vibration in mechanical systems. It covers the mathematical modeling of vibrations, including single and multi-degree freedom systems, vibration isolation techniques, and the experimental methods used to analyze vibration phenomena. Students will explore both the theoretical and practical aspects of vibration, including transient vibrations, response to arbitrary excitations, and the critical speed of shaft-rotor systems. Through simulations and hands-on experiments, learners will gain insights into various vibration analysis tools, measurement techniques, and control methods, equipping them with the skills to address vibration-related challenges in engineering applications.

2. Course Objectives:

1. To grasp the basic principles of vibration, including displacement, velocity, and acceleration, and their relevance in engineering systems.
2. To develop skills in modeling and analyzing single and multi-degree freedom systems, including the use of mathematical models and numerical techniques.
3. To familiarize students with various experimental methods and instruments for vibration measurement, including accelerometers and vibrometers.
4. To engage in simulations of vibration systems using analysis software, enhancing understanding through practical applications.
5. To explore different vibration isolation techniques and control methods, enabling students to design solutions for minimizing vibration in mechanical systems.

3. Syllabus **45 Periods**

Unit-I: Fundamentals of Vibration **9 Periods**

Introduction: Sources of Vibration; Mathematical Models: Displacement, velocity and Acceleration; Review of Single Degree Freedom Systems; Vibration isolation; Vibrometers and accelerometers;

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Response to Arbitrary and non- harmonic Excitations; Transient Vibration; Impulse loads; Critical Speed of Shaft-Rotor systems.

Simulation of simple spring mass system through Analysis software.

Unit-II: Two Degree Freedom System **9 Periods**

Introduction: Free Vibration of Undamped and Damped system; Forced Vibration with Harmonic Excitation System; Coordinate Couplings and Principal Coordinates.

Simulation of a shock absorber with damper by Analysis software.

Unit-III: Multi-Degree Freedom System and Continuous System **9 Periods**

Multi Degree Freedom System: Influence Coefficients and stiffness coefficients; Flexibility Matrix and Stiffness Matrix; Eigen Values and Eigen Vectors: Matrix Iteration Method; Approximate Methods: Dunkerley, Rayleigh's, Holzer Method; Geared Systems: Eigen Values & Eigen vectors for large system of equations using sub space, Lanczos method; Continuous System: Vibration of String, Shafts and Beams.

Simulation in dynamic analysis of cantilever and simply supported beams.

Unit-IV: Experimental Methods in Vibration Analysis **9 Periods**

Vibration Analysis Overview; Experimental Methods in Vibration analysis; Vibration Measuring Instruments; Selection of Sensors; Accelerometer Mountings; Vibration Exciters: Mechanical, Hydraulic, Electromagnetic and Electrodynamics; Frequency Measuring Instruments; System Identification from Frequency Response; Testing for resonance and mode shapes.

Concept of mode shapes and associated mathematical properties; Use of modal superposition to obtain forced vibration response.

Unit-V: Vibration Control **9 Periods**

Specification of Vibration Limits; Vibration severity standards; Vibration as condition Monitoring tool; Vibration Isolation methods: Dynamic Vibration Absorber, Torsional and Pendulum Type Absorber, Damped Vibration absorbers; Static and Dynamic Balancing; Balancing machines; Field balancing; Vibration Control by Design Modification; Active Vibration Control; Advanced isolation materials.

Text Books:

1. Ramamurti. V, "Mechanical Vibration Practice with Basic Theory", Narosa, New Delhi, 2000
2. Rao, S.S.," Mechanical Vibrations," Addison Wesley Longman, 1995.

References:

Reference Books:

1. S. Graham Kelly & Shashidar K. Kudari, "Mechanical Vibrations", Tata McGraw–Hill Publishing. Ltd New Delhi, 2007
2. Thomson, W.T. – "Theory of Vibration with Applications", CBS Publishers and Distributors, New Delhi,1990.
3. David Bies and Colin Hansen, "Engineering Noise Control – Theory and Practice",4th Edition, E and FN Spon, Taylore & Francise e-Library, 2009

Journals:

1. Journal of Sound and Vibration
2. Journal of Vibration and Acoustics
3. Journal of Dynamic Systems, Measurement, and Control

MOOC/NPTEL /SWAYAM Courses:

1. https://www.youtube.com/watch?v=TkExfl4Vm_4

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2. https://ocw.mit.edu/courses/2-003sc-engineering-dynamics-fall-2011/pages/mechanical-vibration/
3. https://www.mobiusinstitute.com/product/vibration-analysis-iso-category-i-online/
4. https://nptel.ac.in/courses/112104040
5. https://archive.nptel.ac.in/courses/112/104/112104211/
6. https://archive.nptel.ac.in/courses/112/107/112107087/

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED405.1	Understand the fundamentals of vibration and its practical applications
P23ED405.2	Model, approximate, analyse and simulate vibratory systems that include general forcing, general boundary conditions, and nonlinearities using approximate computational tools as necessary
P23ED405.3	Discern the relevant principles that must be applied to describe or measure the equilibrium or motion of vibratory systems
P23ED405.4	Explain and describe principles and components of vibration analysis and their inter relationships
P23ED405.5	Establish relation between real system and physical model and examine their vibration response

P23ED406	**Finite Element Methods In Mechanical Design**	**L**	**T**	**P**	**J**	**C**
		3	**1**	**0**	**0**	**4**

1. Course Description:

This course provides an in-depth study of the Finite Element Method (FEM) and its application to one-dimensional, two-dimensional and nonlinear problems. The course begins with the fundamental principles of FEM, including weighted residual methods and variational formulation, before progressing to more complex topics like two-dimensional problems, isoparametric formulation, eigenvalue problems and non-linear analysis. Students will develop the skills necessary to model and analyze mechanical systems, heat transfer and structural problems using FEM. Topics such as shape functions, element equations, mesh generation and numerical integration techniques will be covered, with practical applications in engineering fields like heat transfer and elasticity. This course is crucial for students interested in computational mechanics, structural analysis and advanced engineering design.

2. Course Objectives:

1. To gain a solid foundation in the basic principles of the Finite Element Method, including variational formulations, weighted residual methods and Ritz methods, enabling them to solve boundary value problems.
2. To model and solve one-dimensional problems, such as bar and beam elements and apply FEM to heat transfer problems using linear and higher-order shape functions.

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3. To handle more complex two-dimensional boundary value problems using triangular and quadrilateral elements, with applications in elasticity, plane stress, plane strain and axisymmetric formulations.
4. To use natural coordinate systems, Lagrangian interpolation and iso-parametric elements for one-dimensional and two-dimensional problems with a focus on numerical integration and Jacobian transformation.
5. To solve the dynamic analysis, including free vibration analysis, consistent and lumped mass matrices and determining natural frequencies in mechanical systems.

3. Syllabus **60 Periods**

Unit-I: Finite Element Analysis of One Dimensional Problems **9+3 Periods**

Historical Background; Weighted Residual Methods; Basic Concept of FEM; Variational Formulation of B.V.P.; Ritz Method; Finite Element Modelling; Element Equations; Linear and Higher order Shape functions: Bar, Beam Elements; Applications to Heat Transfer problems.

Unit-II: Finite Element Analysis of Two Dimensional Problems **9+3 Periods**

Basic Boundary Value Problems in two-dimensions; Linear and higher order Triangular, quadrilateral elements; Poisson's and Laplace's Equation; Weak Formulation; Element Matrices and Vectors; Application to scalar variable problems; Introduction to Theory of Elasticity; Plane Stress, Plane Strain; Axisymmetric Formulation; Principle of virtual work; Element matrices using energy approach

Unit-III: Iso-Parametric Formulation **9+3 Periods**

Natural Co-ordinate Systems; Lagrangian Interpolation Polynomials; Iso parametric Elements: Formulation, Shape functions; One dimensional , two dimensional triangular and quadrilateral elements; -Serendipity elements; Jacobian transformation; Numerical Integration; Gauss quadrature: one, two, three point integration

Unit-IV: Eigen Value Problems **9+3 Periods**

Dynamic Analysis; Equations of Motion; Consistent and lumped mass matrices; Free Vibration analysis: Natural frequencies of Longitudinal, Transverse and torsional vibration; Solution of Eigenvalue problems; Introduction to transient field problems

Unit-V: Non-Linear Analysis **9+3 Periods**

Introduction to Non-linear problems; Solution techniques; computational procedure; material non-linearity: Plasticity and viscoplasticity; stress stiffening; contact interfaces; problems of gaps and contact; geometric non-linearity; modeling considerations; Free and Mapped meshing; Mesh quality: Error estimate

Text Books:

1. Bathe K.J., "Finite Element Procedures in Engineering Analysis", Prentice Hall, 1990
2. David Hutton, "Fundamentals of Finite Element Analysis", Tata McGrawHill, 2005
3. Rao, S.S., "The Finite Element Method in Engineering", 6th Edition, Butterworth Heinemann, 2018.

References:

Reference Books:

1. Reddy,J.N. "Introduction to the Finite Element Method", 4 thEdition, Tata McGrawHill,2018
2. Seshu.P, "Text Book of Finite Element Analysis", PHI Learning Pvt. Ltd., NewDelhi, 2012.
3. Tirupathi R. Chandrupatla and Ashok D.Belegundu, "Introduction to Finite Elements in Engineering", International Edition, Pearson Education Limited, 2014.

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Journals:

1. Journal of Finite Elements in Analysis and Design
2. International Journal for Numerical Methods in Engineering
3. International Journal of Computational Methods

MOOC/NPTEL /SWAYAM Courses:

1. https://www.youtube.com/playlist?list=PLREHQnoFMsHDO-cFy7Hy6iek4vinkxDwa
2. https://www.asme.org/learning-development/find-course/advanced-finite-element-analysis/online--oct-21-dec-02nd--2024
3. https://ocw.mit.edu/courses/res-2-002-finite-element-procedures-for-solids-and-structures-spring-2010/
4. https://archive.nptel.ac.in/courses/112/104/112104193/
5. https://nptel.ac.in/courses/112104193
6. https://archive.nptel.ac.in/courses/112/105/112105308/

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED406.1	Understand the fundamentals of vibration and its practical applications
P23ED406.2	Model, approximate, analyse and simulate vibratory systems that include general forcing, general boundary conditions, and nonlinearities using approximate computational tools as necessary
P23ED406.3	Discern the relevant principles that must be applied to describe or measure the equilibrium or motion of vibratory systems
P23ED406.4	Explain and describe principles and components of vibration analysis and their inter relationships
P23ED406.5	Establish relation between real system and physical model and examine their vibration response

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P23ED407	Integrated Product Development	L	T	P	J	C
		3	0	0	0	3

1. Course Description:

This integrated course teaches students to design, develop, and launch successful products. Topics include product planning, specification, industrial design, design for manufacture and assembly, prototyping, testing, project management, and product lifecycle management. Through this course, students gain a holistic understanding of product development, preparing them to create innovative products that meet customer needs and business objectives.

2. Course Objectives:

1. Enable students to apply design thinking principles to identify customer needs, ideate innovative solutions, and prototype effective products.
2. Equip students with a comprehensive understanding of product development processes, including design for manufacture, assembly, and testing.
3. Encourage students to work effectively in teams, communicating design concepts and engineering principles to develop successful products.
4. Develop students' ability to analyze complex product development challenges, identify optimal solutions, and evaluate design trade-offs.
5. Students will possess the knowledge, skills, and attitudes required to make immediate contributions in product design and development roles within various industries.

3. Syllabus: **45 Periods**

Unit-I: Introduction to Product Design **9 Periods**

Characteristics of Successful Product development; Duration and Cost of Product Development; Challenges of Product Development; Product Development Processes and Organizations; Product Planning Process - Process of Identifying Customer Needs;

Unit-II: Product Specifications, Concept Generation, Selection And Testing 9 Periods

Establish Target and Final product specifications; Activities of Concept Generation: Concept Screening and Scoring, Concept Testing Methodologies;

Unit-III: Product Architecture and Industrial Design **9 Periods**

Product Architecture: Implications and establishing the architecture; Delayed Differentiation; Platform Planning; Related system level design issues; Need and impact of industrial design: Industrial design process, management of the industrial design process, assessing the quality of industrial design;

Unit-IV: Design for Manufacture, Prototyping and Robust Design **9 Periods**

DFM Definition; Estimation of Manufacturing cost: Reducing the component costs, costs of supporting function and assembly costs; Impact of DFM decision on other factors; Prototype basics; Principles of prototyping, Prototyping technologies, Planning for prototypes; Robust design: Robust Design Process;

Unit-V: Product Development Economics and Managing Projects **9 Periods**

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Economic Analysis: Elements of Economic Analysis, Understanding and representing tasks; Baseline Project Planning: Accelerating the project, Project execution, Postmortem project evaluation.
References:
Reference Books:
1. Karl T.Ulrich, Steven D.Eppinger, Anita Goyal, "Product Design and Development", McGraw –Hill Education (India) Pvt. Ltd, 4th Edition, 2012. 2. Kevin N Otto, Kristin L Wood, "Product Design – Techniques in Reverse Engineering and New Product Development", Pearson Education, Inc, 2016 3. Stephen Rosenthal, "Effective Product Design and Development", Business One Orwin Homewood, 1992 4. Stuart Pugh, "Total Design – Integrated Methods for successful Product Engineering", Addison Wesley Publishing, Neyourk, NY, 1991. **Journals:** 1. International Journal of Design and Innovation Research 2. Journal of Product Innovation Management (JPIM) **Videos and MOOCs:** 1. https://www.youtube.com/playlist?list=PLXkiW0hNLve-maLVWEssF2xX6ruUpvRPe 2. https://www.youtube.com/watch?v=Lo-AFCv2ggE 3. Product Design and Manufacturing - **https://onlinecourses.nptel.ac.in/noc21_me66/preview** 4. New Product Development - **https://onlinecourses.swayam2.ac.in/imb19_mg01/preview**

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED407.1	(Apply) Apply the principles of generic development process; product planning; customer need analysis for new product design and development.
P23ED407.2	(Apply) Set product specifications and generate, select, screen, test concepts for new product design and development.
P23ED407.3	(Analyze) Apply the principles of product architecture, industrial design and design for manufacturing principles in new product development.
P23ED407.4	(Analyze) Apply the adopt Prototyping techniques and Design of Experiment principles
P23ED407.5	(Analyze) Develop a robust design and document a new product for patent.

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P23ED453	Vibration Laboratory	L	T	P	J	C
		0	0	2	0	1

1. Course Description:

This course is designed to provide a practical understanding of vibration phenomena and control techniques through hands-on experiments. The focus is on the fundamental principles of vibrations in mechanical systems, including free and forced vibrations, damping effects, and torsional vibrations. The course covers methods for determining the natural frequency of different systems, examining forced and undamped vibrations, and exploring damping effects in real-world scenarios. The experiments will provide students with the opportunity to engage with theoretical concepts, measure vibration characteristics, and apply vibration control methods to mechanical systems.

2. Course Objectives:

1. To study the forced vibrations in a beam under different damping conditions, gaining insight into how damping affects system behavior.
2. To determine the radius of gyration 'k' using different systems such as a compound pendulum, bi-filler suspension, and trifilar suspension.
3. To verify Dunkerley's rule, which is useful for estimating the natural frequency of complex systems.
4. To explore the pressure distribution in lubricating systems under varying conditions of load and speed, providing a better understanding of lubrication in mechanical components.
5. To determine the natural frequencies of undamped torsional vibrations in single and two-rotor shaft systems, crucial for analyzing the rotational stability of mechanical systems.

3. Syllabus: **30 Periods**

List of Experiments

1. To study the forced vibration of the beam for different damping.
2. To determine the radius of gyration 'k' of a given compound pendulum.
3. To determine the radius of gyration of given bar using bi-filler suspension.
4. To determine the radius of gyration of trifilar suspension.
5. To verify the dunker lay's rule viz.
6. To study the pressure profile of lubricating conditions of load and speed.
7. To determine the natural frequency of undamped torsional vibration of a single rotor shaft system.
8. To determine the natural frequency of undamped torsional vibration of two rotor shaft system.
9. To determine the frequency of undamped free vibration of an equivalent spring mass system.
10. To determine the frequency of damped force vibration of a spring mass system.

Text Books:

1. Ramamurti. V, "Mechanical Vibration Practice with Basic Theory", Narosa, New Delhi, 2000
2. Rao, S.S.," Mechanical Vibrations," Addison Wesley Longman, 1995.

References:

Reference Books:

1. S. Graham Kelly & Shashidar K. Kudari, "Mechanical Vibrations", Tata McGraw–Hill Publishing. Ltd New Delhi, 2007

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2. Thomson, W.T. – "Theory of Vibration with Applications", CBS Publishers and Distributors, New Delhi,1990.
3. David Bies and Colin Hansen, "Engineering Noise Control – Theory and Practice",4th Edition, E and FN Spon, Taylore & Francise e-Library, 2009

Journals:

1. Journal of Sound and Vibration
2. Journal of Vibration and Acoustics
3. Journal of Dynamic Systems, Measurement, and Control

MOOC/NPTEL /SWAYAM Courses:

1. https://mdmv-nitk.vlabs.ac.in/
2. https://mv-iitg.vlabs.ac.in/
3. https://www.youtube.com/watch?v=TkExfl4Vm_4
4. https://ocw.mit.edu/courses/2-003sc-engineering-dynamics-fall-2011/pages/mechanical-vibration/
5. https://www.mobiusinstitute.com/product/vibration-analysis-iso-category-i-online/
6. https://nptel.ac.in/courses/112104040
7. https://archive.nptel.ac.in/courses/112/104/112104211/
8. https://archive.nptel.ac.in/courses/112/107/112107087/

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED453.1	Understand the basic concepts and behaviour of vibration in machines
P23ED453.2	Evaluate the natural frequencies and other parameters in single degree and two degree vibration systems
P23ED453.3	Demonstrate an understanding on how certain measuring devices are handled for dynamic testing
P23ED453.4	Evaluate the natural frequency of rotating and reciprocating systems
P23ED453.5	Evaluate the natural frequency for different structural members

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P23ED601	Design Project	L	T	P	J	C
		3	0	4	0	2

1. Course Description:

The Design Project course offers students the opportunity to apply design principles, creativity, and technical skills to develop a comprehensive project from concept to completion. Through research, ideation, prototyping, and iterative refinement, students tackle real-world design challenges while working individually or collaboratively. The course emphasizes critical thinking, problem-solving, and the use of design tools, culminating in a final presentation and documentation of the design process and typically focuses on the practical application of design theories and techniques. The course emphasizes creativity, innovation, and collaboration, often with real-world constraints.This capstone experience allows students to showcase their design capabilities and prepares them for professional practice in their field. Working in interdisciplinary teams, students will apply design thinking to real-world projects, progressing from technology formulation (TRL 2) to the working model or prototype be demonstrated in a space environment (TRL 7), creating solutions aligned with the UN's Sustainable Development Goals (SDGs).

2. Course Objectives:

The objective of the Design Project course is to enable students to apply their accumulated knowledge and skills in design to create innovative and functional solutions to real-world problems. It aims to foster critical thinking, creativity, and technical proficiency by guiding students through the entire design process—from research and conceptualization to prototyping, testing, and final execution. By the end of the course, students will have developed a professional-level project that demonstrates their ability to think strategically, work collaboratively, and present their work effectively, preparing them for professional roles in the design industry.

3. Syllabus **60 Periods**

Each student is required to select any new component or an integrated mechanical system that involves various sub components which are to be designed as per design standards and further required to be analyzed for optimum dimensions with respect to the strength and stiffness.

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED601.1	(Apply) Apply the established technical and practical methods to the solution of well-defined engineering problems.
P23ED601.2	(Understand) Understand the scope, principles, norms, accountabilities and bounds of contemporary engineering practice in the area of practice
P23ED601.3	(Apply) Familiarize with respect to the design methodologies applied to any component or mechanical system subjected to static, dynamic and thermo-mechanical loads.

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P23ED601.4	(Apply) Familiarize with respect to design standards, design calculations and analysis in designing any mechanical component or system.
P23ED601.5	(Create) Create the design, based on the engineering disciplines

P23ED602	**Project Work - Phase I**	**L**	**T**	**P**	**J**	**C**
		3	**0**	**4**	**0**	**2**

1. Course Description:

Project Phase 1 in a design course typically focuses on the initial stages of the design process, where students establish the foundation for their project. This phase involves identifying the problem or design challenge, conducting research, and defining project objectives, target audience, and constraints. Students engage in brainstorming sessions, conceptualizing multiple ideas, and developing early sketches or rough prototypes. The goal of Phase 1 is to explore various design directions, assess feasibility, and select a promising concept to move forward. Documentation of research, ideation, and initial design decisions is often required for evaluation at the end of this phase. Working in interdisciplinary teams, students will apply design thinking to real-world projects, progressing from technology formulation (TRL 2) to the working model or prototype be demonstrated in a space environment (TRL 7), creating solutions aligned with the UN's Sustainable Development Goals (SDGs).

2. Course Objectives:

1. To identify a specific problem for the current need of the society and collecting information related to the same through detailed review of literature.
2. To develop the methodology to solve the identified problem.
3. To train the students in preparing project reports and to face reviews and viva-voce examination.

3. Syllabus: **180 Periods**

The student individually works on a specific topic approved by the head of the division under the guidance of a faculty member who is familiar in this area of interest. The student can select any topic which is relevant to the area of engineering design. The topic may be theoretical or case studies. At the end of the semester, a detailed report on the work done should be submitted which contains clear definition of the identified problem, detailed literature review related to the area of work and methodology for carrying out the work. The students will be evaluated through a viva-voce examination by a panel of examiners including one external examiner.

