Shirpur Education Society's

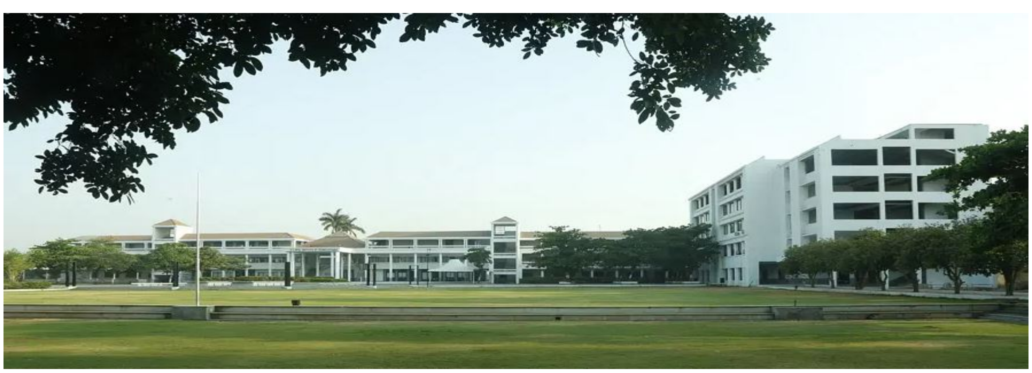
R. C. Patel Institute of Technology, Shirpur

(An Autonomous Institute)

Syllabus Structure

Final Year B.Tech
in Mechanical Engineering

(RCP23 NEP Scheme) with effect from Year 2026-27



Shahada Road, Near Nimzari Naka, Shirpur, Maharashtra 425405 Ph: 02563 259 802,

Web: www.rcpit.ac.in/mechanical-engineering-syllabus

Institute Vision and Mission

Vision of the Institute

"To become a leading Institute in Technical education fostering innovation, research, ethical values, and sustainable development for the betterment of society."

Mission of the Institute

To impart high quality Technical Education through:

M1: Innovative and Interactive learning process and high quality globally recognized instructional programs.

M2: Fostering a collaborative scientific temper among students with ethical responsibility towards the society.

M3: Preparing students from diverse backgrounds to have aptitude for employment, entrepreneurship and research with a spirit of Professionalism.

M4: To contribute to nations sustainable development.

Mechanical Engineering Department

Vision of the Department

" To achieve excellence in Mechanical Engineering education through innovation, research, and strong ethical values for sustainable societal development."

Mission of the Department

M1: To deliver innovative and practical mechanical engineering education through quality instruction and hands-on learning.

M2: To promote teamwork, ethical values, and scientific curiosity through collaborative and socially relevant projects.

M3: To develop competent engineers with technical expertise, research aptitude, and entrepreneurial spirit for sustainable national growth.

Programme Educational Objectives (PEOs)

PEO 1: Graduates will apply scientific, mathematical, and engineering principles to solve complex mechanical problems ethically and sustainably.

PEO 2: Graduates will design and implement efficient mechanical solutions addressing societal needs through innovation, collaboration, and environmental stewardship.

PEO 3: Graduates will demonstrate professional competence, communication, teamwork, and lifelong learning for career growth, entrepreneurship, and higher education.

Programme Specific Outcomes (PSOs)

PSO 1: Students will be able to apply Mechanical Engineering principles and modern tools to design and improve mechanical systems with innovative solutions.

PSO 2: Students will demonstrate ethical practice, teamwork, and communication to develop engineering solutions for societal and sustainable development.

Department of Mechanical Engineering

(Autonomous - RCP23)

Semester – VII/VIII (w.e.f.2026-27)														
Sr. No	Course Category	Course Code	Course Title	Teaching Scheme (hrs.)			Evaluation Scheme (CA) (marks)				ESE (marks)	Total	Credit	
				L	T	P	TA	Term Test 1 (TT1)	Term Test 2 (TT2)	Average (TT1 & TT2)				
							[A]			[B]	[C]	[A+B+C]		
1	PC	RCP23MCPC701	Design of Mechanical Systems	3	-	-	25	15	15	15	60	100	3	4
		RCP23MLPC701	Design of Mechanical Systems Laboratory	-	-	2	25	-	-	-	25	50	1	
2 $	PE	RCP23MCPE711	Prototyping and Design Validation	3	-	-	25	15	15	15	60	100	3	4
		RCP23MLPE711	Prototyping and Design Validation Laboratory	-	-	2	25	-	-	-	25	50	1	
		RCP23MCPE712	Creative Engineering Design	3	-	-	25	15	15	15	60	100	3	
		RCP23MLPE712	Creative Engineering Design Laboratory	-	-	2	25	-	-	-	25	50	1	
		RCP23MCPE713	Cryogenics	3	-	-	25	15	15	15	60	100	3	
		RCP23MLPE713	Cryogenics Laboratory	-	-	2	25	-	-	-	25	50	1	
		RCP23MCPE714	Micro-Electromechanical Systems	3	-	-	25	15	15	15	60	100	3	
		RCP23MLPE714	Micro-Electromechanical Systems Laboratory	-	-	2	25	-	-	-	25	50	1	
		RCP23MCPE715	Vehicle Testing and Safety	3	-	-	25	15	15	15	60	100	3	
		RCP23MLPE715	Vehicle Testing and Safety Laboratory	-	-	2	25	-	-	-	25	50	1	
		RCP23MCPE716	Bionics Engineering	3	-	-	25	15	15	15	60	100	3	
		RCP23MLPE716	Bionics Engineering Laboratory	-	-	2	25	-	-	-	25	50	1	
		RCP23MCPE717	Big Data Analytics	3	-	-	25	15	15	15	60	100	3	
		RCP23MLPE717	Big Data Analytics Laboratory	-	-	2	25	-	-	-	25	50	1	
		RCP23MCPE718	Startup Sustainability and Scalability	3	-	-	25	15	15	15	60	100	3	
		RCP23MLPE718	Startup Sustainability and Scalability Laboratory	-	-	2	25	-	-	-	25	50	1	
3 ~	PE	RCP23MCPE721	Process Equipment Design	3	-	-	25	15	15	15	60	100	3	4
		RCP23MLPE721	Process Equipment Design Laboratory	-	-	2	25	-	-	-	25	50	1	
		RCP23MCPE722	Computational Fluid Dynamics	3	-	-	25	15	15	15	60	100	3	
		RCP23MLPE722	Computational Fluid Dynamics Laboratory	-	-	2	25	-	-	-	25	50	1	
		RCP23MCPE723	Sustainable Manufacturing	3	-	-	25	15	15	15	60	100	3	
		RCP23MLPE723	Sustainable Manufacturing Laboratory	-	-	2	25	-	-	-	25	50	1	
		RCP23MCPE724	Motorsports Engineering	3	-	-	25	15	15	15	60	100	3	
		RCP23MLPE724	Motorsports Engineering Laboratory	-	-	2	25	-	-	-	25	50	1	
		RCP23MCPE725	Flexible Manufacturing Systems	3	-	-	25	15	15	15	60	100	3	
		RCP23MLPE725	Flexible Manufacturing Systems Laboratory	-	-	2	25	-	-	-	25	50	1	
		RCP23MCPE726	Business Analytics	3	-	-	25	15	15	15	60	100	3	
		RCP23MLPE726	Business Analytics Laboratory	-	-	2	25	-	-	-	25	50	1	
		RCP23MCPE727	Startup Compliances and Exit Strategies	3	-	-	25	15	15	15	60	100	3	
		RCP23MLPE727	Startup Compliances and Exit Strategies Laboratory	-	-	2	25	-	-	-	25	50	1	
4	MD	RCP23MCMD701	Industrial Engineering and Management	3	-	-	25	15	15	15	60	100	3	3
5	EL	RCP23ITELX08	Research Ecosystem	-	2	-	50	-	-	-	-	50	2	2
6	HS	RCP23ICHSX09	Disaster Management and Preparedness	2	-	-	-	-	-	-	-	-	A	A
7	EL	RCP23IPEL701	Project Stage - II	-	-	8	50	-	-	-	50	100	4	4
8	SC	RCP23MCSC701	Data Science for Mechanical Engineers	1	-	-	40	-	-	-	-	40	1	1
			Total	15	2	14	315	60	60	60	365	740	22	22

PC-Program Course, PE – Program Elective, MD- Multidisciplinary, EL-Experiential Learning, SC- Skill Course.