4. Course Outcomes:

After successful completion of the course, the student should be able to:

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CO. No.	Course Outcome
P23ED602.1	Demonstrate a sound technical knowledge of their selected project topic.
P23ED602.2	Undertake problem identification, formulation and solution.
P23ED602.3	Design engineering solutions to complex problems utilising a systems approach
P23ED602.4	Effectively present project findings and outcomes to a variety of audiences, utilizing appropriate visual aids and communication strategies.
P23ED602.5	Recognize and apply ethical principles relevant to the project work, ensuring responsible conduct and integrity.

P23ED603	**Project Work - Phase II**	**L**	**T**	**P**	**J**	**C**
		3	**0**	**4**	**0**	**2**

1. Course Description:

Project Work - Phase II focuses on the completion and implementation of the research or design project initiated in the first phase. This stage emphasizes the practical execution of the project, involving the design, experimentation, analysis, and final presentation of results. Students work individually or in teams under faculty supervision to solve complex problems or create innovative solutions based on the objectives outlined in Phase I. Key deliverables include a comprehensive project report, documentation of the research/design process, and a final presentation or demonstration. This phase encourages students to apply their theoretical knowledge, develop critical thinking and problem-solving skills, and prepare for professional challenges in their field. Working in interdisciplinary teams, students will apply design thinking to real-world projects, progressing from technology formulation (TRL 2) to the working model or prototype be demonstrated in a space environment (TRL 7), creating solutions aligned with the UN's Sustainable Development Goals (SDGs).

2. Course Objectives:

1. To solve the identified problem based on the formulated methodology.
2. To develop skills to analyze and discuss the test results, and make conclusions.

3. Syllabus: **180 Periods**

The student should continue the phase I work on the selected topic as per the formulated methodology under the same supervisor. At the end of the semester, after completing the work to the satisfaction of the supervisor and review committee, a detailed report should be prepared and submitted to the head of the department. The students will be evaluated based on the report submitted and the viva-voce examination by a panel of examiners including one external examiner

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4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED603.1	Demonstrate a sound technical knowledge of their selected project topic.
P23ED603.2	Undertake problem identification, formulation and solution.
P23ED603.3	Design engineering solutions to complex problems utilising a systems approach
P23ED603.4	Demonstrate the knowledge, skills and attitudes of a professional engineer to take up any challenging practical problem in the field of engineering design and find better solutions to it
P23ED603.5	Produce clear and comprehensive documentation of the project, including methodologies, results, and conclusions.

Professional Electives

SEMESTER I - PROFESSIONAL ELECTIVE – I

P23ED501	Mechanics of Composite Materials	L	T	P	J	C
		3	0	0	0	3

1. Course Description:

This course provides an in-depth study of composite materials, focusing on their types, properties, manufacturing techniques, and applications. It explores the mechanical behavior of composites, including particulate-reinforced, dispersion-strengthened, and fiber-reinforced composites, and introduces the rule of mixtures for analysing their properties. Upon completion, students will have a thorough understanding of the mechanics, analysis, and design considerations of composite materials, enabling them to apply this knowledge in advanced engineering and industrial applications.

2. Course Objectives:

1. Students will understand the fundamentals, types, and applications of composite materials.
2. Students will Learn various manufacturing techniques for polymer, metal, and ceramic matrix composites.
3. Students will develop skills to derive and analyze lamina constitutive equations and laminate theory.
4. Students will be able to Analyse lamina strength and laminate behavior using failure criteria and mechanical analysis.
5. Students will examine the thermal behavior and expansion characteristics of composite laminates.

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3. Syllabus:	45 Periods
Unit-I: Introduction to Composite Materials	**9 Periods**
Definition; Matrix materials, polymers, metals, ceramics; Reinforcements: Particles, whiskers, inorganic fibres, metal filaments; ceramic fibers; fiber fabrication; natural composite wood, Jute, Advantages and drawbacks of composites over monolithic materials. Mechanical properties and applications of composites, Particulate-Reinforced composite Materials, Dispersion-Strengthened composite, Fiber-reinforced composites Rule of mixtures; Characteristics of fiber; Reinforced composites, Manufacturing fiber and composites.	
Unit-II: Manufacturing of Composites	**9 Periods**
Manufacturing of Polymer Matrix Composites (PMCs); handlay-up, spray technique, filament winding, Pultrusion;Resin Transfer Moulding (RTM): bag moulding, injection moulding, Sandwich Mould Composites (SMC) , Manufacturing of Metal Matrix Composites (MMCs), Solid state, liquid state, vapour state processing; Manufacturing of Ceramic Matrix Composites (CMCs): hot pressing, reaction bonding process;infiltration technique, direct oxidation;interfaces.	
Unit-III: Introduction, Lamina Constitutive Equations	**9 Periods**
Lamina Constitutive Equations: Lamina Assumptions, Macroscopic Viewpoint, Generalized Hooke's Law. Reduction to Homogeneous Orthotropic Lamina; Isotropic limit case, Orthotropic Stiffness matrix (Qij), Definition of stress and Moment Resultants. Strain Displacement relations. 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-IV: Lamina Strength Analysis and Analysis of Laminated Flat Plates	**9 Periods**
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 Equilibrium Equations of Motion; Energy Formulations; Static Bending Analysis; Buckling Analysis; Free Vibrations; Natural Frequencies	
Unit-V: Thermal Analysis	**9 Periods**
Assumption of Constant Co-efficient of Thermal Expansion (C.T.E.); Modification of Hooke's Law; Modification of Laminate Constitutive Equations; Orthotropic Lamina C.T.E's; C.T.E's for special Laminate Configurations; Unidirectional, Off-axis, Symmetric Balanced Laminates, Zero C.T.E. laminates, Thermally Quasi-Isotropic Laminates.	
Text Books:	

1. Agarwal, B.D., and Broutman, L.J., Analysis and Performance of Fiber Composites, 3rd Edition, John Wiley and Sons, 2017.
2. Chung, Deborah D.L., Composite Materials: Science and Applications, 2nd Edition, Springer, 2010.
3. Gibson, R.F., Principles of Composite Material Mechanics, 4th Edition, CRC Press, 2016.

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4. Daniel, I.M., and Ishai, O., Engineering Mechanics of Composite Materials, 2nd Edition, Oxford University Press, 2005.
5. Mukhopadhyay, M., Mechanics of Composite Materials and Structures, 1st Edition, University Press, 2004 (Reprinted 2008).

Reference Books:

1. Halpin, J.C., Primer on Composite Materials Analysis, 2nd Edition, CRC Press, 1992.
2. Hyer, M.W., Stress Analysis of Fiber-Reinforced Composite Materials, 1st Edition, McGraw-Hill, 1998.
3. Mallick, P.K., Fiber-Reinforced Composites: Materials, Manufacturing, and Design, 3rd Edition, CRC Press, 2007.
4. Mallick, P.K., Composite Materials Technology: Processes and Properties, 2nd Edition, CRC Press, 2020.

Journals:

1. Composites Science and Technology— Elsevier
2. Composite Structures – Elsevier

MOOC/NPTEL /SWAYAM Courses:

1. Coursera - Introduction to Composite Materials (University of Illinois)
2. MIT Open Courseware - Composite Materials - Analysis and Desig
3. NPTEL - Mechanics of Composite Materials (IIT Roorkee)
4. NPTEL - Composite Materials and Structures (IIT Madras)

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED501.1	**(Understand)** Summarize the various types of composites and their properties
P23ED501.2	**(Apply)** Summarize the various types of manufacturing methods for composite materials.
P23ED501.3	**(Analyze)** Derive Flat plate Laminate equations
P23ED501.4	**(Analyze)** Analyse Lamina strength, Laminate flat plates and particulates
P23ED501.5	**(Analyze)** Analyse the thermal behavior of Composite laminates

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P23ED502	Design for Sustainability	L	T	P	J	C
		3	0	0	0	3

1. Course Description:

This course explores the principles and practices of sustainable design, emphasizing the importance of creating products, systems, and environments that minimize environmental impact while promoting social equity and economic viability. Students will examine the interconnectedness of design, sustainability, and innovation, and develop the skills to incorporate sustainable practices into their design processes.

2. Course Objectives:

1. Learn the foundational concepts of sustainability and its relevance to design practices.
2. Learn sustainable learning tools
3. Foster creativity in developing innovative and practical solutions that address sustainability challenges
4. Investigate emerging trends and technologies in sustainable design, preparing students for future challenges in the field.
5. Develop skills to incorporate user needs and behaviours into sustainable design solutions

3. Syllabus: **45 Periods**

Unit-I: Basic Concepts In Sustainability **9 Periods**

Understanding the language of sustainable engineering design: construction and operation; Natural resources terminology; Carrying capacity; Sustainable development: corporate responsibility, biophysical constraints, environmental management.

Unit-II: Tools and Techniques **9 Periods**

Sustainable Engineering Design Tools: Life cycle analysis, carbon foot printing; Life cycle assessment (LCA): Types of LCA's, baseline, comparative, streamlined. LCA inventory analysis: process or input□output. Hybrid inventory analysis; Sustainable Product Design: Whole systems design; Light weighting and materials reduction; Designing for a lifetime: Design for durability, repair and upgrade, disassembly and recycling; Energy use in design: Reducing energy losses in design.

Unit-III: Foundational Concepts & Principles for Sustainable Breakthrough Design **9 Periods**

Infrastructure for managing flows of materials; energy and activities: sustainable value creation approaches for all stakeholders; environmental design characteristics; design changes & continual improvement; inclusive sustainable design principles; crowd sourcing; multiple-objective designs; infrastructures that support system thinking; knowledge management for sustainable design: learning systems and experimentation, smart data systems, understanding variation.

Unit-IV: Sustainable Design **9 Periods**

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Industrial ecology; multiple life cycle design: principles of design, green engineering, cradle to cradle design, The Natural Step, biomimicry, design for reuse, dematerialization, modularization, design for flexibility, design for disassembly, design for inverse manufacturing, design for the environment.

Unit-V: Customer and User Needs Assessment **9 Periods**

Identification and breakdown structures that describe customers and stakeholders; green marketing: socially conscious consumerism, sources of customer information, collecting information, analysing customer behaviour, translating the voice of the customer, use analysis, structuring customer needs, service gap analysis, prioritizing customer needs, strategic design, Kano technique.

Text Books:

1. Finster, Mark P., 2013. Sustainable Perspectives to Design and Innovation.
2. Clarke, Abigail & John K. Gershenson 2006. Design for the Life Cycle. Life-cycle Engineering Laboratory, Department of Mechanical Engineering-Engineering Mechanics, Michigan Technological University.

References:

Reference Books:

1. Ramaswamy, Rohit, 1996. Design and Management of Service Processes: Keeping Customers for Life, Prentice Hall.
2. Schmitt, Brent, Customer Experience Management, Wiley and Sons, 2003.

Journals:

1. Design for sustainability
2. Design for sustainability models

MOOC/NPTEL /SWAYAM Courses:

1. System design for sustainability
   https://archive.nptel.ac.in/courses/107/103/107103081/
2. Strategies for suitable design
   https://archive.nptel.ac.in/courses/124/106/124106157/
3. Business and Sustainable development
   https://archive.nptel.ac.in/courses/110/101/110101153/
4. Education for Sustainable development
   https://archive.nptel.ac.in/courses/109/105/109105190/

4. Course Outcomes:

After successful completion of the course, the student should be able to:

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CO. No.	Course Outcome
P23ED502.1	**(Apply)** Apply the concept of sustainability in terms of design, construction and development
P23ED502.2	**(Apply)** Apply design tools and life cycle assessment tools.
P23ED502.3	**(Apply)** Apply sustainable value creation approaches, design changes & continual improvement.
P23ED502.4	**(Apply)** Carry out sustainable design, green engineering, flexible design etc.
P23ED502.5	**(Apply)** Design according to the customer needs and design the products that are environmental friendly.

P23ED503	Bio Materials	L	T	P	J	C
		3	0	0	0	3

1. Course Description:

This course explores the fundamental principles and applications of biomaterials in the engineering and medical field. Students will learn about the types of materials (metals, ceramics, polymers, and composites) used in biomedical devices and implants, their interactions with biological systems, and the criteria for their selection and design. Topics include the chemical, physical, and mechanical properties of biomaterials, biocompatibility, degradation, and the regulatory and ethical considerations in their use. The course also covers the latest advancements in tissue engineering, drug delivery systems, and regenerative medicine, as well as the challenges in designing biomaterials for specific medical applications.

2. Course Objectives:

1. Students will be able to identify and categorize different types of biomaterials, including metals, ceramics, polymers, and composites, based on their chemical, physical, and mechanical properties.
2. Students will apply knowledge of material science to design and select appropriate biomaterials for specific medical applications like implants, prosthetics, and drug delivery systems.
3. Students will understand the interactions between biomaterials and biological tissues, including concepts of biocompatibility, immune responses, and tissue regeneration.
4. Students will assess the performance of biomaterials in various biomedical applications, considering factors such as wear, corrosion, fatigue, and mechanical strength.

3. Syllabus **45 Periods**

Unit-I: Introduction to Bio-Materials **9 Periods**

Bio-Materials — Definition and classification of bio-materials — mechanical properties, visco elasticity, biomaterial performance, body response to implants, wound healing, blood compatibility, Nano scale phenomena.

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Unit-II: Types of biomaterials	**9 Periods**
Types of biomaterials — Metallic, ceramic, polymeric and composite biomaterials; Classification according to physiological response of biomaterials — bioinert, bioactive and bioresorbable biomaterials.	
Unit-III: Tissue Replacement Implants	**9 Periods**
Surface modifications; Surface analysis; Surface-protein interactions; Material-cell interactions — biocompatibility and rejection; Implants and infection.	
Unit-IV: Application of Biomaterials	**9 Periods**
Small intestinal sub mucosa and other decullarized matrix biomaterials for tissue repair; Extra cellular Matrix; Softtissue replacements; sutures; surgical tapes; adhesive; Percutaneous and skin implants; maxillofacial augmentation — Vascular grafts, hard tissue replacement Implants, joint replacements, tissue scaffolding and engineering using Nano biomaterials.	
Unit-V: Testing of Biomaterials	**9 Periods**
Biomaterials test — Biocompatibility, blood compatibility and tissue compatibility tests, Toxicity tests, sensitization, carcinogenicity, mutagenicity and special tests, Invitro and Invivo testing; Sterilisation of implants and devices; ETO, gamma radiation, autoclaving; Effects of sterilization.	

Text Books:

1. Kothandaraman.C.P., Domkundwar. S,Domkundwar. A.V., "A course in Thermal Engineering", Fifth Edition, "Dhanpat Rai & sons , 2-12.
2. Er.Rajput. R. K., "Thermal Engineering", tenth Edition, Lakshmi publication, 2-15.
3. Cengel Y. A. & Boles M. A. "Thermodynamics - an Engineering Approach", 9/e, Tata McGraw Hill, 2-19

Reference Books:

1. Sreeram Ramakrishna, MuruganRamalingam, T. S. Sampath Kumar, and Winston O. Soboyejo, "Biomaterials: A Nano Approach", CRC Press, 2010.
2. Biomaterials- Basic Theory with Engineering Applications C.Mauli Agarwal, Joo L.Ong, Mark R. Appleford, Gopinath Mani. Cambrige University Press, New York-2016.
3. Monika Saini, Yashpal Singh, Pooja Arora, Vipin Arora, and KratiJain. "Implant biomaterials: A comprehensive review", World Journal of Clinical Cases, 2015.
4. Rudramoorthy, R, "Thermal Engineering ", First Edition, Tata McGraw-Hill, New Delhi,2-1-
1. Sonntag R. E., Borgnakke C. & Van Wylen, G. - 'Fundamentals of Thermodynamics', 1-/e John Wiley and Sons , 2-19

Journals:

1. Biofabrication — IOP Publishing
2. Biomaterials–Elsevier

MOOC/NPTEL /SWAYAM Courses:

1. https://onlinecourses.nptel.ac.in/noc19_mm24/preview
2. https://archive.nptel.ac.in/courses/102/106/102106057/#

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3. https://www.youtube.com/watch?v=ZTu8OHlpJw0&list=PLyqSpQzTE6M84uhv2xVd-sF0I1VZU9XVO
4. Surface Modification- https://www.youtube.com/watch?v=NY9IKM1Px0M
5. Biocompatibility of Biomaterials- https://www.youtube.com/watch?v=Xf0LMCgol-U

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED503.1	(Apply) Analyze different types of Biomaterials and its classification and apply the concept of nanotechnology towards biomaterials use.
P23ED503.2	(Apply) Identify significant gap required to overcome challenges and further development in metallic and ceramic materials
P23ED503.3	(Analyze) Identify significant gap required to overcome challenges and further development in polymeric materials
P23ED503.4	(Apply) Create combinations of materials that could be used as a tissue replacement implant.
P23ED503.5	(Analyze) Understand the testing standards applied for biomaterials.

P23ED504	**Additive Manufacturing & Tooling**	**L**	**T**	**P**	**J**	**C**
		3	**0**	**2**	**0**	**4**

1. Course Description:

This course provides a comprehensive exploration of additive manufacturing (AM) technologies and their applications in tooling. Students will gain a deep understanding of various additive processes, including 3D printing techniques such as Fused Deposition Modeling (FDM), Stereolithography (SLA), and Selective Laser Sintering (SLS) and associated errors and means to rectify them.

2. Course Objectives:

This course addresses the principle of various AM techniques and its concept, scope, building strategies, post-processing, and areas of applications along with different rapid tooling methods and reverse engineering

3. Syllabus: **45 Periods**

Unit-I: Introduction **6 Periods**

Introduction: Traditional Prototyping Vs. Rapid Prototyping (RP); Classification of Rapid Manufacturing Processes: Additive, Subtractive, Formative; Generic RP process: STL file Generation, Build File Creation, Part Construction, Part Cleaning, and finishing; Process Strength; limitations.

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CAD Modelling and Data Processing: CAD model preparation; Data interfacing: formats like STL, SLC, CLI, RPI, LEAF, IGES, HP/GL, CT, STEP, conversation; Part orientation and support generation; Support structure design; direct and adaptive slicing; Tool path generation

Unit-II: Processes and Techniques **15 Periods**

Liquid based systems - Stereo lithography: Process, Working principle, Applications, Advantages and Disadvantages; Solid ground curing (SGC): Process, Working, principle, Applications, Advantages and Disadvantage; Rapid Freeze Prototyping (RFP); Solid Object Ultraviolet-Laser Printer (SOUP) process & Two Laser Beams process

Solid based systems - Laminated object manufacturing (LOM): Process, Working principle, Applications, Advantages and disadvantages; Fused Deposition Modeling (FDM): Process, Working principle, Applications, Advantages and disadvantages

Powder Based Systems - Selective laser sintering (SLS): Process, Working principle, Applications, Advantages and Disadvantages; Electron Beam Melting (EBM): Process, Working principle, Applications, Laser Engineered Net Shaping (LENS) & Electron Beam Melting process

Unit-III: Errors in AM Processes **6 Periods**

Errors in AM Processes: Pre-processing, processing, post-processing errors, Part building errors in different additive manufacturing processes

Unit-IV: Rapid Tooling and Reverse Engineering **9 Periods**

Rapid Tooling: Indirect Rapid Tooling: Silicone rubber tooling, Aluminium filled epoxy tooling, Spray metal tooling; Direct Rapid Tooling: Direct AIM, Quick cast process, Direct Metal Laser Sintering Tooling (DMLS) Rapid Tool, ProMetal, Laminate tooling; soft tooling vs hard tooling

Reverse Engineering: Basic concept, Digitization techniques, Model Reconstruction, Data Processing for Rapid Prototyping; Reverse Engineering (RE) Methodologies and Techniques; Selection of RE systems

Unit-V: Additive Manufacturing Applications **9 Periods**

Additive Manufacturing Applications: Design, Engineering Analysis and planning applications, Medical Applications of RP, Forensic Science and Anthropology, Arts and Architecture, Aerospace Industry, Automotive Industry, Jewellery Industry, Coin Industry etc.

Text Books:

1. Rapid Prototyping: A Brief Introduction, Ghosh A., Affiliated East West
2. Rapid Prototyping Technology: Selection and Application, Kenneth G. Cooper, CRC Press

References:

Reference Books:

1. Rapid Prototyping: Principles and Applications, Chua Chee Kai, Leong Kah Fai, Lim Chu - Sing, World Scientific
2. Rapid Prototyping theory & practice, Ali K. Kamarani, Manufacturing System Engineering Series, Springer Verlag
3. Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing, Gibson I, Rosen D W., and Stucker B, Springer

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Journals: 1. Additive Manufacturing, Elsevier 2. Rapid prototyping Journal, Emerald 3. Virtual and Physical Prototyping, Taylor & Francis
MOOC/NPTEL /SWAYAM Courses: 1. https://www.mooc-list.com/course/selective-laser-sintering-and-metal-laser-powder-bed-fusion-coursera 2. https://www.mooc-list.com/course/material-jetting-and-stereolithography-coursera 3. https://www.mooc-list.com/tags/photopolymer-resin 4. https://onlinecourses.nptel.ac.in/noc22_me130/preview 5. https://onlinecourses.nptel.ac.in/noc24_me130/preview 6. https://archive.nptel.ac.in/courses/112/103/112103306/

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcomes
P23ED504.1	Acquire knowledge about the fundamentals for additive manufacturing with compare to traditional manufacturing
P23ED504.2	Understand and use techniques for processing of CAD models for rapid Prototyping
P23ED504.3	Understand the operating principles, capabilities, and limitations of liquid based, solid based & powder based additive manufacturing system
P23ED504.4	Apply the proper tooling methods for rapid prototyping process
P23ED504.5	Discover the rapid prototyping techniques for reverse engineering with different applications

SEMESTER I - PROFESSIONAL ELECTIVE – II

P23ED506	Mechanical Measurements and Analysis	L	T	P	J	C
		3	0	2	0	4

1. Course Description

This course explores the principles and techniques of mechanical measurements. Students will learn to apply various measurement tools and methods to assess mechanical systems and physical quantities. Students can able to identify the appropriate testing techniques and methods for various engineering applications.