$ Any 1 Program Elective III, ~ Any 1 Program Elective IV from given list.

Prepared by	Checked by	BOS Chairman	Dean Academic &Dy. Director	C.O.E.	Director
Mr. R. R. Ozarkar	Mr. S. V. Yeole	Prof. Dr. P. L. Sarode	Prof. Dr. P. J. Deore	Mr. S. P. Shukla	Prof. Dr. J. B. Patil

Department of Mechanical Engineering
(Autonomous - RCP23)

Semester – VII/VIII (w.e.f.2026-27)														
Sr. No	Course Category	Course Code	Course Title	Teaching Scheme (hrs.)			Evaluation Scheme (CA) (marks)				ESE (marks)	Total	Credit	
				L	T	P	TA	Term Test 1 (TT1)	Term Test 2 (TT2)	Average (TT1 & TT2)				
							[A]			[B]	[C]	[A+B+C]		
1 @	PE	RCP23MCPE811	Design for X*	3	-	-	25	15	15	15	60	100	3	3
		RCP23MCPE812	Air Handling Units*	3	-	-	25	15	15	15	60	100	3	
		RCP23MCPE813	Digital Manufacturing*	3	-	-	25	15	15	15	60	100	3	
		RCP23MCPE814	Lean Manufacturing*	3	-	-	25	15	15	15	60	100	3	
		RCP23MCPE815	Soft Computing and Optimization Techniques*	3	-	-	25	15	15	15	60	100	3	
		RCP23MCPE816	Startup Registration and Development*	3	-	-	25	15	15	15	60	100	3	
		RCP23MCPE817	Hydrogen Powered Vehicles*	3	-	-	25	15	15	15	60	100	3	
			NPTEL/SWAYAM Course#	3	-	-	25	15	15	15	60	100	3	
2	EL	RCP23IPELX10	Internship (OJT) cum Project	-	-	36	200	-	-	-	200	400	18	18
3	SC	RCP23MCSC801	Machine Learning for Mechanical Engineers	1	-	-	40	-	-	-	-	40	1	1
			Total	**4**	**0**	**36**	**265**	**15**	**15**	**15**	**260**	**540**	**22**	**22**
PE-Program Elective, EL-Experiential Learning, SC- Skill Course.														

@ Any 1 Program Elective V from given list.

1. *Program Elective Courses offered by institute for the students doing Internship (OJT).
2. #Program Elective Courses offered by NPTEL/SWAYAM for the students doing Internship (OJT).
   These courses are to be studied in self-study mode using NPTEL/SWAYAM platform.
   Students doing Internship (OJT) shall submit certificates of NPTEL examination OR they have to appear examinations conducted by institute like TT1, TT2 and ESE.
   Students undergoing Internship (OJT) have the option to appear for both the NPTEL examination and End Semester Examination (ESE) conducted by institute for respective course. In such cases, the better of the two scores (NPTEL or ESE) shall be considered for final grading.
   List of NPTEL courses will be declared by concerned BOS at the beginning of semester.

Prepared by	Checked by	BOS Chairman	Dean Academic &Dy. Director	C.O.E.	Director
Mr. R. R. Ozarkar	Mr. S. V. Yeole	Prof. Dr. P. L. Sarode	Prof. Dr. P. J. Deore	Mr. S. P. Shukla	Prof. Dr. J. B. Patil

R. C. Patel Institute of Technology, Shirpur Autonomous

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R. C. Patel Institute of Technology, Shirpur

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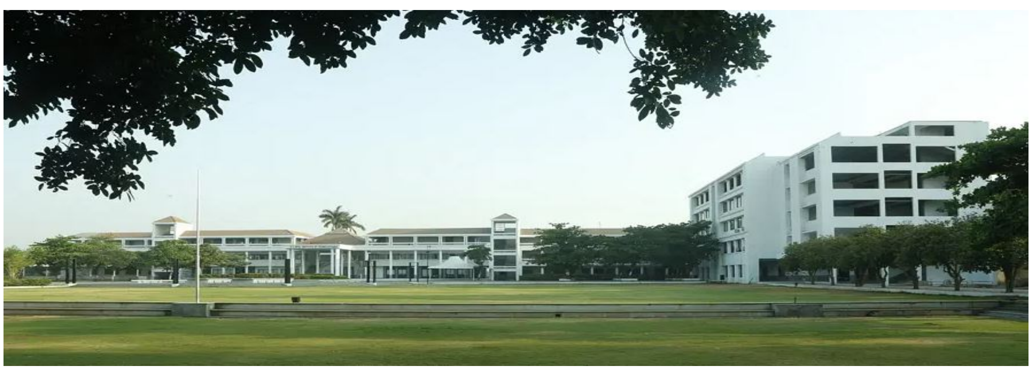
Syllabus Details of Semester-VII

Final Year B.Tech in Mechanical Engineering

(RCP23 NEP Scheme) with effect from Year 2026-27



Shahada Road, Near Nimzari Naka, Shirpur, Maharashtra 425405 Ph: 02563 259 802,

Web: www.rcpit.ac.in/mechanical-engineering-syllabus

Program: Mechanical Engineering	Final Y. B.Tech.	Semester: VII/VIII
Design of Mechanical Systems (RCP23MCPC701)		
Design of Mechanical Systems Laboratory (RCP23MLPC701)		

Prerequisites:

1. Knowledge of Material Technology,
2. Mechanics of Materials,and
3. Design of Machine Elements.

Course Objectives:

1. To acquaint with functional and strength design principles of important machine elements used in mechanical systems.
2. To study the detailed design procedure of the different types of machine elements used in mechanical systems.
3. To familiarize selection of standard elements such as rolling contact bearings.
4. To study system design of various systems such as Gearbox, snatch block, belt conveyors and pumps.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Design gears based on the given conditions and develop multispeed gearboxes for a specified machine tool application.	L6	Create
CO2	Select bearings for a given application.	L4	Analyze
CO3	Design hoisting mechanism of an Electric overhead traveling crane.	L6	Create
CO4	Design belt conveyor systems.	L6	Create
CO5	Design pumps for a given application.	L6	Create

Design of Mechanical Systems (RCP23MCPC701)

Course Contents

Unit-I **15 Hrs.**

Design of Gears

Design of spur, helical, bevel, and worm gears with strength, wear, and thermal considerations.
Design of Gear Box: Design of gearbox (multi-speed) for machine tool applications (Maximum two stages and nine speeds). Determination of variable speed range, Graphical representation of speeds, Structure diagram, Ray diagram, Selection of optimum ray diagram, Estimation of numbers of teeth on gears (Excluding Deviation diagram, Layout of gearbox).

Unit-II **10 Hrs.**

Bearing Design and Selection

Rolling Contact Bearings: Types of bearing and rolling contact bearings, designation of rolling contact bearings, selection of rolling contact bearings based on constant /Variable Load conditions (includes deep groove ball bearing, cylindrical roller, spherical roller, taper roller, self-aligning bearing, and thrust bearing).
Sliding Contact Bearings: Design of hydro dynamically lubricated bearings (self-contained), Introduction to hydrostatic bearings, Types and selection of Mechanical seals.

Unit-III **08 Hrs.**

Design of Hoisting mechanism

Selection of wire rope, Design and selection of sheave pulley, axle and bearings, Design of nut, Selection of thrust bearing, Design of cross-piece with trunnion, Design of shackle plate, Design of rope drum, drum shaft and bearing, Selection of motor (Excluding Selection of hook).

Unit-IV **05 Hrs.**

Design of Belt Conveyors

Selection of belt, Selection of motor, Design of drive pulley assembly, Design of driven pulley assembly, Design of overrunning idler assembly, Design of underrunning idler assembly.

Unit-V **04 Hrs.**

Design of Gear Pump

Selection of motor, Design of gears, Selection of bearings, Design of bolts, Design of suction and delivery pipes.

Design of Mechanical Systems Laboratory (RCP23MLPC701)

Suggested Experiments

A Design and detailed assembly drawing (computer aided drawing on A3 size sheets) of minimum two design problems, from the following:

   1 Design of hoisting mechanisms
   2 Design of belt conveyors
   3 Design of pumps

B Exercises on following topics in the form of design calculations with sketches and / or drawings:

   1 Design of Gears
   2 Rolling contact bearings/ Sliding contact bearing
   3 Design of gearbox

C Course Project:

   Students in a group (2 to 4 students) should be able to apply and integrate the knowledge gained during the course. Design and preparation of working drawings of any system having minimum 5 to 6 components is expected.