2. Course Objectives:

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1. Students will be able to analyze and measure physical quantities, including forces and strains, using various measurement techniques.
2. Students will be able to apply different vibration measurement techniques to assess dynamic behaviors in mechanical systems.
3. Students will apply techniques for crack measurement to evaluate structural integrity and material conditions.
4. Students will select and apply appropriate non-destructive testing methods for diverse engineering applications to ensure reliability and safety.

3. Syllabus: **45 Periods**

Unit-I: Forces And Strain Measurement **9 Periods**

Strain gauge, principle, types, performance and uses; Photo elasticity: Principle and applications; Moire Fringe; Hydraulic jacks and pressure gauges; Electronic load cells, Proving Rings, Calibration of Testing Machines.

Unit-II: Vibration Measurements **9 Periods**

Characteristics of Structural Vibrations, Linear Variable Differential Transformer (LVDT), Transducers for velocity and acceleration measurements. Vibration meter, Seismographs, Vibration Analyzer, Display and recording of signals, Cathode Ray Oscilloscope, XY Plotter, Chart Plotters and Digital data Acquisition systems.

Unit-III: Acoustics And Wind Flow Measurements **9 Periods**

Principles of Pressure and flow measurements, pressure transducers, sound level meter, venture meter and flow meters; Wind tunnel and its use in structural analysis: structural modelling, direct and indirect model analysis.

Unit-IV: Distress Measurements **9 Periods**

Diagnosis of distress in structures, crack observation and measurements; Corrosion of reinforcement in concrete : Half-cell, construction and use, damage assessment and controlled blasting for demolition.

Unit-V: Non-Destructive Testing Methods **9 Periods**

Load testing on structures, buildings, bridges and towers; Rebound Hammer; acoustic mission; Ultrasonic testing principles and application; Holography: use of laser for structural testing, Brittle coating.

Referenes:

Reference Books:

1. Bray Don E and Stanley, R.K., "Non-destructive Evaluation", McGraw Hill Publishing Company, N.Y.1989
2. Garas, F.K., Clarke,J.L and Armer GST, "Structural assessment",Butterworths,London,1987
3. James W. Dally and William Franklin Riley, "Experimental Stress Analysis", McGraw Hill , 3rd Edition,1991
4. Sadhu Singh, Experimental Stress Analysis, Khanna Publishers, New Delhi, 2009.
5. Srinath LS, Raghavan Mr, Lingaiah K, Gargesha G, Pant Band Ramachandra, K, "Experimental Stress Analysis", Tata McGraw Hill Company, New Delhi,1984

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Journals:

1. Journal of Mechanical Measurement — Science Direct

MOOC/NPTEL /SWAYAM Courses:

1. https://archive.nptel.ac.in/courses/112/106/112106138/
2. https://archive.nptel.ac.in/courses/112/107/112107242/
3. Mechanical Measurement Systems - https://onlinecourses.nptel.ac.in/noc24_me12/preview
4. Principles of Mechanical Measurement - https://onlinecourses.nptel.ac.in/noc21_me55/preview

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED506.1	(Analyze) Measure physical quantities such as forces and strains.
P23ED506.2	(Apply) Apply different vibration measurements techniques.
P23ED506.3	(Analyze) Measure physical quantities such as pressure and flow
P23ED506.4	(Apply) Apply techniques involved in crack measurement.
P23ED506.5	(Analyze) Select the appropriate non-destructive testing methods for various engineering applications.

P23ED507	Industrial Robotics and Expert Systems	L	T	P	J	C
		3	0	2	0	4

1. Course Description:

This course covers the fundamentals of robotics, including robot anatomy, coordinate systems, and applications. It explores various robot drive systems, end effectors, sensors, and machine vision technologies. Additionally, students will learn about kinematics, robot programming, artificial intelligence, and expert systems, with practical applications in robotics.

2. Course Objectives:

1. To understand the fundamental concepts of robotics, including robot anatomy, classification, and various applications.
2. To explore different types of robot drive systems and end effectors, and their selection and design considerations.
3. To gain knowledge of sensors, machine vision, and their applications in robot navigation, inspection, and object recognition.
4. To develop skills in robot kinematics, programming, and the integration of artificial intelligence and expert systems in robotic systems.

3. Syllabus: **45 Period**

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Unit-I: Fundamentals of Robot	**9 Periods**
Robot : Definition, Robot Anatomy , Co-ordinate Systems, Work Envelope; Types and Classification: Specifications, Pitch, Yaw, Roll, Joint Notations, Speed of Motion, Pay Load, Robot Parts and their Functions; Need for Robots; Different Applications.	
Unit-II: Robot Drive Systems and End effectors	**9 Periods**
Pneumatic Drives: Hydraulic Drives, Mechanical Drives, Electrical Drives, D.C. Servo Motors, Stepper Motors, A.C. Servo Motors, Salient Features; Applications and Comparison of all these Drives; End Effectors; Grippers: Mechanical Grippers, Pneumatic and Hydraulic Grippers, Magnetic Grippers, Vacuum Grippers; Two Fingered and Three Fingered Grippers; Internal Grippers and External Grippers; Selection and Design Considerations.	
Unit-III Sensors and Machine Vision	**9 Periods**
Requirements of a sensor, Principles and Applications of the following types of sensors; Position sensors, Piezo Electric Sensor, LVDT, Resolvers, Optical Encoders, pneumatic Position Sensors, Range Sensors Triangulations Principles, Structured, Lighting Approach, Time of Flight, Range Finders, Laser Range Meters, Touch Sensors ,binary Sensors, Analog Sensors, Wrist Sensors, Compliance Sensors, Slip Sensors, Camera, Frame Grabber, Sensing and Digitizing Image Data; Signal Conversion, Image Storage, Lighting Techniques, Image Processing and Analysis; Data Reduction, Segmentation, Feature Extraction, Object Recognition, Other Algorithms, Applications; Inspection, Identification, Visual Serving and Navigation.	
Unit-IV: Robot Kinematics and Robot Programming	**9 Periods**
Forward Kinematics, Inverse Kinematics and Difference; Forward Kinematics and Reverse Kinematics of manipulators with Two, Three Degrees of Freedom (in 2 Dimension), Four Degrees of freedom (in 3 Dimension) Jacobians, Velocity and Forces; Manipulator Dynamics, Trajectory Generator, Manipulator Mechanism Design; Derivations and problems. Lead through Programming, Robot programming Languages; VAL Programming; Motion Commands, Sensor Commands, End Effector commands and simple Programs.	
Unit-V: Robot Programming, Artificial Intelligence and Expert Systems	**9 Periods**
Methods of Robot Programming; Characteristics of task level languages lead through programming methods ; Motion interpolation. Artificial intelligence : Basics, Goals of artificial intelligence, AI techniques, problem representation in AI ,Problem reduction and solution techniques , Application of AI and KBES in Robots.	
References:	
Reference Books: 1. Groover M.P., "Industrial Robotics -Technology Programming and Applications", McGraw Hill, 2017. 2. Klafter R.D., Chmielewski T.A and Negin M., "Robotic Engineering - An Integrated Approach",Prentice Hall, 2013. 3. Mittal R. K. and Nagrath, I. J. - 'Robotics and Control' - Tata McGraw Hill Publishing Company Limited, New Delhi - 2014. 4. Craig, J. - 'Introduction to Robotics: Mechanics and Control' - Prentice Hall - 2014 - 3rd Edition 5. Timothy Jordanides et al ," Expert Systems and Robotics ", Springer –Verlag, New York, May 2016. **Journals:**	

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1. International Journal of Intelligent Robotics and Applications – Springer
2. International Journal of Control, Automation and Systems– Springer

MOOC/NPTEL /SWAYAM Courses:

1. https://onlinecourses.nptel.ac.in/noc21_me67
2. https://archive.nptel.ac.in/courses/108/105/108105062/
3. Industrial Automation and Control - https://archive.nptel.ac.in/courses/108/105/108105088/
4. 4. Industrial Robotics Theories for Implementation - https://onlinecourses.nptel.ac.in/noc23_me143/preview

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED507.1	(Apply) Apply the knowledge of robot anatomy to identify and explain the functions of different robot components.
P23ED507.2	(Apply) Demonstrate the ability to select appropriate drive systems and end effectors for specific robotic applications.
P23ED507.3	(Apply) Utilize various sensors and machine vision techniques to solve practical robotic tasks such as object recognition and navigation.
P23ED507.4	(Apply) Solve forward and inverse kinematics problems for robots with multiple degrees of freedom.
P23ED507.5	(Apply) Develop basic robot programs using motion commands and implement simple AI techniques for robotic tasks.

P23ED508	Quality Concepts in Design	L	T	P	J	C
		3	0	2	0	3

1. Course Description:

This course delves into the principles and practices of quality assurance and quality control within the design process, emphasizing the significance of delivering high-quality outcomes that meet user needs and industry standards. Students will explore methodologies such as ISO standards and Six Sigma, learn to integrate quality considerations throughout the design lifecycle, and apply user-centered design techniques, including usability testing and feedback analysis. Through case studies and collaborative projects, participants will develop skills in evaluating design quality using quantitative and qualitative metrics, fostering a culture of continuous improvement, and effectively communicating within design teams. By the end of the course, students will be equipped to champion quality in their design work and contribute to successful project outcomes.

2. Course Objectives:

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By the end of this course, students will be able to:

1. To impart knowledge on various concepts in engineering design, material selection andmanufacturing methods.
2. To learn the principles of implementing quality in a product or services using different tools
3. To enhance the quality of product by use of failure mode effect analysis and implement methods to uphold the status of six sigma
4. To develop a robust product or service using various strategies of design of experiments
5. To maintain the quality of the product by use of statistical tools and enforce methods toimprove the reliability of a product

3. Syllabus: **45 Periods**

Unit-I: Design Fundamentals, Methods and Material Selection **9 Periods**

Morphology of Design – The Design Process – Computer Aided Engineering – Concurrent Engineering – Competition Bench Marking – Creativity – Theory of Problem solving (TRIZ) – Value Analysis - Design for Manufacture, Design for Assembly – Design for casting, Forging, Metal Forming, Machining and Welding

Unit-II: Design For Qualit **9 Periods**

Quality Function Deployment - House of Quality-Objectives and functions-Targets-Stakeholders- Measures and Matrices-Design of Experiments –design process-Identification of control factors, noise factors, and performance metrics - developing the experimental plan-experimental design – testing noise factors- Running the experiments –Conducting the analysis-Selecting and conforming factor-Set points-reflecting and repeating.

Unit-III: Failure Mode Effects Analysis And Design For Six Sigma **9 Periods**

Basic methods: Refining geometry and layout, general process of product embodiment - Embodiment checklist- Advanced methods: systems modeling, mechanical embodiment principles- MEA method - linking fault states to systems modeling - Basis of SIX SIGMA –Project selection for SIX SIGMA- SIX SIGMA problem solving- SIX SIGMA in service and small organizations - SIX SIGMA and lean production –Lean SIX SIGMA and services.

Unit-IV: Design of Experiments **9 Periods**

Importance of Experiments, Experimental Strategies, Basic principles of Design, Terminology, ANOVA, Steps in Experimentation, Sample size, Single Factor experiments - Completely Randomized design, Randomized Block design, Statistical Analysis, Multifactor experiments - Two and three factor full Factorial experiments, 2K factorial Experiments, Confounding and Blocking designs, Fractional factorial design, Taguchi's approach - Steps in experimentation, Design using Orthogonal Arrays, Data Analysis, Robust Design- Control and Noise factors, S/N ratios

Unit-V: Statistical Consideration and Reliability **9 Periods**

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Frequency distributions and Histograms- Run charts –stem and leaf plots- Pareto diagrams-Cause and Effect diagrams-Box plots- Probability distribution-Statistical Process control–Scatter diagrams –Multivariable charts –Matrix plots and 3-D plots.-Reliability-Survival and Failure-Series and parallel systems-Mean time between failure-weibull distribution.

Text Books:

1. Amitava Mitra, "Fundamentals of Quality control and improvement", John Wiley & Sons, 2016
2. George E. Dieter, Linda C. Schmidt, "Engineering Design", McGraw Hill Education Pvt. Ltd., 2013
3. Karl T. Ulrich, Steven D. Eppinger, "Product Design And Development, ,Tata Mcgraw-Hill ,2ducation, 2015

References:

Reference Books:

1. Kevin N. Otto and Kristin L. Wood, "Product Design: Techniques in Reverse Engineering and New Product Development", Prentice Hall, 2001
2. Montgomery, D.C., "Design and Analysis of experiments", John Wiley and Sons, 2017.
3. 6. Phillip J. Ross, "Taguchi techniques for quality engineering", Tata McGraw Hill, 2005.

Journals:

1. The Design Journal - Taylor & Francis
2. Journal of Design Research - Inderscience

MOOC/NPTEL /SWAYAM Courses:

1. https://www.my-mooc.com/en/video/an-introduction-to-quality-by-design
2. https://www.paripassu.com.br/en/blog/quality-concepts
3. https://onlinecourses.nptel.ac.in/noc21_mg24/preview
4. https://onlinelearninginsights.wordpress.com/2015/12/12/mooc-quality-comes-down-to-this-effective-course-design/

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED508.1	Apply fundamentals of design process and material selection for developing a quality product
P23ED508.2	Apply the quality concepts to develop a robust product
P23ED508.3	Perform Failure Mode Effect Analysis on a product and use six sigma principles to enhance its quality
P23ED508.4	Apply different experimental design methods in product development

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P23ED508.5	Implement various statistical tools to improve its quality and reliability

P23ED509	**Wearable Technologies**	**L**	**T**	**P**	**J**	**C**
		3	**0**	**2**	**0**	**4**

1. Course Description:

This course examines the role of wearable technologies in health and wellness. Students will explore device functionality, data collection, and analysis, as well as the implications for personal fitness, healthcare advancements, and ethical considerations, preparing them for future innovations in the field.

2. Course Objectives:

1. Students will be able to grasp the fundamentals of wearable technologies, focusing on design challenges and opportunities.
2. Students will be able to identify and categorize various sensors integral to wearable devices.
3. Students will recognize materials utilized in flexible electronics and understand their power limitations.
4. Students will summarize methods and challenges related to energy harvesting from the human body.
5. Students will apply knowledge to explore practical applications of wearable technology within the healthcare sector.

3. Syllabus **45 Periods**

Unit-I: Introduction **9 Periods**

Attributes of wearables, Meta-wearable, Challenges and opportunities, Future of wearables; Social aspects of wear ability and interaction: Social interpretation of Aesthetics, Case study: Google glass; Wearable haptics: Need for wearable haptic devices; Categories of wearable haptic and tactile display, Wearable sensorimotor enhancer.

Unit-II: Wearable Sensors **9 Periods**

Chemical and Biochemical sensors, System design, Challenges in chemical Bio-chemical sensing, Application areas: Inertia sensors, Parameters from inertia sensors; Applications for wearable motion sensors; Measurement of energy expenditure by body worn heat flow sensors.

Unit-III: Flexible Electronics **9 Periods**

Introduction; Thin-film transistors: Materials and Technologies; Review of Semi conductors in flexible electronics; Low-power Integrated Circuit Design for Bio-potential sensing: Analog circuit design techniques; Low- power design for ADCs; Digital circuit design techniques; Architectural design for low-power bio-potential acquisition, Practical considerations.

Unit-IV: Energy Harvesting Systems **9 Periods**

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Energy harvesting from human body: Temperature gradient, Foot motion; Wireless energy transmission; Energy harvesting from light and RF energy; Energy and power consumption issues; Future considerations.
Unit-V: Monitoring Physical And Physiological Parameters **9 Periods**
Wearable sensors for physiological signal measurement; Physical measurement: Cardiovascular diseases, Neurological diseases, Gastrointestinal diseases; Wearable and non-invasive assistive technologies: Assistive devices for individuals with severe paralysis, Wearable tongue drive system, Sensor signal-processing algorithm, Dual-mode tongue drive system.
References:
Reference Books: 1. Edward Sazonov, Michael R Neuman, "Wearable Sensors: Fundamentals, Implementation and Applications", Academic Press, USA, 2014 2. Tom Bruno, "Wearable Technology: Smart Watches to Google Glass for Libraries", Rowman & Littlefield Publishers, Lanham, Maryland, 2015. 3. Raymond Tong, "Wearable Technology in Medicine and Health Care", Academic Press, USA, 2018. 4. Haider Raad, "The Wearable Technology Handbook", United Scholars Publication, USA, 2017. **Journals:** 1. Journal of Wearable Technology— Science Direct **Videos and MOOCs:** 1. https://nptel.ac.in/courses/108106193 2. Sensor Technologies: Physics, Fabrication, and Circuits - https://onlinecourses.nptel.ac.in/noc23_ee95/preview

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED509.1	(Understand) Understand the fundamentals of wearables, wearable design issues and user interfaces
P23ED509.2	(Understand) Identify the different types of sensors used in wearable devices.
P23ED509.3	(Understand) Recognize the materials used in the field of flexible electronics technology and its power constraints

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P23ED509.4	(Understand) Summarize the techniques and issues associated with energy harvesting from human body
P23ED509.5	(Apply) Elucidate the applications of wearable technology in health care

P23ED510	**Industrial Internet of Things**	**L**	**T**	**P**	**J**	**C**
		3	**0**	**2**	**0**	**4**

1. Course Description:

This course introduces the principles and architecture of the Internet of Things (IoT) and Industrial IoT (IIoT), focusing on their components, communication models, and business frameworks. Students will explore data analytics, machine learning applications, and security considerations within IIoT environments. Real-world case studies from various industries will provide practical insights into the implementation and impact of IoT technologies.

2. Course Objectives:

1. To understand the foundational concepts and architecture of the Internet of Things (IoT), including its communication models, challenges, and evolution.
2. To explore the industrial applications of IoT (IIoT) and its reference architectures, including business models and various IIoT layers.
3. To develop knowledge in big data analytics, machine learning, and software-defined networks, with a focus on IIoT data processing and management.
4. To examine security concerns in IIoT and learn about cloud and fog computing, along with real-world case studies in various industrial sectors.

3. Syllabus **45 Periods**

Unit-I: Introduction and Architecture of IOT **9 Periods**

Introduction : Definition and characteristics of IoT, Physical and Logical Design of IoT, Communication models and APIs, Challenges in IoT , Evolution of IoT, Components of IoT: A Simplified IoT Architecture, Core IoT Functional Stack.

Unit-II: Industrial IOT **9 Periods**

IIoT: Introduction, Industrial IoT: Business Model and Reference Architecture: IIoT Business Models; Industrial IoT: Layers; IIoT Sensing, IIoT Processing, IIoT Communication, IIoT Networking

Unit-III IIOT Analytics **9 Periods**

Big Data Analytics and Software Defined Networks, Machine Learning and Data Science, Julia Programming, Data Management with Hadoop

Unit-IV: IoT Security **9 Periods**

Industrial IoT: Security and Fog Computing; Cloud Computing in IIoT, Fog Computing in IIoT, Security in IIoT

Unit-V: Case study **9 Periods**

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Industrial IOT: Application Domains: Oil, chemical and pharmaceutical industry, Applications of UAVs in Industries, Real case studies: Food Processing and Packaging Industries, Manufacturing Industries
References:
Reference Books: 1. Industry 4.0: The Industrial Internet of Things", by Alasdair Gilchrist (Apress), 2017 2. "Industrial Internet of Things: Cyber manufacturing Systems" by Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat (Springer), 2017 3. Hands-On Industrial Internet of Things: Create a powerful Industrial IoT by Giacomo Veneri, Antonio Capasso, Packt, 2018. **Journals:** 1. IEEE Internet of Things (IoT) 2. Journal of Industrial Information Integration - Elsevier **MOOC/NPTEL /SWAYAM Courses:** 1. https://onlinecourses.nptel.ac.in/noc20_cs69/preview 2. https://archive.nptel.ac.in/courses/106/105/106105195/ 3. Introduction to Industry 4.0 and IIOT :https://archive.nptel.ac.in/noc/courses/noc21/SEM1/noc21-cs20/ 4. Introduction to Internet of Things: https://onlinecourses.nptel.ac.in/noc22_cs53/preview

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED510.1	(Apply) Apply the fundamental concepts, architecture, and components of IoT, including its communication models and design challenges.
P23ED510.2	(Apply) Understand and evaluate the business models, reference architectures, and layers of Industrial IoT (IIoT) systems, including sensing, processing, communication, and networking.
P23ED510.3	(Apply)Apply big data analytics, machine learning techniques, and data management frameworks such as Hadoop for IIoT data analysis and decision-making.
P23ED510.4	(Apply) Identify and address security challenges in IIoT environments, with a focus on cloud and fog computing solutions.
P23ED510.5	(Apply) Apply knowledge of real-world IIoT applications through case studies in various industries such as oil, pharmaceuticals, food processing, and manufacturing.

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SEMESTER II - PROFESSIONAL ELECTIVE – III

P23ED511	Engineering Fracture Mechanics	L	T	P	J	C
		3	0	0	0	3

1. Course Description:

This course explores solid mechanics and fracture mechanics, focusing on stress, strain, crack propagation, and failure analysis. Topics include elastic and plastic deformation, energy-based crack growth, fatigue crack growth, and stress intensity factors. Students will learn to apply theoretical principles and numerical methods to solve engineering problems, ensuring material integrity and preventing structural failure.

2. Course Objectives:

1. Students will be able to explain stress, strain, and deformation in materials under various loading conditions.
2. Students will be able to solve crack propagation problems using stress intensity factors and plastic zone analysis.
3. Students will be able to apply energy-based approaches to assess crack growth and material stability.
4. Students will be able to estimate material life under fatigue loading and understand external factors affecting failure.
5. Students will be able to use fracture mechanics concepts in design, considering mixed-mode fractures and residual stresses.

3. Syllabus: **45 Periods**

Unit-I: Elements of Solid Mechanics **9 Periods**

The geometry of stress and strain, elastic deformation, plastic and elasto-plastic deformation; Limit analysis; Airy's function; field equation for stress intensity factor;

Unit-II: Stationary Crack Under Static Loading **9 Periods**

Two dimension elastic fields; Analytical solutions yielding near a crack front; Irwin's approximation-plastic zone size; Dugdaale model: determination of J integral and its relation to crack opening displacement;

Unit-III: Energy Balanced Crack Growth **9 Periods**

Griffith analysis: stable and unstable crack growth; Dynamic energy balance; crack arrest mechanism; K1c test methods; R curves; determination of collapse load;

Unit-IV: Fatigue Crack Growth Curve **9 Periods**

Empirical relation describing crack growth law; life calculations for a given load amplitude; effects of changing the load spectrum -- rain flow method– external factors affecting the K1c values.- leak before break analysis.

Unit-V: Applications of Fracture Mechanics **9 Periods**

Crack Initiation under large scale yielding; Thickness as a design parameter; Mixed mode fractures; Crack instability in thermal and residual stress fields; Numerical methods;

Text Books:

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1. David Broek, "Elementary Engineering Fracture Mechanics", Sijthoff & Noordhoff International Publisher, 1978.
2. John M.Barson and Stanely T.Rolfe Fatigue and fracture control in structures Prentice hall Inc.

References:

Reference Books:

1. Kare Hellan, "Introduction of Fracture Mechanics", McGraw-Hill BookCompany,1985.
2. Preshant Kumar, "Elements of Fracture Mechanics", Wheeler Publishing, 1999.
3. Tribikram Kundu, "Fundamentals of Fracture Mechanics", Ane Books Pvt. Ltd. New Delhi / CRC Press, 1st Indian Reprint, 2012.

Journals:

1. Engineering Fracture Mechanics – Elsevier
2. International Journal of Fracture –Springer

MOOC/NPTEL /SWAYAM Courses:

1. **https://archive.nptel.ac.in/courses/112/106/112106065/#**
2. Engineering Fracture Mechanics - https://onlinecourses.nptel.ac.in/noc19_me42/preview
3. Fracture Mechanics - https://www.mooc-list.com /tags/fracture-mechanics

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED511.1	(Understand) Explain the concepts of fracture properties of materials under static load conditions
P23ED511.2	(Apply) Apply the crack arresting mechanisms in fatigue loading conditions
P23ED511.3	(Understand) Explain the concept of crack growth and test methods
P23ED511.4	(Understand) Explain the properties of materials under thermal and residual stress fields
P23ED511.5	(Evaluate) Evaluate the analytical solutions for crack under static load conditions

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P23ED512	Design of Hydraulic and Pneumatic Systems	L	T	P	J	C
		3	0	2	0	4

1. Course Description:

This course provides an in-depth exploration of oil hydraulic and pneumatic systems, focusing on the selection and specification of hydraulic power generators, actuators, and control elements. Students will learn to design and analyze hydraulic and pneumatic circuits, applying methodologies for effective control and regulation. The course also covers the integration of electrical control systems, including PLCs and microprocessors, for automation in hydraulic and pneumatic applications.

2. Course Objectives:

1. Gain knowledge of oil hydraulic and pneumatic systems, focusing on component selection and specifications for industrial applications.
2. Develop the ability to design hydraulic and pneumatic circuits, ensuring efficient and safe operation.
3. Learn to integrate electrical control systems with hydraulic and pneumatic circuits using PLCs and microprocessors.
4. Engage in hands-on exercises to troubleshoot and optimize hydraulic and pneumatic systems for real-world challenges.

3. Syllabus: **45 Periods**

Unit-I: Oil Hydraulic Systems and Hydraulic Actuators **9 Periods**

Hydraulic Power Generators: Selection and specification of pumps, pump characteristics; Linear and Rotary Actuators: selection, specification and characteristics, Hydrostatic drives, types, selection

Unit-II: Control and Regulation Elements **9 Periods**

Pressure : direction and flow control valves , relief valves, non-return and safety valves; actuation systems, Proportional Electro hydraulic servo valves

Unit-III Hydraulic Circuits **9 Periods**

Reciprocation, quick return, sequencing, synchronizing circuits, accumulator circuits, industrial circuits, press circuits, hydraulic milling machine, grinding, planning, copying, forklift, earth mover circuits design methodology; design and selection of components: safety and emergency mandrels, Cascade method

Unit-IV: Pneumatic Systems And Circuits **9 Periods**

Pneumatic fundamentals : control elements, position and pressure sensing, Pneumatic equipment, selection of components, design calculations, logic circuits, switching circuits, fringe conditions modules and these integration, sequential circuits: cascade methods, mapping methods, step counter method, compound circuit design; combination circuit design: Karnaugh, Veitch map

Unit-V: Electromagnetic & Electronic Control Of Hydraulics & Pneumatic Circuit

9 Periods

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Electrical control of pneumatic circuits: use of relays, counters, timers, ladder diagrams, use of microprocessor in circuit design, use of PLC in hydraulic and pneumatic circuits, Fault finding, application -fault finding, hydro pneumatic circuits, use of microprocessors for sequencing; PLC; Low cost automation; Robotic circuits.

References:

Reference Books:

1. Anthony Esposito, "Fluid Power with Applications", Prentice Hall, 2009.
2. Jagadeesha T, "Pneumatics Concepts, Design and Applications ", Universities Press, 2015
3. James A. Sullivan, "Fluid Power Theory and Applications", Fourth Edition, Prentice Hall, 1997
4. Majumdar, S.R., "Oil Hydraulics Systems – Principles and Maintenance", Tata McGrawHill, 2001
5. Shanmuga Sundaram.K, "Hydraulic and Pneumatic Controls". Chand & Co, 2006

Journals:

1. Fluid Dynamics Research - IOP Publishing
2. Journal of Hydraulic Research - International Association of Hydraulic Engineering and Research (IAHR)

MOOC/NPTEL /SWAYAM Courses:

1. https://archive.nptel.ac.in/courses/112/106/112106300/
2. https://nptel.ac.in/courses/105103096
3. Hydraulic Engineering - https://onlinecourses.nptel.ac.in/noc21_ce31/preview
4. Principle of Hydraulic Machine and Design : hps://archive.nptel.ac.in/courses/112/103/112103249/

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED512.1	(Apply) Apply the key components of hydraulic systems, including pumps and actuators.
P23ED512.2	(Apply) Apply various control elements in hydraulic circuits, such as flow and pressure control valves.
P23ED512.3	(Apply)Apply hydraulic circuits, including sequencing and accumulator circuits.
P23ED512.4	(Apply) Apply the fundamental principles of pneumatic systems and their components.
P23ED512.5	(Apply) Implement PLC and microprocessor solutions for automation in industrial applications.

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P23ED513	Advanced Metal Forming Techniques	L	T	P	J	C
		3	0	0	0	3

1. Course Description:

This course provides an in-depth exploration of advanced metal forming processes and technologies used in the manufacturing industry. Students will study various techniques, including forging, stamping, rolling, and extrusion, with a focus on both theoretical principles and applications. The course emphasizes the importance of material properties, process parameters, and the latest innovations in metal forming.

2. Course Objectives:

1. Learn the basic principles and concepts underlying various metal forming processes.
2. Gain proficiency in various forging methods and their applications in industry.
3. Explore innovative forming techniques, such as hydroforming and superplastic forming, and their industrial applications
4. Learn defects and failure modes in metal forming.
5. Learn principles of hot and cold rolling, and effects of rolling parameters on material properties and final product quality.

3. Syllabus: **45 Periods**

Unit-I: Introduction to Theory of Plasticity and Forming **9 Periods**

Theory of plastic deformation: Hot and Cold Forming, Cold Isostatic Pressing (CIP), Hot Isostatic Pressing (HIP) forming for aerospace material; Introduction for effect of temperature on materials recrystallization; Yield criteria; Tresca and Von-mises ; Distortion energy; Stress strain relation: Mohr's circle representation of a state of stress; cylindrical and spherical coordinate system; upper and lower bound solution methods; thermo elastic Elasto plasticity; elasto visco plasticity.

Unit-II: Theory and Practice of Bulk Forming Processes **9 Periods**

Analysis of plastic deformation in Forging; Rolling, Extrusion, rod/wire drawing and tube drawing; Effect of friction; calculation of forces, work done; Process parameters; equipment used; Defects; applications; Recent advances in Forging; Rolling, Extrusion and Drawing processes; Design consideration in forming; Formability of laminated sheet; Overview of FEM applications in Metal Forming analysis.

Unit-III: Sheet Metal Forming **9 Periods**

Formability studies; Conventional processes; H E R F techniques; Super plastic forming techniques; Hydro forming; Stretch forming; Water hammer forming; Principles and process parameters; Advantage, Limitations and application; Tooling design and process optimization for sheet metal forming: Spring back compensation techniques.

Unit-IV: Powder Metallurgy and Special Forming Processes **9 Periods**

Overview of P/M techniques: Advantages, applications, Powder preform forging, powder rolling, Tooling, process parameters and applications; Orbital forging; Isothermal forging; High speed extrusion; Rubber pad forming; Fine blanking; Laser beam forming.

Unit-V: Electromagnetic Forming and its Applications **9 Periods**

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Electromagnetic Forming Process: Electro – Magnetic Forming Machines, Process Variables, Coils and Dies, Effect of Resistivity and Geometry, EM tube and sheet forming: stamping shearing and welding, Applications; Finite Element Analysis of EM forming.
Text Books:
1. Altan T., Metal forming fundamentals and applications, American Society of Metals, Metals park, 2003. 2. Marciniak,Z., Duncan J.L., Hu S.J., Mechanics of Sheet Metal Forming, Butterworth-Heinemann An Imprint of Elesevier, 2006
References:
Reference Books: 1. Dieter G.E., Mechanical Metallurgy (Revised Edition II) McGraw Hill Co., 2004 2. Shiro Kobayashi, Altan, T, Metal forming and Finite Element Method, Oxford University Press, 2001. 3. ASM Hand book, Forming and Forging, Ninth edition, Volume – 14, 2003 **Journals:** 1. Manufacturing of advanced smart tooling for metal forming 2. Developments in computational modelling techniques for industrial metal forming processes **MOOC/NPTEL /SWAYAM Courses:** 1. Principles of Metal forming Technology https://archive.nptel.ac.in/courses/112/107/112107250/ 2. Fundamentals of Manufacturing processes https://archive.nptel.ac.in/courses/112/107/112107219/ 3. Advanced Manufacturing processes https://archive.nptel.ac.in/courses/112/107/112107078/ 4. Advances in welding and joining technologies https://archive.nptel.ac.in/courses/112/103/112103244/ 5. Forming https://archive.nptel.ac.in/courses/112/106/112106153/

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED513.1	**(Apply)** Apply theory of plastic deformation concepts for engineering problems
P23ED513.2	**(Analyze)** Analyze the plastic deformation in Forging, Rolling, Extrusion, rod/wire drawing and tube drawing
P23ED513.3	**(Analyze)** Analyze the formability studies and summarize the conventional forming techniques
P23ED513.4	**(Apply)** Apply Powder metallurgy process and special forming techniques

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P23ED513.5	**(Apply)** Apply the Electromagnetic Forming processes.

P23ED514	**Tribology in Design**	**L**	**T**	**P**	**J**	**C**
		3	**0**	**0**	**0**	**3**

1. Course Description:

This course introduces the fundamental concepts of tribology, the study of friction, wear, and lubrication, and their critical role in the design and functioning of mechanical systems. It explores the interaction of surfaces in relative motion and the effects of frictional forces on performance, durability, and efficiency. Students will learn to apply tribological principles to optimize mechanical designs, improve component life, reduce energy losses, and enhance system reliability. The course covers a wide range of applications, from automotive systems to industrial machinery, and includes the selection of lubricants, surface treatments, and materials to minimize wear and friction.

2. Course Objectives:

1. Students will grasp the fundamental concepts of friction, wear, and lubrication, and their significance in mechanical systems.
2. Students can identify and quantify different types of wear (adhesive, abrasive, fatigue, and corrosive) and their implications for system design.
3. Students can able to select appropriate lubricants, additives, and lubrication methods for specific applications to optimize performance and reduce wear.
4. Students able to integrate tribological principles into the design process for mechanical components such as bearings, gears, seals, and sliding surfaces.

3. Syllabus **45 Periods**

Unit-I: Surface Interaction and Friction **9 Periods**

Topography of Surfaces: Surface features, Properties and measurement, Surface interaction; Adhesive Theory of Sliding Friction: Rolling Friction, Friction properties of metallic and non-metallic materials, friction in extreme conditions, thermal considerations in sliding contact. Nano Tribology: fundamentals and applications.

Unit-II: Wear and Surface Treatment **9 Periods**

Types of wear: Mechanism of various types of wear; Laws of wear: Theoretical wear models; Wear of Metals and Non metals; Surface treatments: surface modifications, surface coatings methods, surface Topography measurements, Laser methods, instrumentation; International standards in friction and wear measurements.

Unit-III: Lubricants and Lubrication Regimes **9 Periods**

Lubricants and their physical properties: Viscosity and other properties of oils; Additives-and selection of Lubricants: Lubricants standards ISO, SAE, AGMA, BIS standards: Lubrication Regimes; Solid Lubrication; Dry and marginally lubricated contacts: Boundary Lubrication: Hydrodynamic lubrication, Elasto and plasto hydrodynamic: Magneto hydrodynamic lubrication, Hydro static lubrication, Gas lubrication.

Unit-IV: Theory of Hydrodynamic and Hydrostatic Lubrication **9 Periods**

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Reynolds Equation: Assumptions and limitations, One and two dimensional Reynolds Equation, Reynolds and Sommerfeld boundary conditions, Pressure wave, flow, load capacity and friction calculations in Hydrodynamic bearings: Long and short bearings, Pad bearings and Journal bearings, Squeeze film effects; Thermal considerations; Hydrostatic lubrication of Pad bearing; Pressure, flow, load and friction calculations, Stiffness considerations, Various types of flow restrictors in hydrostatic bearings.

Unit-V: High Pressure Contacts and Elasto Hydrodynamic Lubrication **9 Periods**

Rolling contacts of Elastic solids: contact stresses, Hertzian stress equation, Spherical and cylindrical contacts, Contact Fatigue life, Oil film effects, Elasto Hydrodynamic lubrication Theory-Soft and hard EHL-Reynolds equation for elasto hydrodynamic lubrication; Film shape within and outside contact zones; Film thickness and friction calculation; Rolling bearings, Stresses and deflections, Traction drives.

Text Books:

1. Cameron, A. "Basic Lubrication Theory", Ellis Herward Ltd., UK, 1981
2. G.W.Stachowiak& A.W .Batchelor , Engineering Tribology, Butterworth - Heinemann, UK, 2005

References:

Reference Books:

1. Halling, J. (Editor) – "Principles of Tribology ", Macmillian – 1984.
2. Rabinowicz.E, "Friction and Wear of materials", John Willey &Sons ,UK,1995
3. S.K.Basu, S.N.Sengupta&B.B.Ahuja ,"Fundamentals of Tribology", Prentice – Hall of India Pvt Ltd , New Delhi, 2005
4. Williams J.A. "Engineering Tribology", Oxford Univ. Press, 1994.

Journals:

1. Tribology International- Science Direct
2. Wear- Science Direct

MOOC/NPTEL /SWAYAM Courses:

1. https://nptel.ac.in/courses/112102015
2. https://archive.nptel.ac.in/courses/112/102/112102014/

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED514.1	**(Apply)** Impart knowledge in the friction, wear and lubrication aspects of machine components
P23ED514.2	**(Apply)** Ability to select material / surface properties based on the tribological requirements
P23ED514.3	**(Apply)** Identify methodology for deciding lubricants and lubrication regimes for different operating conditions

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P23ED514.4	**(Analyze)** Analyze ability of different types of bearings for given load / speed conditions
P23ED514.5	**(Analyze)** Understand the analytical behaviour of different types bearings and design of bearings based on analytical /theoretical approach

P23ED515	**Artificial Intelligence and Machine Learning**	**L**	**T**	**P**	**J**	**C**
		3	**0**	**2**	**0**	**4**

1. Course Description:

This course provides a comprehensive introduction to artificial intelligence and machine learning, exploring foundational concepts, techniques, and applications. Students will learn about supervised and unsupervised learning methods, including decision trees, neural networks, and clustering techniques. Additionally, the course covers probabilistic graphical models, enhancing students' understanding of complex data relationships and decision-making processes.

2. Course Objectives:

1. To understand the fundamental concepts and techniques of artificial intelligence and their applications in robotics.
2. To explore the various types and processes of machine learning, focusing on data transformation and statistical methods.
3. To analyse and implement supervised learning methods, including decision trees, neural networks, and support vector machines.
4. To examine unsupervised learning techniques and probabilistic graphical models for effective data analysis and representation.

3. Syllabus: **45 Periods**

Unit-I: Artificial Intelligence **9 Periods**

Artificial intelligence :Basics , Goals of artificial intelligence,AI techniques–problem representation in AI , Problem reduction and solution techniques, Application of AI and KBES in Robots.

Unit-II: Introduction to Machine Learning **9 Periods**

Machine Learning:Types of Machine Learning ,Machine Learning process, preliminaries, testing Machine Learning algorithms, turning data into Probabilities, and Statistics for Machine Learning. Probability theory ,Probability Distributions , Decision Theory.

Unit-III Supervised Learning **9 Periods**

Linear Models for Regression: Linear Models for Classification, Discriminant Functions, Probabilistic Generative Models; Probabilistic Discriminative Models: Decision Tree Learning , Bayesian Learning, Naïve Bayes, Ensemble Methods, Bagging, Boosting, Neural Networks, Multilayer Perceptron, Feed- forward Network, Error Back propagation, Support Vector Machines.

Unit-IV: Unsupervised Learning **9 Periods**

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Clustering K-means; EM Algorithm; Mixtures of Gaussians;Dimensionality Reduction, Linear Discriminant Analysis, Factor Analysis, Principal Components Analysis, Independent Components Analysis.
Unit-V: Probabilistic Graphical Models **9 Periods**
Graphical Models ; Undirected Graphical Models ; Markov Random Fields ; Directed Graphical Models ;Bayesian Networks ; Conditional Independence properties;Markov Random Fields ;Hidden Markov Models ; Conditional Random Fields (CRFs).
References:
Reference Books: 1. Christopher Bishop, "Pattern Recognition and Machine Learning" Springer, 2007 2. Stephen Marsland, "Machine Learning – An Algorithmic Perspective", Chapman and Hall, CRC Press, Second Edition,2014. 3. Kevin P. Murphy, "Machine Learning: A Probabilistic Perspective", MIT Press, 2012. 4. Ethem Alpaydin, "Introduction to Machine Learning", MIT Press, Third Edition, 2014. 5. Tom Mitchell, "Machine Learning",McGraw-Hill,1997 6. Stuart Russell, Peter Norvig, "Artificial Intelligence: A Modern Approach", Pearson, 4th Edition, 2020. 7. Nils J. Nilsson, "Artificial Intelligence: A New Synthesis", Morgan Kaufmann Publishers Inc; Second Edition, 2003. 8. Richard E. Neapolitan, Xia Jiang, "Artificial Intelligence with an Introduction to Machine Learning", Chapman and Hall/CRC; 2nd edition, 2018 **Journals:** 1. Artificial Intelligence - Elsevier 2. Machine Learning – Springer **MOOC/NPTEL /SWAYAM Courses:** 1. https://onlinecourses.nptel.ac.in/noc22_cs56/preview **2.** https://onlinecourses.nptel.ac.in/noc22_cs24/preview 3. https://nptel.ac.in/courses/106102220 4. https://onlinecourses.nptel.ac.in/noc23_ge40/preview

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED515.1	(Apply) Demonstrate an understanding of the fundamental concepts and goals of artificial intelligence and its applications in robotics.
P23ED515.2	(Apply) Apply the types and processes of machine learning, including data transformation into probabilities and relevant statistical concepts.

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P23ED515.3	(Apply) Apply supervised learning techniques such as decision trees, support vector machines, and neural networks to solve classification and regression problems.
P23ED515.4	(Apply)Utilize unsupervised learning methods like clustering and dimensionality reduction to analyze and interpret complex datasets.
P23ED515.5	(Apply) Apply probabilistic graphical models, including Bayesian networks and Markov random fields, to model uncertainty in AI systems.