Books Recommended

Textbooks

1 Richard G. Budynas and J. Keith Nisbett, Shigley's Mechanical Engineering Design, McGraw-Hill Education, New York, 2024.

2 V. B. Bhandari, Design of Machine Elements, McGraw-Hill Education, New Delhi, 2021.

3 S. P. Patil, Mechanical System Design, Jaico Publishing House, Mumbai, 2004.

4 B. Sharma and H. Purohit, Design of Machine Elements, Prentice Hall India, New Delhi, 2008.

5 Robert L. Norton, Machine Design - An Integrated Approach, Pearson Education, Upper Saddle River, NJ, 2006.

6 J.E. Shigley, Mechanical Engineering Design, McGraw Hill, New York, 2009.

Reference Books

1 S. K. Basu and D. K. Pal, Design of Machine Tools, CBS Publishers & Distributors, New Delhi, 2018.

2 N. K. Mehta, Machine Tool Design, McGraw-Hill Education, New Delhi, 2012.

3 PSG College of Technology, Design Data: Data Book of Engineers, Kalaikathir Achchagam, Coimbatore, 2023.

4 S. S. Khandare and A. V. Kale, Design of Engine Parts, Charotar Publishing House, Anand, 2008.

5 Pandya & Shah, Machine Design, Charotar Publishing, Anand, 2020.

6 Reshetov, Machine Design, Mir Publication, Moscow, 2019.

7 Black & Adams, Machine Design, McGraw Hill, New York, 2021.

8 Mahadevan, Design Data Book,CBS Publishers & Distributors Pvt Ltd,2013.

Program: Mechanical Engineering	**Final Y. B.Tech.**	**Semester: VII/VIII**
Prototyping and Design Validation (RCP23MCPE711)		
Prototyping and Design Validation Laboratory (RCP23MLPE711)		

Prerequisites:

1. Fundamentals of Mechanical Engineering

Course Objectives:

1. Understand the importance of prototyping in product development and design validation.
2. Learn various prototyping techniques and tools, including low-fidelity and high-fidelity prototyping methods.
3. Develop skills in gathering and interpreting user feedback to inform prototyping decisions.
4. Explore strategies for rapidly iterating on prototypes to refine product concepts.
5. Gain experience in effectively communicating and presenting prototype designs to stakeholders.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Explain the role of prototyping in product development and design validation.	L2	Understand
CO2	Analyze various methods of prototyping and select a suitable method for a given application.	L4	Analyze
CO3	Apply suitable prototyping technologies, tools, and manufacturing techniques to develop functional product prototypes.	L3	Apply
CO4	Apply design validation tests, including usability, functional, and compliance testing.	L3	Apply
CO5	Explain regulatory and compliance requirements and integrate them into the design validation process.	L5	Evaluate

Prototyping and Design Validation (RCP23MCPE711)

Course Contents

Unit-I **08 Hrs.**

Fundamentals of Prototyping and Design Validation

Product design and development process. Need, role, and business case for prototyping. Dimensions of prototyping (four quadrants). Prototyping process and lifecycle. Concept, need, and goals of product validation. Overview of design validation methodologies. Challenges and key considerations in prototyping and validation.

Unit-II **08 Hrs.**

Classification and Selection of Prototyping Techniques

Low-fidelity prototyping: sketching, wireframing, paper prototyping, storyboarding, card sorting. Mid-fidelity prototyping concepts. High-fidelity prototyping: interactive, functional, AR/VR-based, simulation, emulators. Digital/virtual vs. physical prototyping. Iterative and functional prototyping approaches. Prototype scale: full, half, quarter, desktop, micro, macro. Criteria for selecting appropriate prototyping techniques.

Unit-III **10 Hrs.**

Prototyping Technologies and Tools

Rapid prototyping technologies: 3D printing, CNC machining. Injection molding, vacuum casting. Laser cutting and engraving. Foam modeling and soft prototyping. Materials and tools for physical prototyping. Software tools: CAD modeling and simulation tools. Interactive mockup tools and code-based prototyping. Accessibility and inclusive design tools. Prototyping kits, templates, and cloud-based collaboration platforms.

Unit-IV **08 Hrs.**

Prototyping Planning, Development, and Iteration

Planning prototyping activities: goals, objectives, requirements, constraints. Concept generation and ideation techniques. Prototype design and development process. Prototype fabrication and implementation. Iterative design and refinement strategies. Finalizing design and communication of results. Documentation practices for prototyping.

Unit-V **08 Hrs.**

Design Validation, Testing, and Regulatory Compliance

Design validation testing: functionality, performance, usability, reliability. Qualitative and quantitative testing methods. User and stakeholder feedback integration. Laboratory testing vs. field testing. Regulatory requirements and standards (FDA, ISO, ASTM, etc.). Industry-specific compliance (automotive, aerospace, medical devices). Compliance testing: safety, environmental, EMC. Risk assessment and mitigation strategies. Impact of compliance on design and materials selection. Documentation, recordkeeping, and data management. Case studies on compliance and validation challenges.

Prototyping and Design Validation Laboratory (RCP23MLPE711)

Suggested Experiments/ Exercises/ Assignments

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1. Study the role of prototyping in the product design and development process.
2. Low-fidelity prototyping: sketching, wireframing, paper prototyping, storyboarding, and card sorting.
3. Mid-fidelity prototyping.
4. High-fidelity prototyping: interactive, functional, Augmented Reality (AR), Virtual Reality (VR), simulation and emulators, high-fidelity mockups.
5. Selecting the appropriate prototyping method and scale (Full-, half-, quarter-, desktop-, micro-, and macro-scale).
6. 3D printing/ CNC machining/ Injection molding/ Vacuum casting/ Laser cutting and engraving/ Foam modeling/ and Soft prototyping.
7. Prototyping software for 3D modeling and CAD/ Interactive mockup tools/ Code-based Prototyping/ Accessibility and inclusive design tools/ Prototyping kits and templates.
8. Cloud-based prototyping and collaboration platforms.
9. Prototyping materials and tools.
10. Study on the prototyping planning and execution process.
11. Study on the various regulatory compliance and standards (in a group of 3–4 students).
12. Types of compliance testing: safety, performance, environmental, electromagnetic compatibility (EMC), etc.

A minimum of eight experiments/ exercises/ assignments from the above-suggested list or any other experiments/exercises/assignments based on the syllabus will be included, which will help the learner apply the concepts learned.

Books Recommended

Textbooks

1 Bjarki Hallgrimsson, Prototyping and Modelmaking for Product Design, 2nd Edition, Quercus Publishing, 2023.

2 Chua, C. K. and Leong, K. F., Rapid Prototyping: Principles and Applications in Manufacturing, John Wiley and Sons Inc., 2003.

3 Noorani, R., Rapid Prototyping: Principles and Applications, John Wiley & Sons, Inc., New Jersey, 2006.

Reference Books

1 Todd Zaki Warfel, Prototyping: A Practitioner's Guide, Rosenfeld Media, 2009.

2 Louise Valentine, Prototype: Design and Craft in the 21st Century, Bloomsbury Publishing, 2013.

3 Karl T. Ulrich and Steven D. Eppinger, Product Design and Development, McGraw-Hill/Irwin, 2012.

Web References

1 Electronics Equipment Integration and Prototype Building
https://nptel.ac.in/courses/108108157

2 Physical Modelling for Electronics Enclosures using Rapid Prototyping
https://nptel.ac.in/courses/108108115

Program: Mechanical Engineering	Final Y. B.Tech.	Semester: VII/VIII
Creative Engineering Design (RCP23MCPE712)		
Creative Engineering Design Laboratory (RCP23MLPE712)		

Prerequisites:

1. No prerequisites required. However, the knowledge of the fundamentals of mechanical engineering can have an advantage.

Course Objectives:

1. To develop the ability to systematically identify and analyze customer needs for engineering product design.
2. To enable students to define engineering problems and translate requirements into measurable product specifications.
3. To enhance creative thinking skills for generating and evaluating multiple design concepts.
4. To impart knowledge of detailed design principles, including material selection, CAD modeling, and design for manufacturability.
5. To familiarize students with prototyping, testing, and validation techniques for improving design solutions.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Apply appropriate methods to identify, analyze, and prioritize customer requirements for engineering design problems.	L3	Apply
CO2	Analyze problem definition techniques to convert customer needs into structured engineering specifications.	L4	Analyze
CO3	Apply creative ideation and evaluation techniques to generate and select feasible design concepts.	L3	Apply
CO4	Apply detailed design principles, including material selection, CAD modeling, and DFMA, to develop engineering solutions.	L3	Apply
CO5	Apply prototyping, testing, and validation methods to evaluate and refine engineering design solutions.	L3	Apply

Creative Engineering Design (RCP23MCPE712)

Course Contents

Unit-I **08 Hrs.**

Customer Needs Analysis and Requirement Engineering

- Importance of identifying and analyzing customer needs and preferences.
- Types of customer requirements: functional, performance, usability, reliability, safety, regulatory, environmental, cost, aesthetics, ergonomics.
- Methods of gathering customer data: surveys, interviews, focus groups, observations, feedback, market research.
- Steps in capturing and structuring customer requirements.
- Techniques for prioritization: Pareto analysis, IPA, Kano model, AHP, decision matrix.
- Case studies on understanding customer requirements.

Unit-II **08 Hrs.**

Problem Definition and Product Specifications

- Role of problem definition in engineering design.
- Framing and structuring design problems.
- Product specifications: definition and importance.
- Steps for establishing target specifications.
- Translating customer requirements into engineering specifications.
- Setting final specifications and design targets.
- Case studies on requirement-to-specification transformation.

Unit-III **08 Hrs.**

Concept Generation, Creativity, and Selection

- Concept generation in product design and development.
- Creativity techniques: brainstorming, mind mapping, SCAMPER.
- Innovation and idea evaluation approaches.
- Methods for concept selection and screening.
- Evaluation criteria: feasibility, desirability, viability, alignment with user and business goals.
- Concept testing, iteration, and decision-making.
- Case studies on concept generation and selection.

Unit-IV **09 Hrs.**

Detailed Design and Embodiment Engineering

- Phases of detailed and embodiment design.
- Translation of concepts into detailed engineering designs.
- Material selection and manufacturing considerations.

- Design for Manufacturability and Assembly (DFMA).
- CAD modeling: parametric, feature-based, and assembly modeling.
- Design for reliability and maintainability.
- Modular design, standardization, and component reuse.
- Design simplification: minimizing part count and improving assembly.

Unit-V **09 Hrs.**

Prototyping, Testing, and Design Validation

- Importance of prototyping in design validation.
- Types of prototypes: low-, medium-, high-fidelity.
- Prototyping dimensions: physical, analytical, focused, comprehensive.
- Prototyping technologies: 3D printing, CNC machining, laser cutting, rapid prototyping.
- Planning and cost considerations in prototyping.
- Testing and validation: usability, functional, performance, reliability, environmental testing.
- Laboratory vs. field testing.
- Simulation-based validation: FEA, CFD, tolerance analysis.
- Compliance and regulatory testing.
- Design optimization (cost, size, reliability).
- Iterative refinement using testing feedback.
- Case studies on prototyping and validation.

Creative Engineering Design Laboratory (RCP23MLPE712)

Suggested Experiments/ Exercises/ Assignments/ Activities/ Discussions/ Case studies

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1. Customer requirements analysis: A case study.
2. Customer needs/requirements prioritization exercise.
3. Mock customer feedback session.
4. Problem framing and ideation.
5. Establishing target specifications exercise.
6. Creative design challenge.
7. Concept Selection Simulation.
8. Prototype Comparison and Evaluation.
9. Prototyping Case Study Analysis.
10. Study on the usability testing and iterative refinement.
11. Compliance Testing and Regulatory Compliance.

A minimum of six experiments/exercises/assignments/activities/discussions/case studies from the above-suggested list, or any other experiment/exercise based on the syllabus, will be included, which will help the learner apply the concepts learned.

Books Recommended

Textbooks

1 S. S. Thipse, *Cryogenics: A Textbook*, Alpha Science, 2012.

2 Beth Evans, Tom Bradshaw, and John Vandore, *Cryogenics*, IOP Publishing Ltd, 2022.

3 Mukhopadhyay Mamata, *Fundamentals of Cryogenic Engineering*, PHI Learning, 2018.

Books Recommended

Textbooks

1 Karl T. Ulrich and Steven D. Eppinger, Product Design and Development, McGraw Hill Education, 6th Edition, 2016.

2 C. Charyton, Creative Engineering Design Assessment: Background, Directions, Manual, Scoring Guide, and Uses, Springer London, 2013.

Reference Books

1 A. Chakrabarti, Engineering Design Synthesis: Understanding, Approaches and Tools, Springer, 2002.

2 K. Otto and K. Wood, Product Design, Prentice Hall, 2000.

3 T. Taura, Creative Design Engineering: Introduction to an Interdisciplinary Approach, Elsevier Science, 2016.

Web References

1 Creative Engineering Design https://nptel.ac.in/courses/107108010

2 Understanding Creativity and Creative Writing https://nptel.ac.in/courses/109101017

Program: Mechanical Engineering	Final Y. B.Tech.	Semester: VII/VIII
Cryogenics (RCP23MCPE713)		
Cryogenics Laboratory (RCP23MLPE713)		

Prerequisites:

1. Fundamentals of Thermodynamics
2. Fundamentals of Heat Transfer
3. Fundamentals of Refrigeration

Course Objectives:

1. To gain a comprehensive understanding of the principles and history of cryogenics, including the need and applications of cryogenic technology, and to provide knowledge on the properties of materials at low temperatures.
2. To learn about the unique properties of materials at cryogenic temperatures, such as strength, elasticity, thermal and electrical conductivity, and superconductivity.
3. To explore the principles and systems used for the liquefaction, refrigeration, and storage of cryogenic fluids.
4. To understand the health hazards associated with cryogenic systems and the safety practices required to mitigate these risks.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Explain the principles and history of cryogenics, including the need and applications of cryogenic technology, and describe the unique properties of materials at cryogenic temperatures.	L2	Understand
CO2	Apply knowledge of the properties and handling of various cryogenic fluids to practical scenarios and demonstrate the principles and systems used for the liquefaction of gases.	L3	Apply
CO3	Analyse different cryogenic refrigeration systems and their working principles and compare the requirements, types, and applications of cryocoolers, especially in space technology.	L4	Analyze
CO4	Evaluate the performance of different types of thermal insulation used at cryogenic temperatures and assess the methods and instruments used for measuring pressure, flow rate, liquid level, and temperature in cryogenic systems.	L5	Evaluate
CO5	Understand the design and development of cryogenic storage and transfer systems and safety practices to mitigate health hazards associated with cryogenic systems.	L2	Understand

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Creative Engineering Design (RCP23MCPE712)

Course Contents

Unit-I **08 Hrs.**

Introduction to Cryogenics and Cryogenic Material Properties

Introduction to Cryogenics: Need for Cryogenics, History of Cryogenics, Applications of Cryogenics.
Cryogenic Material Properties: Ultimate and Yield Strength, Fatigue Strength, Impact Strength, Elastic Moduli, Hardness and Ductility, Thermal Conductivity, Specific Heat of Solids, Specific Heat of Liquids and Gases, Coefficient of Thermal Expansion, Electrical Conductivity, Superconductivity, Theories of Superconductivity, Applications of Superconductivity.

Unit-II **08 Hrs.**

Cryogenic Fluids and Liquefaction Systems

Cryogenic Fluids: Properties of Cryogens (LN2, LO2, LH2, LHe, LCO2).
Liquefaction System: Ideal Liquefaction System, Joule-Thomson (J-T) Effect, Adiabatic Expansion in Turbine, Simple Linde-Hampson (L-H) System, Claude and Cascade System.

Unit-III **09 Hrs.**

Cryogenic Refrigeration Systems and Cryocoolers

Cryogenic Refrigeration Systems: Ideal Refrigeration System, Joule-Thomson (JT) Refrigeration, Phillips Refrigerator, Vuilleumier (VM) Refrigerator, Solvay Refrigerator, Gifford-McMahon (G-M) Refrigerator, Magnetic Cooling.
Cryocoolers: Cryocooler Requirements, Cryocooler vs Cryostat, Joule-Thomson (JT) Cryocooler, Brayton Cryocooler, Gifford-McMahon (G-M) Cryocooler, Pulse Tube Cryocooler, Stirling Cryocooler, Applications of Cryocoolers in Space.