SEMESTER III - PROFESSIONAL ELECTIVE – IV

P23ED516	**Surface Engineering**	**L**	**T**	**P**	**J**	**C**
		3	**0**	**0**	**0**	**3**

1. Course Description:

Surface Engineering is a multidisciplinary field that focuses on modifying the surface properties of materials to improve their performance in various environments. This course typically covers the principles, techniques, and applications of surface modification processes that enhance characteristics such as wear resistance, corrosion protection, friction reduction, and aesthetic appeal. This course equips students with knowledge about the techniques used to modify surfaces for improved durability and functionality, preparing them for careers in advanced manufacturing, materials science, and product development.

2. Course Objectives:

1. Students will be able to understand the surface morphology and applying fundamental principles and concepts related to friction.
2. Students will develop expertise in wear phenomenons and enhance the performance of system using advanced engineering techniques.
3. Students will gain adequate knowledge about corrosion and its preventive major to develop advance system.
4. Students will capable to develop high efficient materials or composites and enhnce the properties through surface treatments.

3. Syllabus **45 Periods**

Unit-I: Friction **9 Periods**

Topography of Surfaces; Surface features – Properties and measurement; Surface interaction – Adhesive, Theory of Sliding Friction – Rolling Friction; Friction properties of metallic and non-metallic materials – Friction in extreme conditions – Thermal considerations in sliding contact

Unit-II: Wear **9 Periods**

Introduction – Abrasive wear, Erosive, Cavitation, Adhesion, Fatigue wear and Fretting Wear- Laws of wear – Theoretical wear models – Wear of metals and non-metals – International standards in friction and wear measurements.

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Unit-III: Corrosion	**9 Periods**
Introduction – Principle of corrosion – Classification of corrosion – Types of corrosion – Factors influencing corrosion – Testing of corrosion – In-service monitoring, Simulated service, Laboratory testing – Evaluation of corrosion – Prevention of Corrosion – Material selection, Alteration of environment, Design, Cathodic and Anodic Protection, Corrosion inhibitors	
Unit-IV: Surface Treatments	**9 Periods**
Introduction – Surface properties, Superficial layer – Changing surface metallurgy – Wear resistant coatings and Surface treatments – Techniques – PVD – CVD – Physical CVD – Ion implantation – Surface welding – Thermal spraying – Laser surface hardening and alloying, Applications of coatings and surface treatments in wear and friction control – Characteristics of Wear resistant coatings – New trends in coating technology – DLC – CNC – Thick coatings – Nano-engineered coatings – Other coatings, Corrosion resistant coatings;	
Unit-V: Engineering Materials	**9 Periods**
Introduction – Advanced alloys, Super alloys, Titanium alloys, Magnesium alloys, Aluminium alloys, and Nickel based alloys, Ceramics, Polymers, Biomaterials – Applications – Bio Tribology Nano Tribology	

Text Books:

1. Fontana G., "Corrosion Engineering", McGraw Hill, 1985
2. G.W.Stachowiak & A.W .Batchelor , "Engineering Tribology", Butterworth-Heinemann, UK, 2005

References:

Reference Books:

1. Halling, J. (Editor) – "Principles of Tribology ", Macmillian – 1984.
2. Rabinowicz.E, "Friction and Wear of materials", John Willey & Sons,UK,1995
3. S.K.Basu, S.N.Sengupta & B.B.Ahuja ,"Fundamentals of Tribology", Prentice –Hall of India Pvt Ltd , New Delhi, 2005
4. Williams J.A. "Engineering Tribology", Oxford Univ. Press, 1994

Journals:

1. Tribology International— ScienceDirect
2. Friction–Springer

MOOC/NPTEL /SWAYAM Courses:

1. https://nptel.ac.in/courses/112102015
2. https://archive.nptel.ac.in/courses/112/102/112102014/
3. https://www.youtube.com/watch?v=l3JGTppvj0c&list=PLp6ek2hDcoNCHbxZBFYkwv8ma4o1WkOEW&index=1
4. Data-Enabled Tribological Engineering- https://onlinecourses.nptel.ac.in/noc24_me75/preview

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5. Tribology related to mechanical engineering and design- https://nptel.ac.in/courses/113108083

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED516.1	(Understand) Understand the basics of surface features, laws of friction and different types of friction.
P23ED516.2	(Apply) Develop the knowledge of various wear mechanism and its measurement.
P23ED516.3	(Understand) Understand the types of corrosion and its preventive measures.
P23ED516.4	(Apply) Familiarize the types of surface properties and various surface modification techniques.
P23ED516.5	(Understand) Ability to understand the different types of materials used in the friction and wear applications.

P23ED517	Supply Chain Management	L	T	P	J	C
		3	0	0	0	3

1. Course Description

This course provides a comprehensive overview of supply chain management (SCM), focusing on the strategies, practices, and technologies that optimize the flow of goods, information, and services from suppliers to customers. Students will explore the key components of supply chains, including demand, Supply, Sourcing, and inventory, and information systems.

2. Course Objectives:

1. Learn the fundamental principles and terminology of supply chain management.
2. Evaluate the elements of effective supply chain design and their impact on operational efficiency
3. Formulate strategies for sourcing materials and selecting suppliers to optimize cost and quality
4. Utilize various forecasting methods to predict customer demand and align supply chain activities accordingly
5. Explore the role of information technology in enhancing supply chain performance

3. Syllabus **45 Periods**

Unit-I: Introduction Supply Chain Management **9 Periods**

Introduction; Types of supply chains with and examples, Evolution of SCM concepts; Supply chain performance: Strategic Fit, Drivers of Supply Chain Performance, key decision areas, External Drivers of Change; Supply contracts; centralized vs. decentralized system.

Unit-II: Supply Chain Network Design **9 Periods**

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Need for distribution network design; Factors affecting, Design options for distribution network, Network design decisions, Framework, factors influencing, Models of facility location and capacity allocation; Role of Transportation in supply chain: modes of transportation Modal Selection, Classification of carriers, Carrier Selection, Transportation Execution and Control; Food Mile Concept; design options.

Unit-III: Demand and Supply in Supply Chain **9 Periods**

Forecasting in supply chain: Methods, Approach, Errors; Aggregate planning in supply chain Problem: Strategies and Implementation; Predictable variability in supply chain; Managing supply and demand: Distribution strategies, direct shipment, traditional warehousing, cross docking, inventory pooling, transhipment, Choosing appropriate strategy, Milk Run Model.

Unit-IV: Sourcing and Inventory Decisions in Supply Chain **9 Periods**

Purchasing versus Procurement versus Strategic Sourcing; Item procurement importance matrix: Strategic Sourcing Methodology, Managing sourcing and procurement process, Supplier selection and evaluation, Bullwhip effect and its management; Economies of scale in supply chain; Cycle inventory, Estimation, Quantity discounts, Multi Echelon cycle inventory; Uncertainty in supply chain: Safety inventory, Determination of appropriate level, Impact on uncertainty.

Unit-V: Supply Chain and Information Systems **9 Periods**

Information in supply chain: Role of Information technology, IT framework in supply chain, Supplier and Customer relationship management; Role of e-business in supply chain: e-sourcing and e-procurement; Technology drivers in supply chain; Risk management.

Text Books:

1. Chopra S. and Meihdl P., "Supply Chain Management- Strategy, Planning and Operations", Pearson Education Asia. 2007.
2. Kaminsky S., "Design and Managing the Supply chain" , McGraw Hill International Edition. 2000.

References:

Reference Books:

Dougart L., Stock J. and Ellram L., "Logistic Management", Irwin McGraw Hill International Edition" 1998.

Raghuram G, and N.Rangaraj, "Logistics and Supply Chain Management -cases and concepts", McMilan India Pvt Ltd, New Delhi,. 2000.

Sahay B.S. "Supply Chain Management: For Global Competitiveness", 2nd Edition, Macmillan, India Ltd, 2011.

Journals:

1. Journal of Supply chain Management
2. Supply Chain Management: An International Journal

Videos and MOOCs:

1. Operation and Supply Chain Management https://archive.nptel.ac.in/courses/110/106/110106045/
2. Supply Chain Analytics https://archive.nptel.ac.in/courses/110/107/110107074/
3. Modelling and Analytics for Supply Chain Management https://archive.nptel.ac.in/courses/110/105/110105141/

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4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED517.1	**(Apply)** Apply the concepts and elements of supply chain management.
P23ED517.2	**(Analyse)** Analyse supply chain network design aspects for various manufacturing and service sectors.
P23ED517.3	**(Apply)** Apply the principle of demand and supply in supply chain.
P23ED517.4	**(Apply)** Apply the sourcing and inventory approaches in supply chain.
P23ED517.5	**(Apply)** Apply the concepts of supply chain information systems.

P23ED518	Product Lifecycle Management	L	T	P	J	C
		3	0	0	0	3

1. Course Description

This course provides a comprehensive understanding of Product Lifecycle Management (PLM), a strategic approach that integrates people, processes, and technology to manage a product's lifecycle from inception through design, manufacturing, and service to disposal. Students will explore key concepts, methodologies, and tools essential for effective PLM in today's fast-paced, competitive environment.

2. Course Objectives:

1. Students will learn Comprehend the history, concepts, and terminology of Product Lifecycle Management (PLM) and its various components, including Engineering Data Management (EDM) and Product Data Management (PDM).
2. Students can explore the key functions and features of PLM/PDM systems, including data management, workflow processes, and communication utilities.
3. Students can able to learn the case studies of leading PLM/PDM software tools, examining their architecture, functionalities, and criteria for selection based on specific organizational needs.
4. Students able to apply the impact of PLM on various industries through case studies, focusing on implementation strategies, financial justifications, and the benefits of PLM for business processes.

3. Syllabus **45 Periods**

Unit-I: History, Concepts and Terminology of PLM **9 Periods**

Introduction to PLM, Need for PLM, opportunities of PLM, Different views of PLM: Engineering Data Management (EDM), Product Data Management (PDM), Collaborative Product Definition Management (cPDm), Collaborative Product Commerce (CPC), Product Lifecycle Management (PLM). PLM/PDM Infrastructure: Network and Communications, Data Management, Heterogeneous data sources and applications.

Unit-II: PLM/PDM Functions and Features **9 Periods**

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User Functions: Data Vault and Document Management, Workflow and Process Management, Product Structure Management, Product Classification and Programme Management. Utility Functions: Communication and Notification, data transport, data translation, image services, system administration and application integration.

Unit-III: Details of Modules in A PDM/PLM Software **9 Periods**

Case studies based on top few commercial PLM/PDM tools: Teamcenter, Windchill, ENOVIA, Aras PLM, SAP PLM, Arena, Oracle Agile PLM and Autodesk Vault. Architecture of PLM software: selection criterion of software for particular application.

Unit-IV: Role of PLM in Industries **9 Periods**

Case studies on PLM selection and implementation (like auto, aero, electronic): other possible sectors, PLM visioning, PLM strategy, PLM feasibility study, change management for PLM, financial justification of PLM. Barriers to PLM implementation, Ten step approach to PLM, benefits of PLM for business, organization, users, product or service, process performance- process compliance and process automation.

Unit-V: Basics on Customisation/Integration of PDM/PLM Software **9 Periods**

PLM Customization, use of EAI technology (Middleware), Integration with legacy data base, CAD, SLM and ERP

Text Books:

1. Antti Saaksvuori and Anselmi Immonen, "Product Lifecycle Management", Springer Publisher, 2008 (3rd Edition).
2. International Journal of Product Lifecycle Management, Inderscience Publishers

Reference Books:

1. Ivica Crnkovic, Ulf Asklund and Annita Persson Dahlqvist, "Implementing and Integrating Product Data Management and Software Configuration Management", Artech House Publishers, 2003.
2. John Stark, "Global Product: Strategy, Product Lifecycle Management and the Billion Customer Question", Springer Publisher, 2007.
3. John Stark, "Product Lifecycle Management: 21st Century Paradigm for Product Realisation", Springer Publisher, 2011 (2nd Edition).
4. Michael Grieves, "Product Life Cycle Management", Tata McGraw Hill, 2006.

Journals:

1. International Journal of Product Lifecycle Management
2. Journal of Product Innovation Management

MOOC/NPTEL /SWAYAM Courses:

1. https://www.udemy.com/course/plm-basics-ecourse/
2. https://nptel.ac.in/courses/112107217

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4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED518.1	**(Apply)** Apply the key developments and terms related to Product Lifecycle Management.
P23ED518.2	**(Apply)** Apply the various functions and features of Product Data Management and PLM systems.
P23ED518.3	**(Apply)** Use the various modules available in leading PLM/PDM software solutions.
P23ED518.4	**(Analyze)** Analyze and apply PLM/PDM strategies effectively in industrial contexts.
P23ED518.5	**(Analyze)** Analyze integration methods for PLM/PDM with existing databases, CAD systems, and ERP solutions.

P23ED519	**Optimization Techniques In Design**	**L**	**T**	**P**	**J**	**C**
		3	**0**	**2**	**0**	**4**

1. Course Description:

This course provides a comprehensive exploration of additive manufacturing (AM) technologies and their applications in tooling. Students will gain a deep understanding of various additive processes, including 3D printing techniques such as Fused Deposition Modeling (FDM), Stereolithography (SLA), and Selective Laser Sintering (SLS) and associated errors and means to rectify them.

2. Course Objectives:

This course addresses the principle of various AM techniques and its concept, scope, building strategies, post-processing, and areas of applications along with different rapid tooling methods and reverse engineering

3. Syllabus: **45 Periods**

Unit-I: Introduction **6 Period**

Introduction to Optimization; Definitions of objective functions; Constraints; Feasibility condition; examples on formulation of optimization problems

Unit-II: Optimization & Linear Programming **15 Periods**

Analytical methods: Single Optimization with and without constraints; Multivariable Optimization with and without constraints

Linear Programming: Simplex method; Two-phase simplex method

Unit-III: Non-Linear Programming - Unconstrained **6 Periods**

Non-linear programming: 1D minimization methods, Direct &Indirect search methods; Multivariable unconstrained minimization; problems-Direct & Indirect search methods;

Unit-IV: Non-Linear Programming - Constrained **9 Periods**

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Non-linear programming: Multivariable constrained minimization problems; Direct & Indirect search methods; Examples using MATLAB programming
Unit-V: Applications Of Calculus **9 Periods**
Applications of calculus of variations to optimal control, Non-traditional optimization methods
Text Books:
1. S. S. Rao, Engineering Optimization: Theory and Practice, 4thedition, John Wiley & Sons, 2009 P. Y. 2. Papalambros and D. J. Wilde, Principles of Optimal Design: Modeling and Computation, 2nd edition, Cambridge University Press, 2000
Reference Books:
1. K. Deb, Optimization for Engineering Design, 2nd edition, PHI Learning Pvt. Ltd., 2009. 2. P. Venkataraman, Applied Optimization with MATLAB Programming, 2ndedition, John Wiley & Sons, 2009. ISBN: 047008488X. 3. D. G. Luenberger, Linear and Nonlinear Programming, 3rdedition, Springer,2008
Journals: 1. Journal of Optimization Theory and Applications 2. Applied Mathematics & Optimization 3. Optimization and Engineering
MOOC/NPTEL /SWAYAM Courses: 1. https://www.mooc-list.com/course/selective-laser-sintering-and-metal-laser-powder-bed-fusion-coursera 2. https://www.mooc-list.com/course/material-jetting-and-stereolithography-coursera 3. https://www.mooc-list.com/tags/photopolymer-resin 4. https://www.youtube.com/watch?v=aJKuM4U-eYg 5. https://nptel.ac.in/courses/111105039 6. https://archive.nptel.ac.in/courses/108/103/108103108/

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcomes
P23ED519.1	Comprehend the techniques and applications of Engineering optimization
P23ED519.2	Analyze characteristics of a general linear programming problem
P23ED519.3	Analyse various methods of solving the unconstrained minimization problem.
P23ED519.4	Analyse various methods of solving the constrained minimization problem.
P23ED519.5	Comprehend the applications of calculus of variations in optimization

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P23ED520	Mechanical Behaviour of Materials	L	T	P	J	C
		3	0	0	0	3

1. Course Description:

This course examines the behaviour of materials under various conditions, focusing on elasticity, plasticity, strengthening mechanisms, and failure analysis. It covers both metallic and non-metallic materials, exploring fracture mechanics, fatigue, dynamic loads, and high-temperature behaviours. Modern materials like HSLA steels, shape memory alloys, and advanced ceramics are also studied. The course emphasizes material selection, deformation maps, and advanced material properties for engineering applications.

2. Course Objectives:

1. Students can able to understand the behavior of materials under elastic, plastic, and high-temperature conditions.
2. Students can able to explore strengthening mechanisms and the effects of temperature, strain, and strain rate on materials.
3. Students can able to introduce fracture mechanics, fatigue, and failure analysis techniques.
4. Students can able to study modern metallic materials and their applications in engineering.
5. Students can able to examine the properties and applications of advanced non-metallic materials, including polymers and ceramics.

3. Syllabus **45 Periods**

Unit-I: Basic Concepts of Material Behaviour **9 Periods**

Elasticity in metals and polymers; Strengthening mechanisms: work hardening, solid solutioning, grain boundary strengthening, poly phase mixture, precipitation, particle, fibre and dispersion strengthening; Effect of temperature, strain and strain rate on plastic behaviour; Super plasticity; Griffith's theory, Ductile, brittle transition in steel, High temperature fracture, creep; Larson Miller parameter; Deformation and fracture mechanism maps;

Unit-II: Behaviour Under Dynamic Loads and Design Approaches **9 Periods**

Stress intensity factor and fracture toughness; Fatigue, low and high cycle fatigue test, crack initiation and propagation mechanisms and Paris law. Safe life, Stress life, strain-life and fail - safe design approaches; Effect of surface and metallurgical parameters on fatigue; Fracture of non-metallic materials; Failure analysis, sources of failure, procedure of failure analysis;

Unit-III: Selection of Materials **9 Periods**

Griffith analysis: stable and unstable crack growth; Dynamic energy balance; crack arrest mechanism; K1c test methods; R curves; determination of collapse load;

Unit-IV: Modern Metallic Materials **9 Periods**

Dual phase steels, High strength low alloy (HSLA) steel, Transformation induced plasticity (TRIP) Steel, Maraging steel, Nitrogen steel; Intermetallics, Ni and Ti aluminides; Smart materials, Shape memory alloys Metallic glass and nano crystalline materials;

Unit-V: Non Metallic Materials **9 Periods**

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Polymeric materials: Formation of polymer structure; Production techniques of fibers, foams, adhesives and coating; Structure, properties and applications of engineering polymers; Advanced structural ceramics, WC, TiC, TaC, Al2O3, SiC, Si3N4 CBN and diamond; Properties, processing and applications;
Text Books:
1. Ashby M.F., materials selection in Mechanical Design 2nd Edition, Butter worth 1999. 2. Charles, J.A., Crane, F.A.A. and Fumess, J.A.G., Selection and use of engineering materials, (34d edition), Butterworth - Heiremann, 1997. 3. George E.Dieter, Mechanical Metallurgy, McGraw Hill, 1988.
Reference Books:
1. Flinn, R.A., and Trojan, P.K., Engineering Materials and their Applications, (4th Edition) Jaico, 1999. 2. Metals Hand book, Vol.10, Failure Analysis and Prevention, (10th Edition), Jaico, 1999. 3. Thomas H. Courtney, Mechanical Behavior of Materials, (2nd edition), McGraw Hill, 2000. **Journals:** 1. Journal of Mechanical Behaviour of Materials – Walter de Gruyter GmbH 2. Journal of the Mechanical Behavior of Biomedical Materials – Elsevier **MOOC/NPTEL /SWAYAM Courses:** 1. https://archive.nptel.ac.in/courses/113/106/113106101/ 2. Mechanical Behaviour of Materials - https://onlinecourses.nptel.ac.in/noc21_mm27/preview 3. Mechanical Behaviour of Materials (Part-I) - https://onlinecourses.nptel.ac.in/noc22_mm04/preview

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED520.1	(Understand) Understand the various behaviour of materials and strengthening mechanism
P23ED520.2	(Apply) Apply the various dynamic loads and design approaches for materials
P23ED520.3	(Analyze) Select the suitable material for the various applications
P23ED520.4	(Apply) Design and develop modern metallic materials
P23ED520.5	(Analyze) Analyze the processing, properties and applications of non-metallic materials

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SEMESTER III - PROFESSIONAL ELECTIVE – V

P23ED521	Advanced Finite Element Analysis	L	T	P	J	C
		3	0	0	0	3

1. Course Description:

This integrated course teaches students to design, develop, and launch successful products. Topics include product planning, specification, industrial design, design for manufacture and assembly, prototyping, testing, project management, and product lifecycle management. Through this course, students gain a holistic understanding of product development, preparing them to create innovative products that meet customer needs and business objectives.

2. Course Objectives:

1. Equip students with the knowledge to understand and apply Finite Element Formulation in the analysis of plate and shell structures.
2. Equip students to solve non-linear problems, focusing on material non-linearity, plasticity, and applications in metal forming and contact issues.
3. Provide students with the tools to formulate and solve dynamic problems, including free, transient, and forced responses, using advanced solution methods
4. Enable students to analyze fluid-structure interactions and solve fluid mechanics problems using potential formulations and the Navier-Stokes equation in both steady and transient states.
5. Teach students the concepts of error estimation and adaptive refinement to improve the accuracy and convergence of numerical solutions.