Unit-IV **09 Hrs.**

Cryogenic Insulation and Instrumentation

Cryogenic Insulation: Thermal insulation and its performance at cryogenic temperatures, super insulation, vacuum insulation, powder insulation.
Cryogenic Instrumentation and Measurement: Pressure, flow rate, liquid level, and temperature measurements. Types of heat exchangers used in cryogenic systems (only descriptions), and cryo-pumping applications.

Unit-V **08 Hrs.**

Cryogenic Storage, Transfer Systems and Safety

Cryogenic Storage and Transfer Systems: Cryogenic storage or Dewar vessel, cryogenic industrial storage tanks, cryogenic storage in space, cryogenic piping, cryogenic transfer systems.
Safety for Cryogenic Systems: Cryogenic health hazards, personal safety in cryogenic plants, general safety practices for cryogenic plants.

Cryogenics Laboratory (RCP23MLPE713)

Suggested Experiments/ Exercises/ Assignments

A Study-Type/ Case-Study-based Experiments (Theoretical and Conceptual Learning):

1 Compare the thermal properties of cryogens LN_2, LO_2, LH_2, LHe, LCO_2 and study their real-world applications.

2 Study material properties of steel, aluminum and copper at cryogenic temperatures and propose their selection criteria for cryogenic applications.

3 Study Joule-Thomson effect and its role in gas liquefaction.

4 Compare Joule-Thomson, Linde-Hampson and Claude system.

5 Analyze Stirling, Gifford-McMohan and Pulse tube cryocoolers and their applications.

6 Study insulation methods used at cryogenic temperatures.

7 Analyze hazards and safety measures in cryogenic plants.

8 Study BCS Theory of superconductivity and its application in MRI machines, Maglev Train, and Quantum Computers.

9 Report on cryogenics Industry/Lab visit.

Books Recommended

Textbooks

1 S. S. Thipse, Cryogenics A Textbook, Alpha Science, 2012.

2 Beth Evans, Tom Bradshaw and John Vandore, Cryogenics, IOP Publishing Ltd, 2022.

3 Mukhopadhyay Mamata, Fundamentals of Cryogenic Engineering, PHI Learning, 2018.

Reference Books

1 Thomas M. Flynn, Cryogenic Engineering, Second Edition, Marcel Dekker, New York, 2005.

2 Randall F. Barron, Cryogenic Systems, Oxford University Press, 1985.

3 J. G. Weisend II, Handbook of Cryogenic Engineering, Taylor & Francis, 1998.

Web References

1 Cryogenic Engineering https://archive.nptel.ac.in/courses/112/101/112101004/

2 Cryogenic Hydrogen Technology https://nptel.ac.in/courses/112105422

Program: Mechanical Engineering	Final Y. B.Tech.	Semester: VII/VIII
Micro-Electromechanical Systems (RCP23MCPE714)		
Micro-Electromechanical Systems Laboratory (RCP23MLPE714)		

Prerequisites:

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Course Objectives:

1. Learn the evolution of MEMS, microsensors, and micro machines, and grasp the key concepts in both electrical and mechanical engineering that underpin MEMS technology.
2. Gain an in-depth understanding of the materials used in MEMS, as well as the various deposition, patterning, and micromachining techniques for fabrication.
3. Explore the wide range of MEMS devices, from sensors to energy harvesters, and understand the methods for bonding and packaging MEMS devices for integration into larger systems.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Explain the evolution of MEMS technology and its applications across various industries.	L2	Understand
CO2	Demonstrate understanding of scaling laws and their impact on miniaturization and performance in MEMS systems.	L3	Apply
CO3	Explain fabrication processes such as deposition, etching, micromachining, and the LIGA process used in MEMS device fabrication.	L2	Understand
CO4	Ability to design and analyse MEMS-based sensors, including mechanical, magnetic, thermal, and radiation sensors.	L4	Analyze
CO5	Acquire the skills to choose and apply proper bonding and packaging techniques for MEMS devices to ensure system functionality and reliability.	L3	Apply

Micro-Electromechanical Systems (RCP23MCPE714)

Course Contents

Unit-I **06 Hrs.**

Introduction to Micro Electro Mechanical System (MEMS)

Introduction to MEMS: Evolution of micro sensors, evolution of MEMS, emergence of micro machines, features in MEMS, benefits of MEMS, MEMS applications, clean rooms.
Semiconductor Substrate: Crystal structure, crystal defects, doping of semiconductors, Czochralski growth, wafer preparation, and specifications.
Review of Electrical and Mechanical Concepts: Conductivity and resistivity, stress and strain, flexural beam bending, mechanical vibration, overview of commonly used mechanical structures in MEMS—Beams, Cantilevers, Plates, Diaphragms.

Unit-II **09 Hrs.**

Scaling Law and MEMS Materials

Scaling laws in miniaturization—scaling in geometry, scaling in rigid body dynamics, Trimmer force scaling vector, scaling in electrostatic and electromagnetic forces, scaling in electricity and fluidic dynamics, scaling in heat conducting and heat convection.
MEMS Materials: Semiconductors, insulating materials, conductors, polymers (photoresist and adhesive), special materials: piezoelectric, piezoresistive, thermoelectric, shape memory alloy.

Unit-III **10 Hrs.**

Deposition and Patterning in MEMS and Micromachining

Deposition and Patterning in MEMS:
Epitaxy—classification, molecular beam epitaxy.
Silicon oxidation—oxidation process, kinetics of growth.
Etching—wet and dry etching.
Deposition—chemical vapor deposition, physical vapor deposition, diffusion and ion implantation.
Lithography—types of photoresists, photolithography.
Surface and Bulk Micromachining in MEMS:
Bulk micromachining, surface micromachining, and LIGA process.

Unit-IV **08 Hrs.**

MEMS Devices

Mechanical Sensors: MEMS pressure sensors, MEMS accelerometers, MEMS gyroscopes, MEMS energy harvesters, flow microsensors.
Magnetic Sensors: Magneto galvanic microsensors, magneto resistive devices.
Thermal and Radiation Sensors: Resistive temperature microsensors, micro thermocouples, thermodiodes and thermotransistors, photoconductive devices, photovoltaic devices, micro antenna.

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Unit-V **06 Hrs.**

Bonding Techniques and Microsystem Packaging

Bonding techniques for MEMS: surface bonding, anodic bonding, silicon-on-insulator, wire bonding, sealing—assembly of micro systems.
Microsystem Packaging: General considerations in packaging design—levels of microsystem packaging.

Micro-Electromechanical Systems Laboratory (RCP23MLPE714)

Suggested Experiments

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1 To simulate the thermal oxidation process for different conditions (e.g., oxidation type, orientation, time, temperature, thickness, etc.) and comment on the results obtained.

2 To simulate the diffusion of dopants in the silicon process for different conditions (e.g., source, time, temperature, concentration profile) and comment on the results obtained.

3 To study and simulate the photolithography process for pattern transfer and to analyze the effect of exposure and development on feature formation in photoresist layers.

4 To simulate the deflection behaviour of a MEMS cantilever beam under an applied load and to study the effect of beam dimensions and material properties on displacement.

5 To analyze the stress and displacement characteristics of a fixed-fixed MEMS beam under applied loading conditions and compare its mechanical response with that of a cantilever beam.

6 To determine the natural (resonant) frequency of a MEMS beam and to study the influence of geometrical parameters and material properties on its dynamic response.

7 To simulate a capacitive MEMS sensor and to study the variation in capacitance due to displacement of the sensing element under applied mechanical input.

8 To analyze the behavior of a parallel plate electrostatic actuator and to study the relationship between applied voltage, electrostatic force, and displacement, including pull-in instability.

9 To study the effect of temperature rise on the deformation of a MEMS beam due to thermal expansion and to analyze the relationship between temperature and induced displacement.

10 To simulate the working of a micro machined piezo resistive pressure sensor and to study the variation in electrical resistance with applied pressure due to induced mechanical stress.

11 To simulate a MEMS-based accelerometer and to analyze the displacement of the proof mass and corresponding electrical output under varying acceleration inputs.

12 To simulate the deflection behavior of a MEMS cantilever beam under applied load and to study the relationship between force, displacement, and material properties.

Books Recommended

Textbooks

1 Tai-Ran Hsu, MEMS and Microsystems Design and Manufacture, TMH, 2002.

2 Sorab K. Gandhi, VLSI Fabrication Principles, Wiley, Student Edition.

3 Mark Madou, Fundamentals of Micro Fabrication, CRC Press, New York, 1997.

Reference Books

1 N. Maluf and K. Williams, An Introduction to Micro-Electromechanical Systems Engineering, Artech House Inc., Second Edition.

2 G. S. May and S. M. Sze, Fundamentals of Semiconductor Fabrication, Wiley, First Edition.

3 Julian W. Gardner, V. K. Varadan, O. O. Awadelkarim, Microsensors, MEMS, and Smart Devices, John Wiley & Sons, 2001.

4 Thomas B. Jones, Electromechanics and MEMS, Cambridge University Press, 2001.

5 Stephen D. Senturia, Microsystem Design, Springer (India), 2006.

Program: Mechanical Engineering	Final Y. B.Tech.	Semester: VII/VIII
Vehicle Testing and Safety (RCP23MCPE715)		
Vehicle Testing and Safety Laboratory (RCP23MLPE715)		

Prerequisites:

1. Basics of automotive systems
2. Basics of engineering mechanics and materials
3. Basic electronics

Course Objectives:

1. To impart knowledge of vehicle level testing philosophies and validation processes.
2. To impart knowledge of safety principles in vehicle design, testing, and maintenance.
3. Interpret road accident data and safety metrics relevant to Indian conditions.
4. Relate vehicle ergonomics and maintenance to overall safety.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Explain vehicle safety standards, testing methodologies, and validation procedures used for evaluating automotive systems.	L2	Understand
CO2	Analyze the performance of vehicle systems under laboratory and real-world operating conditions using appropriate testing and validation techniques.	L4	Analyze
CO3	Analyze the influence of vehicle ergonomics and maintenance practices on vehicle safety, reliability, and occupant comfort.	L4	Analyze
CO4	Analyze road accident data, traffic safety measures, and traffic control systems to recommend appropriate road safety improvements.	L4	Analyze

Vehicle Testing and Safety (RCP23MCPE715)

Course Contents

Unit-I **09 Hrs.**

Vehicle - Level Testing & Regulations

Introduction to vehicle safety: active vs passive safety, crashworthiness and energy absorption. Crash mechanics, deformation and crumple zone types, occupant injury criteria, and biomechanics.
Role of testing agencies & regulatory bodies (ARAI, ICAT, GARC, CIRT), including battery electric vehicle (BEV) testing.
Introduction to New Car Assessment Program (NCAP), Global, Euro & Bharat NCAP assessment methods of safety features and technologies.

Unit-II **09 Hrs.**

Vehicle System - Level Testing & Performance

Overview of AIS, CMVR, SAE & ISO system-level standards.
Testing methodologies: Hardware-in-the-Loop, track testing, and on-road testing.
Brake testing: stopping distance, fade test, ABS vs. non-ABS comparisons.
Steering and handling: stability, cornering, and slalom test.
Suspension, ride comfort, and NVH testing, powertrain performance testing, HVAC system tests, environmental testing (temperature, dust, humidity).
BEV system tests and standards.

Unit-III **09 Hrs.**

Vehicle Ergonomics and NVH

Fundamentals of ergonomics in automotive design, driver visibility: field of vision, blind spots, mirror and camera systems, driver reach & control layout: steering, pedals, dashboard controls.
Seating design: posture, fatigue, long-drive comfort, whiplash injury prevention.
Human-machine interface (HMI): displays, alerts, distraction minimization, cognitive load & driver behavior, crash safety from the occupant perspective.
Introduction to types of automotive noises, source-path-receiver concept, noise limits and testing procedures for vehicles, acoustic source characteristics in ICE vehicles and EVs.
Vibration control, vibration isolators, passive and active engine mounts, crankshaft damping, and active vibration control.

Unit-IV **08 Hrs.**

Vehicle Maintenance & Workshop Safety

Workshop layout & hazard identification, personal protective equipment (PPE).
Safe handling of tools & machinery: lifts, jacks, torque tools.
Electrical safety in EVs: high-voltage systems, battery thermal runaway metrics.
Fire safety: fuel systems, battery fires.
Chemical safety: oils, coolants, brake fluids.
Preventive maintenance & inspection protocols, lockout/tagout (LOTO) procedures.
Waste disposal & environmental compliance.

Unit-V **07 Hrs.**

Road Safety Engineering

Accident causation theories, road accident statistics and analysis, road design factors affecting safety. Traffic engineering basics, safety features: signage, barriers, signals.
Intelligent Transportation Systems (ITS), role of agencies like the Ministry of Road Transport and Highways, pedestrian safety and accessibility.

Vehicle Testing and Safety Laboratory (RCP23MLPE815)

Suggested Experiments

A Case Study based:

1 Identify and illustrate B-NCAP metrics and compare ratings for any 3 vehicles.
2 Case study: ABS sensor failure and root cause analysis
3 Case study: Vehicle failure modes in endurance testing
4 Case study: Traffic flow management methods

B Simulation based:

1 Simulation of braking distance vs. speed on MATLAB Simulink Software
2 Crash impact analysis of different deformation zone designs on ANSYS / Solidworks
3 Data analysis and visualization of vehicle parameters using an OBD scan tool

C Performance based:

1 Ergonomic evaluation of a passenger vehicle cabin
2 Investigation of vibration in a light motor vehicle in dynamic conditions.
3 Experimental brake test data acquisition and analysis
4 Experimental determination of volumetric efficiency of any engine
5 Experimental investigations on an automotive HVAC system
6 Field visit to an automotive service station / Workshop risk assessment audit

A minimum of 8 experiments from the above-suggested list or any other experiment based on the syllabus will be included, helping the learner apply the concept.

Books Recommended

Reference Books

1 Raymond M. Brach and R. Matthew Brach, Vehicle Accident Analysis and Reconstruction Methods, SAE International, 2011.

2 J. G. Giles, Vehicle Operation and Performance, Wildlife Publications, London, 1969.

3 W. H. Crouse and L. Anglin, Motor Vehicle Inspection, McGraw Hill Book Co., 1978.

4 Ulrich Seiffert and Lothar Wech, Automotive Safety Handbook, SAE International, 2007.

Web References

1 AIS Standards.

2 NCAP Test Standards.

3 ARAI, ICAT and NATRIP Vehicle Standards.

Program: Mechanical Engineering	Final Y. B.Tech.	Semester: VII/VIII
Bionics Engineering (RCP23MCPE716)		
Bionics Engineering Laboratory (RCP23MLPE716)		

Prerequisites:

1. Fundamentals of Mechanical Engineering.
2. Fundamentals of Design, Manufacturing, Assembly.
3. Biological Concepts
4. Sensors and Instrumentation
5. Robotics Fundamentals

Course Objectives:

1. To introduce the fundamental concepts of bionics and biomimetics and bio-inspired design methodologies.
2. To develop an understanding of bio-inspired materials, their properties, and emerging technologies for sustainable design.
3. To provide knowledge of bio-inspired sensors and their role in robotics, healthcare, and environmental monitoring.
4. To familiarize students with bio-inspired manufacturing and fabrication techniques, including micro and nano-fabrication methods.
5. To explore bio-inspired motion and robotics systems and their applications across various engineering domains.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Explain the principles of bio-inspired design and biomimetics and their role in solving engineering problems.	L2	Understand
CO2	Evaluate bio-inspired and smart materials based on their properties, performance, and applications in sustainable engineering.	L5	Evaluate
CO3	Analyze the working principles, classifications, and applications of bio-inspired sensors in engineering systems.	L4	Analyze
CO4	Apply bio-inspired manufacturing and fabrication techniques to develop sustainable engineering solutions.	L3	Apply
CO5	Design bio-inspired robotic systems and motion mechanisms for engineering applications in aerospace, biomedical, and energy sectors.	L6	Create

Bionics Engineering (RCP23MCPE716)

Course Contents

Unit-I **09 Hrs.**

Bio-Inspired Design

Introduction to Bionics & Biomimetics, scope, importance of bionics in engineering, historical background and key advancements, nature-inspired design principles, fundamentals of bio-inspired design, biomimetic design methodology, structural and functional adaptations in nature, computational approaches in bio-inspired design, case studies on bio-inspired mechanical systems.