3. Syllabus: **45 Periods**

Unit-I: Bending of Plates and Shells **9 Periods**

Review of Elasticity Equations; Bending of Plates and Shells; Finite Element Formulation of Plate and Shell Elements: Conforming and Non-Conforming Elements, C0 and C1 Continuity Elements, Degenerated shell elements; Application and Examples;

Unit-II: Non-Linear Problems **9 Periods**

Introduction; Iterative Techniques: Material non-linearity, Elasto Plasticity, Plasticity, Visco Plasticity; Geometric Non linearity; large displacement Formulation; Solution procedure; Application in Metal Forming Process and Contact Problems;

Unit-III: Dynamic Problem **9 Periods**

Direct Formulation: Free, Transient and Forced Response; Solution Procedures: Eigen solution; Subspace Iterative Technique; Response analysis: Houbolt, Wilson, Newmark, Methods: Explicit & Implicit Methods- Lanchzos, Reduced method for large size system equations.

Unit-IV: Fluid Mechanics And Heat Transfer **9 Periods**

Governing Equations of Fluid Mechanics; Solid structure interaction: Inviscid and Incompressible Flow, Potential Formulations, Slow Non-Newtonian Flow; Metal and Polymer Forming; Navier Stokes Equation; Steady and Transient Solution.

Unit-V: Error Estimates And Adaptive Refinement **9 Periods**

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Error norms and Convergence rates: h-refinement with adaptivity, Adaptive refinement.
References:
Reference Books:
1. Bathe K.J., "Finite Element Procedures in Engineering Analysis", Prentice Hall, 1990. 2. Cook R.D., "Concepts and Applications of Finite Element Analysis", John Wiley and Sons Inc., New York, 1989. 3. Zienkiewicz, O.C. and Taylor, R.L., "The Finite Element Method", Fourth Edition, Volumes 1 &2, McGraw Hill International Edition, Physics Services, 1991. **Journals:** 1. International Journal for Numerical Methods in Engineering 2. International Journal of Computational Methods **MOOC/NPTEL /SWAYAM Courses:** 1. https://www.youtube.com/playlist?list=PLE3449F56F084DE22 2. https://www.udemy.com/course/the-finite-element-method/?couponCode=ST15MT100124B 3. Advanced Finite Element Analysis- https://archive.nptel.ac.in/courses/112/106/112106130/ 4. Finite Element Method - https://onlinecourses.nptel.ac.in/noc22_me43/preview

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED521.1	(Apply) Implement finite element formulation with conforming and non-conforming elements for bending analysis of plates and shells.
P23ED521.2	(Apply) Use iterative techniques and material non-linearity models to solve non-linear problems in metal forming and contact processes.
P23ED521.3	(Analyze) Evaluate the performance of explicit and implicit methods in solving dynamic problems, including free, transient, and forced responses.
P23ED521.4	(Analyze) Assess the governing equations of fluid mechanics and their applications in inviscid, incompressible flow, and solid-structure interaction.
P23ED521.5	(Analyze) Examine error norms and convergence rates in finite element analysis and evaluate the effectiveness of h-refinement and adaptive refinement techniques.

P23ED522	Design For X	L	T	P	J	C
		3	0	0	0	3

1. Course Description:

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This course provides a comprehensive overview of Design for Manufacturability (DFM) and Design for Assembly (DFA), focusing on optimizing the design process to enhance manufacturability, assembly and product performance. Students will explore key concepts such as design principles for manufacturability, tolerance analysis, material selection, machining considerations and sustainable design approaches. The course covers both manual and automatic assembly processes and integrates advanced topics like reliability, maintainability and sustainable design practices. Special attention is given to modern design strategies that reduce costs, improve product quality and minimize environmental impact throughout the product lifecycle. Case studies and practical examples will enhance understanding, preparing students to develop products that are not only easy to manufacture but also environmentally sustainable and cost-effective.

2. Course Objectives:

1. To learn the general principles of DFM, including strength, mechanical factors, process capabilities, geometric and feature tolerances and how these factors influence form design, especially for welded members, forgings and castings.
2. To explore techniques for optimizing component designs to facilitate machining, reduce machined areas and improve economy and manufacturability.
3. To develop designs that simplify assembly processes, minimize part count and improve ease of assembly.
4. To incorporate reliability into the design process, using tools like failure analysis, reliability allocation and corrective action plans
5. To explore sustainable design principles such as green engineering, cradle-to-cradle design and biomimicry.
6. To minimize material usage, design for disassembly and recyclability and optimize energy efficiency while adhering to regulations and environmental standards.

3. Syllabus **45 Periods**

Unit-I: Introduction **9 Periods**

General design principles for manufacturability - strength and mechanical factors, mechanisms selection, evaluation method, Process capability - Feature tolerances Geometric tolerances - Assembly limits - Datum features - Tolerance stacks.-FACTORS INFLUENCING FORM DESIGN- Working principle, Material, Manufacture, Design- Possible solutions - Materials choice –Influence of materials on form design - form design of welded members, forgings and castings.

Unit-II: Component Design - Machining Consideration **9 Periods**

Design features to facilitate machining - drills - milling cutters - keyways - Doweling procedures, counter sunk screws - Reduction of machined area- simplification by separation - simplification by amalgamation - Design for machinability - Design for economy - Design for clampability – Design for accessibility.

Unit-III: Design for Assembly **9 Periods**

Design for assembly – General assembly recommendations – Minimizing the no. of parts – Design considerations for: Rivets – Screw fasteners – Gasket & Seals – Press fits – Snap fits – Design for assembly – Product design for manual assembly - Product design for automatic assembly – Robotic assembly-Automatic assembly – Computer Application for DFMA -Case studies

Unit-IV: Design for Reliability and Maintainability **9 Periods**

Reliability design process, system effectiveness, economic analysis and life cycle cost, reliability allocation, design methods, parts and material selection, derating, stress-strength and analysis, failure analysis, identification determination of causes, assessments of effects, computation of criticality index, corrective action, system safety – analysis of down-time – the repair time distribution, stochastic point processes system repair time, reliability under preventive maintenance state dependent system with repair. MTTR – mean system down time, repair vs replacement,

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replacement models, proactive, preventive, predictive maintenance maintainability and availability, optimization techniques for system reliability with redundancy heuristic methods applied to optimal system reliability

Unit-V: Sustainable Design **9 Periods**

Industrial ecology, multiple life cycle design, principles of design, green engineering, cradle to cradle design, The Natural Step, biomimicry, design for reuse, dematerialization, modularization, Design to minimize material usage – Design for disassembly – Design for recyclability – design for flexibility, design for disassembly, design for inverse manufacturing, design for the environment, – Design for energy efficiency – Design to regulations and standards

Text Books:

1. Boothroyd, G, 1980 Design for Assembly Automation and Product Design. New York, Marcel Dekker.
2. Dickson, John. R, and Corroda Poly, Engineering Design and Design for Manufacture and Structural Approach, Field Stone Publisher, USA, 1995.
3. Bralla, Design for Manufacture handbook, McGraw hill, 1999.

References:

Reference Books:

1. Boothroyd, G, Heartz and Nike, Product Design for Manufacture, Marcel Dekker, 1994.
2. "Maintenance Engineering and Management": K.Venkataraman-PHI Learning - 2007
3. David J. Smith, "Reliability and Maintainability in Perspective", McMillan,2nd Edition, 1985.
4. Fixel, J. Design for the Environment McGraw Hill., 1996
5. Finster, Mark P., 2013. Sustainable Perspectives to Design and Innovation.

Journals:

1. Journal of Manufacturing Processes
2. Journal of Manufacturing Science and Engineering (ASME)
3. International Journal of Advanced Manufacturing Technology
4. International Journal of Sustainable Engineering
5. International Journal of Reliability, Quality and Safety Engineering

MOOC/NPTEL /SWAYAM Courses:

1. https://www.youtube.com/playlist?list=PL85A6ED9A77F7B8DD
2. https://www.youtube.com/playlist?list=PLwdnzlV3ogoXD4NBvgyZJhsDUgaEB1nV3
3. https://www.youtube.com/watch?v=l87X1Hap-9c
4. https://nptel.ac.in/courses/107103012
5. https://onlinecourses.nptel.ac.in/noc19_me48/preview

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4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED522.1	Select relevant process; apply the general design principles for manufacturability; GD&T
P23ED522.2	Apply design considerations while designing the formed and machined components
P23ED522.3	Apply design considerations for assembled systems.
P23ED522.4	Exposed to maintenance systems and reliability based design
P23ED522.5	Apply design considerations for environmental issues

P23ED523	**Advanced Machine Tool Design**	**L**	**T**	**P**	**J**	**C**
		3	**0**	**0**	**0**	**3**

1. Course Description:

This course focuses on the comprehensive design of machine tools, aiming to equip students with the skills to select and design mechanisms, gearboxes, and feeds, as well as components like guideways, power screws, spindles, and bearings. The course covers the regulation of speeds and feeds, machine tool structures, and dynamic components like spindles. Students will learn about machine tool drives, mechanisms, kinematics, and the design considerations for key parts to ensure proper performance in manufacturing contexts.

2. Course Objectives:

By the end of this course, students will be able to:

1. To select the different machine tool mechanisms.
2. To Design the multi-speed gearboxes and feed drives.
3. To Design the machine tool structures.
4. To Design the guide ways and power screws.
5. To Design the spindles and bearings.

3. Syllabus: **45 Periods**

Unit-I: Introduction To Machine Tool Design **9 Periods**

Introduction to Machine Tool Drives and Mechanisms; Auxiliary Motions in Machine Tools, Kinematics of Machine Tools, Motion Transmission

Unit-II: Regulation Of Speeds and Feeds **9 Periods**

Aim of Speed and Feed Regulation, Stepped Regulation of Speeds, Multiple Speed Motors, Ray Diagrams and Design Considerations, Design of Speed Gear Boxes, Feed Drives, Feed Box Design

Unit-III: Design of Machine Tool Structures **9 Periods**

Functions of Machine Tool Structures and their Requirements; Design for Strength, Design for Rigidity, Materials for Machine Tool Structures, Machine Tool Constructional Features, Beds and Housings, Columns and Tables, Saddles and Carriage

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Unit-IV: Design Of Guideways and Power Screws	**9 Periods**
Functions and Types of Guideways; Design of Guideways, Design of Aerostatic Slide ways, Design of Anti-Friction Guideways, Combination Guideways. Design of Power Screws	
Unit-V: Design of Spindles and Spindle Support	**9 Periods**
Functions of Spindles and Requirements: Effect of Machine Tool Compliance on Machining Accuracy, Design of Spindles, Antifriction Bearings. Dynamics of Machine Tools: Machine Tool Elastic System, Static and Dynamic Stiffness	

Text Books:

1. Basu, S.K. and Pal, D.K., *Design of Machine Tools*, Oxford IBH, 2015.
2. Sen, G.C. and Bhattacharyya, A., *Principles of Machine Tools*, New Central Book Agency, 2009.

References:

Reference Books:

1. N.K. Mehta, Machine Tool Design and Numerical Control, TMH, New Delhi, 3rd edition 2012 2. G.C. Sen and A. Bhattacharya, Principles of Machine Tools, New Central Book Agency, 2015
2. K Pal, S. K. Basu, "Design of Machine Tools", 6th Edition. Oxford IBH, 2014
3. N. S. Acherkhan, "Machine Tool Design", Volume 2 University Press of the Pacific, 2000
4. F. Koenigsberger, Design Principles of Metal-Cutting Machine Tools, Pergamon Press, 1964
5. F. Koenigsberger, Machine Tool Structures, Pergamon Press,1970

Journals:

1. International Journal of Machine Tools and Manufacture - Elsevier
2. Journal of Materials Processing Technology - Elsevier

MOOC/NPTEL /SWAYAM Courses:

1. https://nptel.ac.in/courses/112105233
2. https://www.coursera.org/courses?query=machine%20design
3. Principles of Machine Tool Design and Analysis – IIT

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcomes
P23ED523.1	Analyze and select appropriate machine tool mechanisms and components for various manufacturing applications
P23ED523.2	Design multi-speed gearboxes, feed drives, and structural elements that optimize machine tool performance and stability.
P23ED523.3	Develop effective designs for spindles and bearings, focusing on load capacity, reliability, and lubrication systems.

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P23ED523.4	Evaluate the dynamics of machine tool components to predict performance and enhance operational efficiency
P23ED523.5	Apply advanced machine tool design principles to solve real-world challenges in manufacturing processes and systems

P23ED524	**Vehicles Dynamics**	**L**	**T**	**P**	**J**	**C**
		3	**0**	**0**	**0**	**3**

1. Course Description:

Vehicles Dynamics design course is a core field of mechanical engineering design which examines and applies the theory of vehicle dynamic systems components to design, analysis, and optimised operation of automotive vibration systems. This course provides students an in-depth knowledge of the principles that monitor the functioning of different vehicle dynamic systems and their components.

2. Course Objectives:

1. To provide fundamental knowledge of the vibration,
2. To impart knowledge on tyres
3. To provide basic concepts on suspension design and function, ride modes
4. To Evaluate the performance, longitudinal dynamics and control in an automobile
5. To provide basic analysis on handling, cornering stability and control

3. Syllabus **45 Periods**

Unit-I: Concept of Vibration **9 Periods**

Definitions, Modelling and Simulation, Global and Vehicle Coordinate System, Free, Forced, Undammed and Damped Vibration, Response Analysis of Single DOF, Two DOF, Multi DOF, Magnification factor, Transmissibility ratio, Base excitation. Vibration absorber, Vibration measuring instruments, Torsional vibration, Critical speed;

Unit-II: Tyres **9 Periods**

Tyre axis system, tyre forces and moments, tyre marking, tyre structure, hydroplaning, wheel and rim. Rolling resistance, factors affecting rolling resistance, Longitudinal and Lateral force at various slip angles, Tractive and cornering property of tire. Camber and camber trust. Performance of tire on wet surface. Ride property of tyres. Various test carried on a tyre;

Unit-III: Vertical Dynamics **9 Periods**

Human response to vibration, Sources of Vibration. Suspension requirements; types. State Space Representation. Design and analysis of Passive, Semi active and Active suspension using Quarter car, Bicycle Model, Half car and full car vibrating model. Influence of suspension stiffness, suspension damping, and tire stiffness. Control law. Suspension optimization techniques. Air suspension system and their properties;

Unit-IV: Longitudinal Dynamics And Control **9 Periods**

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Aerodynamic forces and moments; Equation of motion; Load distribution for three wheeler and four wheeler. Calculation of maximum acceleration, tractive effort and reaction forces for different drive vehicles. Power limited acceleration and traction limited acceleration. Estimation of CG location. Stability of vehicles resting on slope. Driveline dynamics. Braking and Driving torque. Prediction of Vehicle performance. ABS, stability control, Traction control;

Unit-V: Lateral Dynamics **9 Periods**

Steering Geometry ;Steady state handling characteristics; Steady state response to steering input ;Yaw velocity gain; Lateral acceleration gain; curvature response gain; Testing of handling characteristics; Transient response characteristics; Directional stability. Stability of vehicle on banked road, during turn; Effect of suspension on cornering; Roll centre ; Roll axis;

Text Books:

1.Singiresu S. Rao, "Mechanical Vibrations," Fifth Edition, Prentice Hall, 2010.

References:

Reference Books:

1. J. Y. Wong, "Theory of Ground Vehicles", Fourth Edition, Wiley-Interscience, 2008
2. Rajesh Rajamani, "Vehicle Dynamics and Control," Second edition, Springer, 2012
3. Thomas D. Gillespie, "Fundamentals of Vehicle Dynamics," Society of Automotive Engineers Inc, 2014 4. Dean Karnopp, "Vehicle Dynamics, Stability, and Control", Second Edition, CRC Press, 2013
4. R. Nakhaie Jazar, "Vehicle Dynamics: Theory and Application", Second edition, Springer, 2013
5. Michael Blundell & Damian Harty, "The Multibody Systems Approach to Vehicle Dynamics", Elsevier Limited, 2004
6. Hans B Pacejka, "Tyre and Vehicle Dynamics," Second edition, SAE International, 2005

Journals:

1. Journal of Society of Automotive Engineering — SAE Journals
2. International Journal of Vibration –Elsevier

MOOC/NPTEL /SWAYAM Courses:

1. https://nptel.ac.in/courses/107106080
2. https://onlinecourses.nptel.ac.in/noc24_ee30/preview
3. https://www.nptelvideos.com/course.php?id=598
4. Advanced Dynamics - https://onlinecourses.nptel.ac.in/noc21_me96/preview
5. Control System- https://nptel.ac.in/courses/107106081

4. Course Outcomes:

After successful completion of the course, the student should be able to:

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CO. No.	Course Outcome
P23ED524.1	(Understand) Develop physical and mathematical models of a mechanical vibrating system
P23ED524.2	(Understand) Indicate the forces and moment acting on tyres
P23ED524.3	(Apply) Identify the suspension parameters that governs ride comfort
P23ED524.4	(Evaluate)Evaluate the vehicle performance in longitudinal direction
P23ED524.5	(Evaluate)Evaluate the lateral dynamics and control in an automobile

P23ED525	Bearing Design and Rotor Dynamics	L	T	P	J	C
		3	0	0	0	3

1. Course Description:

Bearing Design and Rotor Dynamics design course is a core field of mechanical engineering design which examines and applies the theory of rotor dynamics systems components to design, analysis, and optimised operation of bearing design and rotor dynamics systems. This course provides students an in-depth knowledge of the principles that monitor the functioning of different bearing and rotor dynamics systems and their components.

2. Course Objectives:

1. Understand about different types of bearings
2. Bearing design and their operating principles
3. Acquiring research knowledge in the developing area of the rotor dynamics
4. Identification of rotor bearing system parameters and its usage
5. Futuristic model-based condition monitoring and fault diagnostic.

3. Syllabus: **45 Periods**

Unit-I: Classification and Selection of Bearings **9 Periods**

Selection criteria; Dry and Boundary Lubrication Bearings; Hydrodynamic and Hydrostatic bearings; Electro Magnetic bearings ;Dry bearings-Rolling Element bearings- Bearings for Precision Applications; Foil Bearings-Special bearings; Selection of plain Bearing materials ;Metallic and Non metallic bearings;

Unit-II: Selection and Design of Rolling Bearings **9 Periods**

Design and performance analysis of Thrust and Journal bearings ; Full, partial, fixed and pivoted journal bearings design procedure; Design and performance analysis of Rolling bearings; Contact Stresses and Centrifugal stresses; Elasto hydrodynamic lubrication; Fatigue life calculations; dynamics of hydro dynamic bearings -Squeeze film effects in journal bearings and thrust bearings -Rotating loads, alternating and impulse loads in journal bearings;

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Unit-III: Torsional Vibration of Rotating Members And Their Instability	**9 Period**
Flexural and torsional vibrations; critical speeds of shafts using Rayleigh's method; matrix iteration methods, Prohal and Myklested method; equivalent discrete systems, geared and branched systems.; Instability of rotors mounted on fluid film bearings; rigid rotor instability, instability of a flexible rotor, instability threshold by transfer matrix methods, internal hysteresis of shafts, instability in torsional vibrations;	
Unit-IV: Balancing of Rotors	**9 Periods**
Balancing of rotors; Concepts and principles of Single-plane balancing; Two plane balancing, balancing criteria for flexible rotors; bearing dynamic parameters estimation; measurement and digital processing techniques;	
Unit-V: Conditioning Monitoring	**9 Periods**
Introduction to rotary machinery maintenance; fundamentals of data acquisition; principles of condition monitoring, transducers for condition monitoring; fault diagnosis in rotating machines; NDT methods in condition monitoring, wear and debris analysis; case studies in condition monitoring;	

Text Books:

1. J. S. Rao, "Rotor Dynamics", New Age International Publishers, New Delhi, 2010.
2. T. Yamamoto and Y. Ishida, "Linear and Nonlinear Rotor Dynamics: A Modern Treatment with Applications", John Wiley

References:

Reference Books:

1. J. S. Rao, "Vibratory Condition Monitoring of Machines", Narosa Publishing House.
2. Neale, M.J. "Tribology Hand Book", Butterworth Heinemann, United Kingdom 2001.
3. Cameron, A. "Basic Lubrication Theory", Ellis Herward Ltd., UK, 1981.
4. Halling, J. (Editor) – "Principles of Tribology ", Macmillian – 1984. 4. Williams J.A. " Engineering
5. Tribology", Oxford Univ. Press, 1994.
6. S.K.Basu, S.N.Segupta & B.B.Ahuja ,"Fundamentals of Tribology", Prentice –Hall of India Pvt Ltd ,New Delhi, 2005.
7. G.W.Stachowiak& A.W .Batchelor , Engineering Tribology, Butterworth-Heinemann, UK, 2005

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Journals:

1. Journal of Society of Automotive Engineering — SAE Journals
2. International Journal of Vibration –Elsevier

MOOC/NPTEL /SWAYAM Courses:

1. https://archive.nptel.ac.in/courses/112/103/112103025/
2. https://nptel.ac.in/courses/112103024
3. Advanced Dynamics - https://onlinecourses.nptel.ac.in/noc21_me96/preview
4. Theory and Practice of Rotor Dynamics - http://acl.digimat.in/nptel/courses/video/112103025/

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED525.1	(Understand) acquisition of knowledge in the analysis of all types of bearings.
P23ED525.2	(Apply) ability to make specifications of all types of bearings
P23ED525.3	(Apply) ability to develop the vibration models of rotor bearing systems with changing complexities for real engineering systems.
P23ED525.4	(Apply) ability to formulate the response due to unbalance and instability in practical rotor systems.
P23ED525.5	(Evaluate) ability to identify rotor bearing system parameters and capability to carry out research in condition monitoring and fault identification in rotors

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SEMESTER IIII - PROFESSIONAL ELECTIVE – VI

P23ED526	Computational Fluid Dynamics	L	T	P	J	C
		3	0	0	0	3

1. Course Description:

This course provides an introduction to Computational Fluid Dynamics (CFD), focusing on the numerical simulation of fluid flow, heat transfer, and related phenomena. Students will learn the fundamental principles of CFD, including the formulation and solution of fluid flow equations, grid generation, and the application of numerical methods to solve real-world engineering problems. The course will cover various aspects of CFD, from theoretical foundations to practical implementation, using commercial or open-source CFD software tools.