Unit-II **09 Hrs.**

Bio-Inspired Materials

Introduction, Types of Materials (Structure, functional), mechanical properties, smart materials like self-healing, shape memory, micro and nano-materials and their applications, composite materials like Bone (collagen + hydroxyapatite) and Shells (nacre structure), sustainable & green biomaterials—biopolymers, biodegradable plastics and circular materials. Advanced & Emerging Technologies like AI in Material Design, Protein-based Materials, Biohybrid Systems, Necrobotics and Edible Electronics.

Unit-III **08 Hrs.**

Bio-Inspired Sensors

Introduction, biological sensors—Vision (eyes), Touch (skin), Hearing (ears), Smell & Taste, classification of bionic sensors—Bioelectric Signal Sensors: Heart, Brain, Muscle; Molecular Sensors: Enzyme-based, DNA, Immuno; Biomechanical Sensors: Piezoresistive, Capacitive, Piezoelectric; Multimodal Integrated Sensors (Pressure + Temperature, Chemical + Electrical, Motion + Humidity), key applications like Prosthetics & Robotics, Electronic Skin, Tactile Sensing, Health Monitoring, Environmental Sensing, etc., and their features: high sensitivity, selectivity, adaptability, low energy consumption.

Unit-IV **08 Hrs.**

Bio-Inspired Manufacturing & Fabrication

Introduction, fabrication techniques: top-down and bottom-up approach; self-assembly, 3D printing, electrospinning, biomineralization, micro-fabrication techniques—photolithography, soft lithography, micro-moulding, nano-fabrication techniques: electron beam lithography, nanoimprinting, atomic layer deposition, hybrid fabrication techniques: lithography + self-assembly, 3D printing + electrospinning, sustainable and green manufacturing approaches inspired by nature.

Unit-V **08 Hrs.**

Bio-Inspired Motion & Robotics

Locomotion principles in biological systems, bio-inspired robotic mechanisms: insect-inspired robots, snake robots, fluid dynamics in natural locomotion—fish, birds, energy-efficient motion strategies from nature.

Applications of Bionics in Engineering: Aerospace: Bio-inspired wings, drag reduction techniques; Automotive: Nature-inspired aerodynamics and materials; Biomedical: Prosthetics, exoskeletons, and tissue engineering; Renewable Energy: Bio-inspired energy harvesting devices like solar panels, wind turbines, etc.

Bionics Engineering Laboratory (RCP23MLPE716)

Suggested Experiments

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1 Experimental Investigation of Hydrophobic/Drag-Reduction Using Micro-Textured Coatings/Structure Using Metallurgical Microscope.

2 Comparative Load-Bearing Analysis of Honeycomb and Solid Structures Using Physical Compression Testing.

3 Experimental Study of Aerodynamic Drag Reduction Using Bio-Inspired Nose Shapes in a Simulated Airflow Setup through Simulation Software/Wind Tunnel.

4 Design and Experimental Evaluation of a Pneumatically Actuated Soft Robotic Gripper Inspired by Octopus Arms.

5 Experimental Analysis of Light Absorption Enhancement Using Biomimetic Surface Textures for Solar Applications.

6 Comparative Experimental Study of Locomotion Efficiency in Snake-Inspired and Legged Robotic Models.

7 Field Experimental Investigation of Termite Mound Cooling Mechanism Using a Laser-Based Temperature Measuring Device.

8 Experimental Study of Dry Adhesion Mechanisms Using Gecko-Inspired Surface Materials.

9 Hardware-Centric Integration: Providing proprietary MMG sensors and the Grippy bionic hand to teach direct mechatronic control and signal acquisition.

10 Software and Telemetry Integration: Utilizing the Brawn Band wearable device and cloud backend, so students can design and analyze closed-loop gamified rehabilitation software.

11 Comprehensive Ecosystem Adoption: A full-stack deployment combining the hardware and telemetry pipelines, serving as a robust foundation for final-year capstone projects.

12 Case Study Presentation on Biomimetic Innovations.

A minimum of eight experiments from the above-suggested list or any other experiment based on the syllabus will be included, helping the learner apply the concept.

Books Recommended

Textbooks

1 Yoseph Bar-Cohen, Biomimetics: Nature-Based Innovation, CRC Press, 2011.

2 Wole Soboyejo and Leo Daniel, Bioinspired Structures and Design: Butterfly Wings, Lotus Leaves, and Other Natural Wonders, Cambridge University Press, 2018.

3 Janine M. Benyus, Biomimicry: Innovation Inspired by Nature, Harper Perennial, 2002.

4 Junzhi Yu, Bioinspired Robotics: Mechanisms and Control, Elsevier, 2022.

5 Nathan F. Lepora, Anna Mura, and Tony J. Prescott (Eds.), Biomimetic and Biohybrid Systems, Springer, 2013.

Reference Books

1 Alicia Kim, Bioinspired Engineering, Wiley, 2021.

Web References

1 https://onlinecourses.nptel.ac.in/noc22_ge24/preview

2 https://www.youtube.com/watch?v=ksk4ScMz1io

3 https://www.youtube.com/watch?v=2gn8i3lepIM

4 https://www.youtube.com/channel/UCIXuV51iFsvyiZta2zp7TzQ

Program: Mechanical Engineering	Final Y. B.Tech.	Semester: VII/VIII
Big Data Analytics (RCP23MCPE717)		
Big Data Analytics Laboratory (RCP23MLPE717)		

Prerequisites:

1. Basic knowledge of Engineering Mathematics (linear algebra, calculus, optimization concepts)
2. Fundamentals of Probability and Statistics
3. Introductory understanding of Programming (Python/MATLAB)
4. Basic concepts of Artificial Intelligence / Data Analytics

Course Objectives:

1. To understand the architecture and components of big data systems for engineering applications
2. To develop knowledge of distributed storage and data management techniques for large-scale datasets
3. To apply big data processing frameworks for handling industrial and sensor-generated data
4. To analyze mechanical engineering systems using big data-driven approaches
5. To interpret and visualize large datasets for informed engineering decision-making

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Explain big data concepts, architecture, and distributed computing frameworks used in engineering systems	L2	Understand
CO2	Apply distributed storage and NoSQL database techniques for managing large-scale engineering data	L3	Apply
CO3	Implement big data processing frameworks (e.g., Hadoop/Spark) for batch and real-time data analysis	L3	Apply
CO4	Analyze industrial and mechanical system data using big data techniques for applications such as predictive maintenance and system monitoring	L4	Analyze
CO5	Develop data visualization solutions and interpret big data insights for engineering decision-making and optimization	L6	Create

Big Data Analytics (22PEME7046T)

Course Contents

Unit-I **08 Hrs.**

Big Data Fundamentals and Architecture

- Introduction to Big Data: Characteristics (5V/7V), limitations of conventional data systems.
- Types of engineering data: structured, semi-structured, unstructured.
- Big data sources in mechanical engineering: Sensors, IoT devices, SCADA systems; Manufacturing and maintenance data.
- Big data architecture: Data ingestion layer, storage layer, processing layer, visualization layer.
- Distributed computing concepts: Cluster computing, parallel processing, fault tolerance.
- Introduction to Hadoop ecosystem: HDFS architecture (NameNode, DataNode); MapReduce paradigm (conceptual, no overlap with programming basics).

Unit-II **08 Hrs.**

Big Data Storage and Management Systems

- Distributed file systems: HDFS working and data replication.
- NoSQL databases: Key-value stores (Redis); Document databases (MongoDB); Column-family (HBase); Graph databases.
- Data modeling for big data systems.
- Data partitioning and replication strategies.
- Data warehousing vs. Data lakes (engineering perspective).
- Introduction to cloud storage platforms (AWS S3, Azure Data Lake).
- Data governance, security, and privacy in industrial environments.

Unit-III **10 Hrs.**

Big Data Processing Frameworks

- Limitations of MapReduce and need for advanced frameworks.
- Apache Spark architecture: RDD, DataFrames, DAG execution.
- Spark ecosystem: Spark SQL; Spark Streaming; MLlib (overview only, no ML overlap).
- Real-time vs. batch processing.
- Stream processing frameworks: Apache Kafka (basics); Apache Flink (overview).
- Workflow scheduling: Apache Airflow (introductory).

Unit-IV **08 Hrs.**

Big Data Analytics in Mechanical Engineering Systems

- Industrial IoT (IIoT) data analytics.
- Predictive maintenance using large-scale sensor data (conceptual, not ML-heavy).
- Digital twin integration with big data.
- Time-series data analytics for mechanical systems.