2. Course Objectives:

1. Students can enhance the knowledge in the basic principles of fluid flow, heat transfer, computational fluid dynamics (CFD) and its applications
2. Students grasp the experience in solving the fundamental governing equations and turbulence models used in CFD solvers
3. Students can improves the skills in grid generation techniques and post processing techniques
4. Students can apply CFD tools to analyze and solve complex fluid flow problems in various engineering contexts.

3. Syllabus **45 Periods**

Unit-I: Introduction **9 Periods**

Introduction to fluid flow and heat transfer: Mathematical description of fluid flow and heat transfer, incompressible and compressible flows, turbulent flows, boundary layer theory. Introduction to Computational Fluid Dynamics (CFD): Objectives, modelling process, 2D and 3D simulations, advantages, limitations, application domains, software tools.

Unit-II: Governing Equations **9 Periods**

Mass and momentum conservation equations; Energy conservation equation; Equation of state; Species transport equations; Scalar transport equations. Turbulence models: RANS, LES and DNS models.

Unit-III: Grid Generation and Post Processing Techniques **9 Periods**

Surface preparation: Volume meshing, cell types, structured, unstructured and hybrid meshing. Considerations for accurate and fast solutions. Mesh generation techniques: dynamic meshing, overset meshing, mesh size control, y+ and wall layer, adaptive mesh refinement, grid independence study. Post processing techniques: Vector plot, scalar plot, streamline plot, flow animation, x-y plot, surface area and mass flow integrated reports.

Unit-IV: Numerical Methods **9 Periods**

Finite volume method; Discretization schemes: First order, higher order and hybrid schemes, stability of schemes. Steady and unsteady flow solvers: CG and AMG solvers, SIMPLE,

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SIMPLER & PISO solution algorithms. Initial and boundary conditions: material properties, solver control, convergence criteria, parallel processing.

Unit-V: Advanced CFD Simulations **9 Periods**

Compressible flow: conjugate heat transfer, VOF, MRF, porous media, radiation, combustion and emission simulations. Fluid flow and heat transfer modelling of IC engine: thermal systems, power generation and storage systems, turbomachinery; Introduction to fluid-structure interaction modelling.

Text Books:

1. Versteeg and Malalasekera, N, "An Introduction to computational Fluid Dynamics The Finite Volume Method," Pearson Education, Ltd., Second Edition, 2014.
2. Ghoshdastidar, P.S., "Computer Simulation of Flow and Heat Transfer", Tata McGrawHill Publishing Company Limited, New Delhi, 1998.

References:

Reference Books:

1. Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 2003.
2. Subas and V.Patankar "Numerical heat transfer fluid flow", Hemisphere Publishing Corporation,1980.
3. Jiyuan Tu, Guan Heng Yeoh, Chaogun Liu, "Computational Fluid Dynamics A Practical Approach" Butterworth – Heinemann An Imprint of Elsevier, Madison, U.S.A., 2008
4. John D. Anderson. JR. "Computational Fluid Dynamics The Basics with Applications" McGraw-Hill International Editions, 1995.

Journals:

1. Journal of Computational Physics- Science Direct
2. Computers & Fluids- Science Direct

MOOC/NPTEL /SWAYAM Courses:

1. https://www.coursera.org/learn/applied-computational-fluid-dynamics
2. https://onlinecourses.nptel.ac.in/noc21_me126/preview

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED526.1	**(Understand)** Understand the basic principles of fluid flow, heat transfer, computational fluid dynamics (CFD) and its applications
P23ED52.2	**(Analyse)** Analyse the governing equations and boundary conditions
P23ED526.3	**(Apply)** Create grid for any simulation domain and post process various simulations
P23ED526.4	**(Analyze)** Setup solvers and perform all common simulations

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P23ED526.5	**(Analyze)** Perform advance fluid flow and heat transfer simulations

P23ED527	Design of Hybrid and Electric Vehicles	L	T	P	J	C
		3	0	0	0	3

1. Course Description:

Automotive hybrid and electric vehicle design course is a core field of mechanical engineering design which examines and applies the theory of hybrid and electric components to design, analysis, and optimised operation of automotive systems. This course provides students an in-depth knowledge of the principles that monitor the functioning of different hybrid and electric systems and their components.

2. Course Objectives:

1. To understand the concept of electric vehicles and its operations
2. To present an overview of Electric Vehicle (EV), Hybrid Electric vehicle (HEV) and their architecture
3. To understand the need for energy storage in hybrid vehicles
4. To provide knowledge about various possible energy storage technologies that can be used in electric vehicles

3. Syllabus: **45 Periods**

Unit-I: Electric Vehicles and Vehicle Mechanics **9 Periods**

Electric Vehicles (EV) ; Hybrid Electric Vehicles (HEV); Engine ratings: Comparisons of EV with internal combustion Engine vehicles: Fundamentals of vehicle mechanics;

Unit-II: Architecture of Ev's and Power Train Components **9 Periods**

Architecture of EV's and HEV's : Plug-n Hybrid Electric Vehicles:(PHEV), Power train components and sizing: Gears; Clutches; Transmission and Brakes;

Unit-III: Power Electronics and Motor Drives **9 Periods**

Electric drive components ; Power electronic switches; four quadrant operation of DC drives ; Induction motor and permanent magnet synchronous motor based vector control operation ; Switched reluctance motor (SRM) drives-;EV motor sizing;

Unit-IV: Battery Energy Storage System **9 Periods**

Battery Basics; Different types; Battery Parameters; Battery life and safety impacts; Battery modelling; Design of battery for large vehicles;

Unit-V: Alternative Energy Storage Systems **9 Periods**

Introduction to fuel cell ; Types, Operation and characteristics; proton exchange membrane (PEM) fuel cell for E-mobility; hydrogen storage systems ;Super capacitors for transportation applications;

Text Books:

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1. Iqbal Hussain, "Electric & Hybrid Vehicles – Design Fundamentals", Second Edition, CRC Press, 2011.

References:

Reference Books:

1. James Larminie, "Electric Vehicle Technology Explained", John Wiley & Sons, 2003.
2. Mehrdad Ehsani, Yimin Gao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles:Fundamentals", CRC Press, 2010.
3. Emadi, A. (Ed.), Miller, J., Ehsani, M., "Vehicular Electric Power Systems" Boca Raton, CRC Press,2003.
4. Sheldon S. Williamson, "Energy Management Strategies for Electric and Plug – in Hybrid Electric Vehicles", Springer, 2013.

Journals:

1. Journal of Society of Automotive Engineering — SAE Journals
2. International Journal of Thermal Engineering –Springer

MOOC/NPTEL /SWAYAM Courses:

1. **https://archive.nptel.ac.in/courses/108/103/108103009/**
2. **https://onlinecourses.nptel.ac.in/noc24_ee30/**
3. **https://archive.nptel.ac.in/courses/108/106/108106182/**
4. Electric Vehicle Introduction - https://onlinecourses.nptel.ac.in/noc22_ee53/preview
5. Introduction to Electric and Hybrid Vehicle- https://onlinecourses.swayam2.ac.in/nou24ec10/preview

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED527.1	(Understand) Understand the concept of electric vehicle and energy storage systems.
P23ED527.2	(Understand) Describe the working and components of Electric Vehicle and Hybrid Electric Vehicle
P23ED527.3	(Apply) Apply the principles of power converters and electrical drives
P23ED527.4	(Apply)Illustrate the operation of storage systems such as battery and super capacitors
P23ED527.5	(Analyse) Analyse the various energy storage systems based on fuel cells and hydrogen storage

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P23ED528	Industry 4.0	L	T	P	J	C
		3	0	2	0	4

1. Course Description:

This course provides an in-depth exploration of Industry 4.0, covering its historical evolution, technological advancements, and global developments. Students will learn about IoT, smart manufacturing, and the integration of big data, AI, and cyber security. The course also addresses the strategic business implications and the future of work in the Industry 4.0 era.

2. Course Objectives:

1. Understand the historical context and evolution of industrial revolutions leading up to Industry 4.0.
2. understand the role of IoT, IIoT, and smart technologies in transforming manufacturing, logistics, and urban development.
3. Understand the insights into the integration of big data, AI, robotics, cyber security, and other advanced technologies within Industry 4.0.
4. Apply the significance of data as a strategic resource and the impact of cloud computing on organizational knowledge and collaboration.
5. Understand the business implications, opportunities, challenges, and strategic approaches for thriving in the Industry 4.0 landscape.

3. Syllabus **45 Periods**

Unit-I: Introduction to Industry 4.0 **9 Periods**

The Various Industrial Revolutions; Digitalisation and the Networked Economy: Drivers, Enablers, Compelling Forces and Challenges for Industry 4.0; The Journey so far: Developments in India, USA, Europe, China and other countries; Comparison of Industry 4.0 Factory and Today's Factory; Trends of Industrial Big Data and Predictive Analytics for Smart Business Transformation.

Unit-II: Road to Industry 4.0 **9 Periods**

Internet of Things (IoT), Industrial Internet of Things (IIoT) & Internet of Services; Smart Manufacturing: Smart Devices and Products, Smart Logistics, Smart Cities, Predictive Analytics, Integration of Advanced Robotics in Industrial Operations.

Unit-III: Related Disciplines, System, Technologies for Enabling Industry 4.0 9 Periods

Big data: Physical Systems, Robotic Automation and Collaborative Robots, Support System for Industry 4.0; Mobile Computing: Artificial intelligence and Machine learning, Cyber Security; Digital twin: Digital thread, Product Life cycle Management, Augmented reality and Virtual Reality.

Unit-IV: Role of Data, Information, Knowledge and Collaboration in Future Organizations **9 Periods**

Resource based view of a firm: Data as a new resource for organizations, Harnessing and sharing knowledge in organizations; Cloud Computing Basics: Cloud Computing and Industry 4.0

Unit-V: Business Issues in Industry 4.0 **9 Periods**

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Opportunities and Challenges; Future of Works and Skills for Workers in the Industry 4.0 Era; Strategies for competing in an Industry 4.0 world
References:
Reference Books: 1. Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things, APress, 2016. 2. Kiran Kumar Pabbathi, "Quick Start Guide to Industry 4.0: One-Stop Reference Guide for Industry4.0", Createspace Independent Publishing Platform, 2018. **Journals:** 1. Journal of Manufacturing Systems – Elsevier 2. IEEE Transactions on Industrial Informatics – IEEE **MOOC/NPTEL /SWAYAM Courses:** 1. https://onlinecourses.nptel.ac.in/noc23_me03/preview 2. https://onlinecourses.nptel.ac.in/noc22_cs86/preview 3. Manufacturing Systems Technology - Part 1 & 2 - https://onlinecourses.nptel.ac.in/noc22_me36/preview 4. Smart Materials and Intelligent System Design - https://onlinecourses.nptel.ac.in/noc23_me34/preview

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED528.1	Understand the Evolution and Impact of Industrial Revolutions
P23ED528.2	Understand Digitalization and Networked Economy
P23ED528.3	Understand the Key Technologies and Enablers of Industry 4.0
P23ED528.4	Understand the Role of Data and Cloud Computing
P23ED528.5	Apply Business Strategies and Workforce Implications

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P23ED529	Solid Freeform Manufacturing	L	T	P	J	C
		3	0	0	0	3

1. Course Description:

This course provides a comprehensive understanding of Additive Manufacturing (AM) technologies, including their need, development, and applications. It covers the design principles for AM, such as part consolidation, topology optimization, and lightweight structures. The course explores various AM processes like VAT polymerization, sheet lamination, material extrusion, powder bed fusion, jetting, and direct energy deposition. Students will learn about the materials, processes, advantages, limitations, and applications of each technique, supported by real-world case studies in industries like bioprinting, electronics, and rapid tooling.

2. Course Objectives:

1. Students can able to acquaint the students with evolution of Solid Freeform Manufacturing (SFM) / Additive Manufacturing (AM), proliferation into various fields and its effects on supply chain.
2. Students can able to gain knowledge on Design for Additive Manufacturing (DFAM) and its importance in quality improvement of fabricated parts.
3. Students can able to acquaint with polymerization and sheet lamination processes and their applications.
4. Students can able to acquaint with material extrusion and powder bed fusion processes.
5. Students can able to gain knowledge on jetting and direct energy deposition processes and their applications.

3. Syllabus: **45 Periods**

Unit-I: Introduction **9 Periods**

Need; Development of SFM systems; Hierarchical structure of SFM; SFM process chain: Classification, Applications; Case studies: Bio printing, Food Printing, Electronics printing; Rapid Tooling; Building printing; AM Supply chain; Economics aspect: Strategic aspect, Operative aspect;

Unit-II: Design for Additive Manufacturing **9 Periods**

Concepts and Objectives; AM Unique Capabilities; Part Consolidation, Topology Optimization; Lightweight Structures; DFAM for Part Quality Improvement; CAD Modeling: Model Reconstruction, Data Processing for AM, Data Formats, Data Interfacing, Part Orientation, Support Structure Design and Support Structure Generation; Model Slicing: Tool Path Generation; Design Requirements of Additive Manufacturing: For Part Production, For Mass Production, For Series Production; Case Studies;

Unit-III: VAT Polymerization and Sheet Lamination Processes **9 Periods**

Stereolithography Apparatus (SLA): Principles, Photo Polymerization of SL Resins; Pre Build Process: Part-Building and Post-Build Processes; Part Quality and Process Planning, Recoating Issues; Materials; Advantages, Limitations and Applications;
Laminated Object Manufacturing (LOM): Working Principles, Process, Materials, Advantages, Limitations and Applications; Ultrasonic Additive Manufacturing (UAM): Process, Parameters, Applications; Case Studies;

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Unit-IV: Material Extrusion and Powder Bed Fusion Processes	**9 Periods**
Fused deposition Modeling (FDM): Working Principles, Process, Materials and Applications. Design Rules for FDM; Selective Laser Sintering (SLS): Principles, Process, Indirect and Direct SLS, Powder Structure, Materials, Surface Deviation and Accuracy, Applications; Multijet Fusion; Selective Laser Melting (SLM) and Electron Beam Melting (EBM): Principles, Processes, Materials, Advantages, Limitations and Applications; Case Studies;	
Unit-V: Jetting and Direct Energy Deposition Processes	**9 Periods**
Binder Jetting; Three dimensional Printing (3DP): Principles, Process, Physics of 3DP; Types of printing: Continuous mod; Drop on Demand mode; Process, Materials, Advantages, Limitations, Applications; Material Jetting: Multi Jet Modelling (MJM) Principles, Process, Materials, Advantages and Limitations; Laser Engineered Net Shaping (LENS): Processes, Materials, Advantages, Limitations and Applications; Case Studies;	

Text Books:

1. Andreas Gebhardt and Jan-Steffen Hotter, "Additive Manufacturing:3D Printing for Prototyping and Manufacturing", Hanser publications Munchen, Germany, 2016. ISBN:978-1-56990-582-1.
2. Ben Redwood, Brian Garret, FilemonSchöffer, and Tony Fadel, "The 3D Printing Handbook: Technologies, Design and Applications", 3D Hubs B.V., Netherland, 2017. ISBN-13: 978-9082748505.

References:

Reference Books:

1. Ian Gibson, David W. Rosen and Brent Stucker, "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing" Springer – New York, USA, 2nd Edition, 2015. ISBN13: 978-1493921126.
2. Liou, L.W. and Liou, F.W., "Rapid Prototyping and Engineering applications: A tool box for prototype development", CRC Press, 1st Edition, 2007 FL, USA. ISBN-9780849334092.
3. Milan Brandt., "Laser Additive Manufacturing 1st Edition Materials, Design, Technologies, and Applications", Woodhead Publishing, UK, 2016. ISBN-9780081004333

Journal:

1. Solid Freeform Fabrication: A New Direction in Manufacturing – Springer

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4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED529.1	(Analyze) Relate the importance in the evolution of SFM/AM, proliferation into the various fields and its effects on supply chain.
P23ED529.2	(Analyze) Analyze the design for AM and its importance in the quality of fabricated parts.
P23ED529.3	(Apply) Build knowledge on principles and applications of polymerization and sheet lamination processes with case studies.
P23ED529.4	(Understand) Explain the principles of material extrusion and powder bed fusion processes and design guidelines.
P23ED529.5	(Understand) Elaborate jetting and direct energy deposition processes and their applications.

P23ED530	**CREATIVITY AND INNOVATION**	**L**	**T**	**P**	**J**	**C**
		3	**0**	**0**	**0**	**3**

1. Course Description:

This course explores creativity and innovation principles essential for engineering design. Students will apply creativity heuristics, tools, and design principles to develop innovative solutions in product design. Emphasis is placed on analysing the impact of these practices and evaluating effective innovation management strategies in new product development.

2. Course Objectives:

1. Students will understand the theoretical foundations of creativity heuristics, tools, design principles, and innovation practices as applied in engineering design and product development.
2. Students will apply creativity tools, design principles, and innovation practices effectively to develop novel and practical solutions in new product design and development.
3. Students will analyse the influence of creativity heuristics, tools, design principles, and innovation practices on product design decisions and outcomes.
4. Students will evaluate the principles and practices of innovation management in guiding the development, implementation, and commercialization of innovative products.

3. Syllabus: **45 Periods**

Unit-I: Creativity Theory, Heuristics & Model **9 Periods**

Directed creativity: Five Mental Actions in Directed Creativity – Five Factors Driving the Need for Creativity and Innovation in Organizations – Two Key Challenges on the Road to Innovation – Quality Management & Creativity and Innovation – Proper Definition of Creativity & Innovation with Practical Advice – A High-level Model of Mechanics of Mind

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– Role of Perception in Creative Thinking with Practical Advice – Role of Memory in Creative Thinking with Practical Advice – Role of Judgment in Creative Thinking with Practical Advice – Amabile's Seven Heuristics on Creativity – Perkin's Ten Heuristics on Creativity – Plsek's Eight Heuristics on Creativity – Model of Directed Creativity Process.

Unit-II: Creativity Principles & Tools **9 Periods**

Creative Thinking Tools: Trans-disciplinary Analogy – Stepping Stones – Dreamscape – Manipulative Verbs – Three basic principles: Attention – Escape – Movement – Tools for Preparation Phase – Tools for Imagination Phase – Harvesting Ideas – Eight Steps to Transforming Organization – Tools for Development and Action Phase – Idea Enhancement Checklist – Documenting Idea – Techniques for Action Phase.

Unit-III: Creativity Design & Application **9 Periods**

ICEDIP: Inspiration, Clarification, Distillation, Perspiration, Evaluation and Incubation – Norman's Three Levels of Emotional Design: Visceral, Behavioral and Reflective – Application of Creativity in Process Design & Reengineering – Application of Creativity in Customer Needs Analysis – Application of Creativity in Innovative Product and Service Design – Symptoms of Stuck Thinking - Seven Tools in Creative Problem Solving and Incremental Quality Improvement.

Unit-IV: Innovation Principles & Practices **9 Periods**

Routine and Inventive Problems – Difficulty of a Problem – Psychological Inertia – Methods of Creativity Activation – Checklists and Questionnaires – Morphological Box – Decision Aids – Problem Solving and Information – Requirements for Inventive Problem Solving – Necessary Qualities for the Solver of Nonroutine Problems – Altshuller's Engineering Parameters – Altshuller's Inventive Principles – Altshuller's Contradiction Matrix Algorithm.

Unit-V: Innovation Management **9 Periods**

Disruptive Innovation Model – Disruption at Work: How Minimills Upended Integrated Steel Companies – Two Types of Disruption: New-Market Disruptions – Low-End Disruptions – Three Litmus Tests – Three Approaches to Creating New-Growth Businesses – New Market Disruptions: Three Case Histories – Product Architectures and Integration – Process of commoditation and decommoditation – Two Processes of Strategy Formulation – Role of Senior Executive in Leading New Growth

Text Books:

1. Paul E. Plsek, "Creativity, Innovation and Quality", ASQ Quality Press, Milwaukee, Wisconsin, 2000.

ReferenceS:

Reference Books:

1. Donald A. Norman, "Emotional Design", Perseus Books Group, New York, 2004.
2. Geoffrey Petty, "How to be better at Creativity", The Industrial Society, 1999.
3. Semyon D. Savransky, "Engineering of Creativity – TRIZ", CRC Press, New York, USA, 2000.

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4. Clayton M. Christensen and Michael E. Raynor, "The Innovator's Solution", Harvard Business School Press, Boston, USA, 2003.

Journals:

1. Journal of Mechanical Design - American Society of Mechanical Engineers (ASME)
2. Creativity and Innovation Management - Wiley
3. Research in Engineering Design – Springer

MOOC/NPTEL /SWAYAM Courses:

1. https://www.coursera.org/learn/innovation-management
2. https://www.coursera.org/learn/creativity-innovation-change
3. https://ocw.mit.edu/courses/esd-051j-engineering-innovation-and-design-fall-2012/
4. Design, Technology and Innovation - https://onlinecourses.nptel.ac.in/noc20_de03/preview
5. Design Thinking and Innovation - https://onlinecourses.swayam2.ac.in/aic23_ge17/preview

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23ED530.1	(Apply) Apply the heuristics of theory of creativity in new product design and development.
P23ED530.2	(Evaluate) Evaluate the practical application of creativity tools and their impact on product innovation.
P23ED530.3	(Analyse) Analyse how design principles enhance creativity and contribute to innovative product designs.
P23ED530.4	(Analyse) Analyse the integration of innovation principles like disruptive innovation and continuous improvement in product development.
P23ED530.5	(Evaluate) Evaluate the role of innovation management in aligning product development with strategic objectives and enhancing market competitiveness.

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Open Electives (OEs):

P23OE501	Business Analytics	L	T	P	J	C
		3	0	0	0	3

1. Course Description:

This course provides a comprehensive introduction to business analytics, focusing on the techniques and tools used to derive actionable insights from data. Students will explore key concepts such as descriptive, predictive, and prescriptive analytics, as well as the application of statistical methods and data visualization techniques. Topics include data mining, forecasting, and optimization, with hands-on experience using popular analytics software through Case studies

2. Course Objectives:

1. Students will learn the fundamental principles of business analytics, including the distinctions between data scientists, data engineers, and business analysts
2. Students can explore the architecture and processes involved in data warehousing, including ETL processes, and evaluate the methodologies of business performance management. Understand key data mining concepts and tasks, including OLAP and the handling of data quality issues.
3. Students can able Utilize descriptive statistics and data visualization tools to effectively summarize and interpret data. Employ techniques for sampling, estimation, and probability distributions in data analysis.
4. Students able to predictive models using statistical techniques such as regression analysis and formulate prescriptive models that utilize non-linear optimization and simulation techniques, demonstrating the ability to recommend data-driven solutions.

3. Syllabus: **45 Periods**

Unit-I: Introduction **9 Periods**

Introduction: business analytics, Historical Overview of data analysis, Data Scientist vs. Data Engineer vs. Business Analyst, Career in Business Analytics. Statistics Vs Data Mining Vs Data Analytics Vs Data Science. Supervised Learning and Unsupervised Learning.

Unit-II: Data Warehousing & Data Mining **9 Periods**

Data Warehousing: Concepts, Process overview, Architecture, ETL process. Business Performance Management: BPM, Strategy, Plan, Monitoring, Performance, Measurement, Business Performance Management Methodologies. Introduction to Data Mining, The origins of Data Mining, Data Mining Tasks. OLAP and Multidimensional data analysis Data preparation, incomplete data, missing data, erroneous data, outliers. Basic concept of Association Analysis and Cluster Analysis.

Unit-III: Descriptive Analytics **9 Periods**

Introduction to Descriptive analytics, Visualizing, and Exploring Data, Descriptive Statistics, Sampling and Estimation, Probability Distribution for Descriptive Analytics, Analysis of Descriptive analytics.

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Unit-IV: Predictive Analytics	**9 Periods**
Introduction to Predictive analytics, Logic and Data Driven Models, Predictive Analysis Modeling and procedure, Analysis of Predictive analytics. Regression analysis, Decision theory and Cluster analysis.	
Unit-V: Prescriptive Analytics	**9 Periods**
Introduction to Prescriptive analytics, Prescriptive Modeling, Non-Linear Optimization, Simulation, Demonstrating Business Performance Improvement.	
Text Books:	
1. U. Dinesh Kumar, Business Analytics, The Science of Data- Driven Decision Making, Willey Second edition ,2022.	
References:	
Reference Books: 1. Umesh R Hodeghatta and Umesha Nayak, Business Analytics Using R: A Practical Approach Apress, 2017. 2. Jeffery D.Camm, James J. Cochran, Michael J. Fry, Jeffrey W. Ohlmann, David R. Anderson, Essentials of Business Analytics, Cengage Learning, 2015 3. Sandhya Kuruganti, Business Analytics: Applications to Consumer Marketing, McGraw Hill, 2015 **Journals:** 1. Journal of Business Analytics 2. Business Analytics Journal **MOOC/NPTEL /SWAYAM Courses:** 1. https://www.coursera.org/professional-certificates/microsoft-business-analyst 2. https://onlinecourses.nptel.ac.in/noc20_mg11/preview	

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23OE501.1	**(Apply)** Analyze the differences between the roles of a Data Scientist, Data Engineer, and Business Analyst, and their relevance in business analytics.
P23OE501.2	**(Analyze)** Assess various business performance management methodologies and their effectiveness in strategic planning and monitoring.
P23OE501.3	**(Analyze)** Interpret probability distributions in the context of descriptive analytics and their implications for business decision-making.

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P23OE501.4	**(Analyze)** Critically evaluate the outcomes of predictive analytics models and their potential business applications.
P23OE501.5	**(Analyze)** Formulate prescriptive models using non-linear optimization and simulation techniques to recommend business improvements.

P23OE502	**Industrial Safety**	**L**	**T**	**P**	**J**	**C**
		3	**0**	**2**	**0**	**4**

1. Course Description:

This course provides a comprehensive overview of industrial safety fundamentals, maintenance engineering principles, mechanisms of wear and corrosion, effective fault tracing techniques, and strategies for implementing preventive and periodic maintenance for optimal performance.

2. Course Objectives:

1. Students will be able to grasp the fundamentals of industrial safety.
2. Students will be able to grasp the fundamentals maintenance engineering.
3. Students will be able to understand the concepts of wear and corrosion.
4. Students will be able to illustrate fault tracing.
5. Students will be able to identify preventive and periodic maintenance.

3. Syllabus **45 Periods**

Unit-I: Introduction **9 Periods**

Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

Unit-II: Fundamentals Of Maintenance Engineering **9 Periods**

Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment

Unit-III: Wear And Corrosion And Their Prevention **9 Periods**

Wear: types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

Unit-IV: Fault Tracing **9 Periods**

Fault tracing: concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine

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tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, i. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes
Unit-V: Periodic And Preventive Maintenance **9 Periods**
Periodic inspection: concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: i. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance
References:
Reference Books: 1. Hans F. Winterkorn, Foundation Engineering Handbook, Chapman & Hall London,2013. 2. Audels, Pump-hydraulic Compressors, Mcgrew Hill Publication, 1978. 3. Garg H P, Maintenance Engineering, S. Chand and Company,1987. 4. Higgins & Morrow, Maintenance Engineering Handbook, Eighth Edition,2008. **Journals:** 1. International Journal of Occupational Safety and Ergonomics— Taylor & Francis. **MOOC/NPTEL /SWAYAM Courses:** 1. http://www.digimat.in/nptel/courses/video/110105094/L01.html 2. Industrial Safety Engineering - https://archive.nptel.ac.in/courses/110/105/110105094/

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23OE502.1	(Apply) Ability to summarize basics of industrial safety
P23OE502.2	(Understand) Ability to describe fundamentals of maintenance engineering
P23OE502.3	(Apply) Ability to explain wear and corrosion
P23OE502.4	(Apply) Ability to illustrate fault tracing
P23OE502.5	(Apply) Ability to identify preventive and periodic maintenance

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P23OE503	Operations research	L	T	P	J	C
		3	0	2	0	4

1. Course Description:

This course explores linear programming, covering graphical methods, simplex method, transportation and assignment problems, project management challenges, and scheduling techniques, providing essential skills for effective decision-making and optimization.

2. Course Objectives:

1. Students will be able to acquire the knowledge of optimization techniques and approaches. Formulate a real world problem as a mathematical model and finding solutions
2. Students will be able to learn about revised simplex method and sensitivity analysis of LPP
3. Students will be able to solve networking problems like transportation, Assignment, Maximal flow, Minimum spanning tree and shortest path problems
4. Students will be able to learn about Queuing models and Decision making under uncertainty and certainty conditions.

3. Syllabus **45 Periods**

Unit-I: Linear Programming **9 Periods**

Introduction to Operations Research: assumptions of Linear Programming Problems, Formulations of linear programming problem, Graphical method; Solutions to LPP using simplex algorithm, Two phase method, Big M method

Unit-II: Advances In Linear Programming **9 Periods**

Revised simplex method; primal dual relationships; Dual simplex algorithm; Sensitivity analysis: changes in RHS value, changes in Coefficient of constraint, Adding new constraint, Adding new variable.

Unit-III: Network Analysis **9 Periods**

Transportation problems: Northwest corner rule, least cost method, Vogel's approximation method, stepping stone method, MODI method; Unbalanced transportation, Assignment problem, Hungarian algorithm, Travelling salesman problem, project management; Minimum spanning tree problem: prim's algorithm, Kruskal's algorithm; Shortest path problem: Dijkstra's algorithms, Floyds algorithm; maximal flow problem: Maximal flow minimum cut theorem, Maximal flow algorithm.

Unit-IV: Decision And Game Theory **9 Periods**

Decision making under certainty, Decision making under risk, Decision making under uncertainty; Decision tree analysis, Introduction to MCDM; AHP. Game Theory: Two person zero sum games, pure and mixed strategies; Theory of dominance; Graphical Solution; Solving by LP.

Unit-V: Queuing Theory **9 Periods**

Queuing theory terminology: Single server, multi-server, limited and unlimited queue capacity, limited and unlimited population; Dynamic Programming.

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References:

Reference Books:

1. Hamdy A Taha, "Operations Research – An Introduction", Pearson, 2017.
2. Panneerselvam. R, "Operations Research", PHI, 2009
3. Philips, Ravindran and Solberg, "Operations Research principles and practices", John Wiley, 2007
4. Ronald L Rardin, "Optimisation in Operations Research", Pearson, 2018.
5. Srinivasan. G, "Operations Research Principles and Applications", PHI, 2017.

Journals:

1. European Journal of Operation Research — Science Direct

MOOC/NPTEL /SWAYAM Courses:

1. https://archive.nptel.ac.in/courses/110/106/110106062/
2. Operation Research - https://onlinecourses.nptel.ac.in/noc22_ma48/preview

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23OE503.1	(**Apply**) Learn how to translate a real-world problem, given in words, into a mathematical Formulation
P23OE503.2	(**Apply**) Learn to apply simplex algorithm for LPP.
P23OE503.3	(**Apply**) Be able to build and solve Transportation Models and Assignment Models, maximal flow problem, minimum spanning tree and shortest path problem
P23OE503.4	(**Analyze**) The students will be able to handle issues in Decision making under various conditions.
P23OE503.5	(**Apply**) The students acquire capability in applying and using of queuing models for day today problems.

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P23OE504	Cost Management of Engineering Projects	L	T	P	J	C
		3	0	2	0	4

1. Course Description:

This course covers costing concepts for decision-making, explores project management selection aspects, interprets costing in execution, develops service sector techniques, and illustrates budgetary control and quantitative cost management methods.

2. Course Objectives:

1. Students will be able to summarize the costing concepts and their role in decision making
2. Students will be able to Infer the project management concepts and their various aspects in selection.
3. Students will be able to Interpret costing concepts with project execution.
4. Students will be able to develop knowledge of costing techniques in service sector and various budgetary control techniques.
5. Students will be able to illustrate with quantitative techniques in cost management.

3. Syllabus: **45 Periods**

Unit-I: Introduction To Costing Concepts **9 Periods**

Objectives of a Costing System; Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost; Creation of a Database for operational control.

Unit-II: Introduction To Project Management **9 Periods**

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities, Detailed Engineering activities, Pre project execution main clearances and documents, Project team: Role of each member, Importance Project site: Data required with significance, Project contracts.

Unit-III: Project Execution And Costing Concepts **9 Periods**

Project execution Project cost control, Bar charts and Network diagram, Project commissioning: mechanical and process, Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis, Various decision-making problems, Pricing strategies: Pareto Analysis, Target costing, Life Cycle Costing.

Unit-IV: Costing Of Service Sector And Budgetery Control **9 Periods**

Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Activity Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis, Budgetary Control: Flexible Budgets; Performance budgets; Zero-based budgets.

Unit-V: Quantitative Techniques For Cost Management **9 Periods**

Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Learning Curve Theory.

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Reference Books:
1. Vohra N.D., Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd, 2007. 2. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher, 1991. 3. Charles T. Horngren and George Foster, Advanced Management Accounting, 1988. 4. Charles T. Horngren et al Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi, 2011. 5. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting, 2003. **Journals:** 1. The Journal of Cost Analysis & Management — Taylor & Francis **MOOC/NPTEL /SWAYAM Courses:** 1. https://archive.nptel.ac.in/courses/110/104/110104073/ 2. Project Management - https://onlinecourses.nptel.ac.in/noc19_mg30/preview

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23OE504.1	(**Understand**) Understand the costing concepts and their role in decision making
P23OE504.2	(**Understand**) Understand the project management concepts and their various aspects in selection
P23OE504.3	(**Apply**) Interpret costing concepts with project execution
P23OE504.4	(**Understand**) Gain knowledge of costing techniques in service sector and various budgetary control techniques
P23OE504.5	(**Apply**) Become familiar with quantitative techniques in cost management

P23OE505	Composite Materials	L	T	P	J	C
		3	0	0	0	3

1. Course Description:

This course provides a comprehensive introduction to the science and engineering of composite materials, focusing on their fundamental principles, design, and applications. It covers the classification of composite materials, including fiber-reinforced, particle-reinforced, and structural composites, and explores their advantages over traditional materials. Students will learn about the properties of composite constituents, such as fibers

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and matrices, and how these affect the mechanical, thermal, and environmental behavior of the final composite structure.
2. Course Objectives:
1. Students will understand the fundamental concepts, classifications, and applications of composite materials. 2. Students can explore the mechanical and thermal properties of composite materials. 3. Students will understand the various manufacturing methods used for composites. 4. Students can develop skills for the analysis of the strength and behavior of composite structures. 5. Students will understand the durability and environmental impact of composite materials.
3. Syllabus **45 Periods**
Unit-I: Introduction **9 Periods**
Introduction to composite materials: Definition, Classification, Types of matrices & reinforcements, characteristics & selection, Fiber composites, laminated composites, particulate composites, prepegs, sandwich construction. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance. Advantages and application of composites.
Unit-II: Reinforced Materials and Matrix **9 Periods**
Reinforcements Materials: Metallic, Polymer, Ceramic and Composite fibres, Whiskers and Particulates, Nano-fillers used in polymer composites, Reinforcement fibres, Woven fabrics and Nonwoven random mats.Types of matrix: Commonly used Matrices (Metal matrix, Polymer matrix, Ceramic matrix, Intermetallic matrix, Carbon-Carbon composites), Basic Requirements in Selection of constituents.
Unit-III: Production Techniques and Properties **9 Periods**
Processing of cast composites - XD process, Spray processes (Osprey Process, Rapid solidification processing), In-situ Dispersion Processes (Stir-casting & Compo casting, Screw extrusion), Liquidmetal impregnation technique (Squeeze casting, Pressure infiltration, Lanxide process). Hand lay-up processes – Spray up processes, Compression moulding, Reinforced reaction injection moulding, Resin transfer moulding, Pultrusion, Filament winding, Injection moulding.
Unit-IV: Mechanical Properties of Composites **9 Periods**
Stress-strain relationships for anisotropic materials; Elastic constants and stiffness matrices. Micromechanics of composites: rule of mixtures, iso-strain and iso-stress conditions; Failure modes in composites: matrix cracking, fiber fracture, delamination. Strength theories for composites: Maximum stress, Maximum strain, Tsai-Wu, Tsai-Hill criteria Stress analysis of laminates using Classical Laminate Theory (CLT)
Unit-V: Applications and Future Trends **9 Periods**
Case studies: aerospace, automotive, civil engineering, sports equipment. Role of composites in sustainable engineering; Advances in bio-composites and green materials; Nanocomposites and their emerging applications; Recycling and disposal of composite materials; Future trends in composite materials research and development

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Text Books:
1. Jones, R. M. (2015). *Mechanics of composite materials* (2nd ed.). CRC Press. 2. Chawla, K. K. (2019). *Composite materials: Science and engineering* (4th ed.). Springer.
Reference Books:
1. Tsai, S. W., & Hyer, M. W. (2001). Introduction to composite materials (2nd ed.). Technomic Publishing. 2. Gay, D. (2014). Composite materials: Design and applications (3rd ed.). CRC Press. 3. Mallick, P. K. (2007). Fiber-reinforced composites: Materials, manufacturing, and design (3rd ed.). CRC Press. **Journals:** 1. Journal of Composite Materials — SAGE 2. Composites Science and Technology – Elsevier **MOOC/NPTEL /SWAYAM Courses:** 1. Coursera - Introduction to Composite Materials (University of Illinois) 2. MIT Open Courseware - Composite Materials - Analysis and Design 3. NPTEL - Composite Materials (IIT Kahargpur) 4. NPTEL - Composite Materials and Structures (IIT Madras)

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23OE505.1	Understand the fundamental concepts, classifications, and applications of composite materials.
P23OE505.2	Apply the choices made for using certain types of composites in certain applications with reference to composite properties.
P23OE505.3	Understand the challenges of manufacturing composites and propose suitable techniques.
P23OE505.4	Analyse composite structures for strength and mechanical behavior.
P23OE505.5	Apply knowledge of composites to real-world applications and predict future material trends.

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P23OE506	Waste To Energy	L	T	P	J	C
		3	0	0	0	1

1. Course Description:

The Waste to Energy course covers the production of energy from various types of waste through thermal, chemical, and biological methods. The course is intended to help young scientific professionals keep up with the latest technology and ideas in the field of waste utilization for energy production.

2. Course Objectives:

1. Students will be able to know how to reduce waste that goes to disposal and use waste as a resource for energy
2. Students will develop expertise how to apply science, and engineering to solid waste collection, processing, and route optimization
3. Students will develop how to design composting systems and operate aerobic and anaerobic composting processes
4. Students will gain knowledge to learn how waste generation is affected by urbanization and economic growth

3. Syllabus: **45 Periods**

Unit-I: Introduction **9 Periods**

The Principles of Waste Management and Waste Utilization, Waste Management, Hierarchy and 3R Principle of Reduce, Reuse and Recycle, Waste as a Resource and Alternate Energy source

Unit-II: Waste Sources **9 Periods**

Waste production in different sectors such as domestic, industrial, agriculture, postconsumer, waste etc. Classification of waste – agro based, forest residues, domestic waste, industrial waste (hazardous and non-hazardous), Characterization of waste for energy utilization

Unit-III: Technologies For Waste To Energy **9 Periods**

Biochemical Conversion: Energy production from organic waste through anaerobic digestion and fermentation, Thermo-chemical Conversion: Combustion, Incineration and heat recovery, Pyrolysis, Gasification; Plasma Arc Technology and other newer technologies.

Unit-IV: Waste To Energy Options **9 Periods**

Landfill gas, collection and recovery, Refuse Derived Fuel (RDF) – fluff, briquettes, pellets; Alternate Fuel Resource (AFR) – production and use in Cement plants; Thermal power plants and Industrial boilers, Conversion of wastes to fuel resources for other useful energy applications, Energy from Plastic Wastes – Non-recyclable plastic wastes for energy recovery, Energy Recovery from wastes and optimization of its use, benchmarking and standardization.

Unit-V: E-Waste **9 Periods**

E-waste; E-waste in the global context, Growth of Electrical and Electronics Industry in India, Environmental concerns and health hazards, Recycling e-waste; a thriving economy of the unorganized sector, Global trade in hazardous waste, impact of hazardous e-waste in

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India, Management of e-waste- e-waste legislation- Government regulations on e-waste management, International experience, need for stringent health safeguards and environmental protection laws of India
Text Books:
1. Nicholas P. Cheremisinoff. Handbook of Solid Waste Management and Waste Minimization Technologies. An Imprint of Elsevier, New Delhi (2003). 2. M. Dutta , B. P. Parida, B. K. Guha and T. R. Surkrishnan. Industrial Solid Waste Management and Landfilling practice. Narosa Publishing House, New Delhi (1999).
References:
Reference Books: 1. Waste-to-Energy in Austria – White Book – Figures, Data Facts, 2nd edition , May 2010 2. Hagerty, D.Joseph; Pavoni, Joseph L; Heer, John E., "Solid Waste Management", New York, Van Nostrand **Journals:** 1. Journal of Environmental Technology & Innovation — Science Direct 2. Journal of Nature Science and Sustainable Technology –Springer **MOOC/NPTEL /SWAYAM Courses:** 1. https://archive.nptel.ac.in/courses/103/107/103107125/ 2. https://elearn.nptel.ac.in/shop/nptel/waste-to-energy-conversion/?v=c86ee0d9d7ed 3. https://onlinecourses.nptel.ac.in/noc20_ch16/preview

4. Course Outcomes:

After successful completion of the course, the student should be able to:

CO. No.	Course Outcome
P23OE506.1	(Understand) Principles of Waste Management and Waste Utilization
P23OE506.2	(Analyse) Analyze the waste sources from Waste production in different sectors
P23OE506.3	(Analyse) Analyse various Energy technologies to convert the Waste to energy
P23OE506.4	(Understand) Understand the various options of waste to energy
P23OE506.5	(Understand) Understand the Sources and impact of hazardous e-waste

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