- Fault detection and diagnostics using big data pipelines.
- Applications and case studies.

Unit-V **08 Hrs.**

Advanced Big Data Applications and Visualization

- Data visualization for big data: Dashboards (Tableau, Power BI); Engineering visualization (trend plots, anomaly visualization).
- Big data analytics lifecycle: ingestion → storage → processing → insights.
- Edge computing and fog computing in mechanical systems.
- Integration with AI/ML (only system-level, no algorithm overlap).
- Case studies: Smart manufacturing (Industry 4.0); Supply chain analytics in mechanical industries; Reliability and lifecycle analytics.
- Challenges and future trends: Scalability; Data quality issues; Ethical considerations.

Big Data Analytics Laboratory (RCP23MLPE717)

Suggested Experiments

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1. Perform data ingestion and preprocessing on large-scale engineering datasets.
2. Implement distributed file storage for mechanical system data.
3. Analyze large sensor datasets from rotating machinery.
4. Perform batch processing of manufacturing data using distributed frameworks.
5. Implement real-time data streaming for industrial monitoring systems.
6. Analyze time-series data from mechanical components for trend identification.
7. Perform fault detection analysis using large-scale equipment data.
8. Develop data pipelines for predictive maintenance applications.
9. Analyze energy consumption data of mechanical systems at scale.
10. Perform clustering analysis on large manufacturing datasets.
11. Analyze vibration data from mechanical systems using big data tools.
12. Perform anomaly detection in industrial process data.
13. Develop dashboards for the visualization of large-scale engineering datasets.
14. Analyze lifecycle data of mechanical components for reliability assessment.
15. Process and analyze thermal system data at a large scale.
16. Perform supply chain data analysis for the mechanical industries.
17. Analyze the performance data of electric vehicles using big data techniques.
18. Develop a big data model for the condition monitoring of equipment.
19. Integrate IoT data with big data frameworks for mechanical systems.
20. Perform comparative analysis of multiple engineering datasets for decision-making.

A minimum of eight experiments from the above-suggested list or any other experiment based on the syllabus will be included, helping the learner apply the concept.

Books Recommended

Textbooks

1 M. Thangaraj, S. Suguna, and G. Sudha, Big Data Analytics: Concepts, Techniques, Tools and Technologies, PHI Learning Pvt. Ltd., 2022.

2 B. L. S. Prakasa Rao, S. B. Rao, and Saumyadipta Pyne, Big Data Analytics: Methods and Applications, Springer India, 2016.

3 EMC Education Services, Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data, Wiley, 2014.

4 David Loshin, Big Data Analytics: From Strategic Planning to Enterprise Integration with Tools, Techniques, NoSQL, and Graph, Morgan Kaufmann, 2013.

Reference Books

1 Edward L. Robinson, Data Analysis for Scientists and Engineers, Princeton University Press, 2016.

2 Parikshit N. Mahalle, Pravin P. Hujare, and Gitanjali Rahul Shinde, Predictive Analytics for Mechanical Engineering: A Beginners Guide, Springer Nature Singapore, 2023.

3 Venkat Ankam, Big Data Analytics, Packt Publishing, 2016.

4 Dina Darwish, Big Data Analytics Techniques for Market Intelligence, IGI Global, 2023.

5 Francesco Corea, Big Data Analytics: A Management Perspective, Springer International Publishing, 2016.

6 Mohammed Guller, Big Data Analytics with Spark: A Practitioner's Guide to Using Spark for Large Scale Data Analysis, Apress, 2015.

Web References

1 Algorithms for Big Data
https://nptel.ac.in/courses/106106142

2 Big Data Computing
https://nptel.ac.in/courses/106104189

Program: Mechanical Engineering	Final Y. B.Tech.	Semester: VII/VIII
Startup Sustainability and Scalability (RCP23MCPE718)		
Startup Sustainability and Scalability Laboratory (RCP23MLPE718)		

Prerequisites:

1. Fundamentals of Business Development
2. Entrepreneurial Business Models
3. Startup Registration and Development

Course Objectives:

1. To understand the concepts of sustainability and scalability in the context of startups with focus on engineering ventures.
2. To equip learners with strategies for achieving long-term sustainable growth while scaling operations.
3. To develop skills for scaling teams, supply chains, and market reach without compromising quality, values or environmental impact.
4. To integrate environmental, social, and economic sustainability into core startup strategies and decision making.
5. To analyze risks, build resilience and prepare financially healthy scaling plans for technology and mechanical engineering-based startups.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Differentiate sustainability and scalability concepts in the context of engineering startups.	L2	Understand
CO2	Design and implement sustainable business practices tailored to engineering and hardware-driven ventures.	L6	Create
CO3	Develop scalable operations, supply chains, team structures, and funding strategies.	L6	Create
CO4	Evaluate sustainability, scalability, and business risks using key performance metrics and risk management tools.	L5	Evaluate
CO5	Create a comprehensive sustainability and scalability roadmap for a mechanical engineering startup.	L6	Create

Startup Sustainability and Scalability (RCP23MCPE718)

Course Contents

Unit-I **08 Hrs.**

Introduction to Sustainability and Scalability

Concepts of sustainability including economic, social and environmental aspects known as Triple Bottom Line. Difference between scalability and sustainable growth. Importance of both concepts for engineering and technology startups. Case studies highlighting sustainable versus non-sustainable scaling approaches in startups.

Unit-II **08 Hrs.**

Sustainable Business Models and Operations

Integrating sustainability into the core business model. Application of circular economy principles for manufacturing and hardware startups. Green supply chain management and sustainable sourcing practices. Implementation of ESG framework in day-to-day operations.

Unit-III **08 Hrs.**

Scaling Strategies and Operations

Types of scaling including horizontal, vertical and geographic expansion. Building scalable processes, technology infrastructure and automation systems. Team scaling approaches and maintaining organizational culture. Technology leverage and automation specifically useful for mechanical and engineering startups.

Unit-IV **08 Hrs.**

Financial Sustainability and Funding for Scale

Understanding unit economics and path to profitability at scale. Financial modeling techniques for scaling phase. Methods of raising growth capital such as Series A/B, private equity and strategic investors. Trade-offs between bootstrapping and aggressive scaling strategies.

Unit-V **10 Hrs.**

Risk Management, Resilience, Adaptation and Long-term Impact

Identifying scalability risks, bottlenecks and crisis management techniques. Building resilient systems and ensuring regulatory compliance during scaling. Adaptive strategies in rapidly changing markets and technologies. Key performance indicators for measuring sustainability and scalability. Impact measurement tools, continuous innovation and final project on sustainability and scalability roadmap presentation along with course review.

Startup Sustainability and Scalability Laboratory (RCP23MLPE718)

Exercise Title

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1. Sustainability Audit of a Startup: Analyse an existing startup (or your own idea) on environmental, social, and economic parameters. Identify gaps and propose improvements.
2. Scalable Business Model Redesign: Redesign the Business Model Canvas for a mechanical/engineering-based startup to scale (including automation, outsourcing, or platform elements).
3. Supply Chain and Operations Scaling Plan: Develop a scalable supply chain and operations strategy with focus on sustainability (e.g., for a product involving manufacturing, automotive component, or energy device).
4. Financial Projections for Scaling: Create multi-year financial models showing unit economics, break-even at scale, and capital requirements.
5. Risk Assessment and Mitigation Roadmap: Identify key risks during scaling and prepare contingency plans with resilience strategies.
6. ESG Integration and Impact Measurement: Design ESG metrics and an impact dashboard for the startup.
7. Team and Culture Scaling Exercise: Develop a hiring and culture plan for scaling from 10 to 100+ team members.
8. Final Project: Comprehensive Sustainability and Scalability Plan: Prepare and present a detailed roadmap for a chosen startup idea, including implementation timeline and metrics.

Books Recommended

Textbooks

1 Alexander Osterwalder and Yves Pigneur, Business Model Generation / Value Proposition Design.

2 Eric Ries, The Lean Startup / The Startup Way.

3 Reid Hoffman and Chris Yeh, Blitzscaling.

4 Peter Thiel, Zero to One.

5 John Elkington, Green Swans: The Coming Boom in Regenerative Capitalism.

6 Stuart L. Hart, Capitalism at the Crossroads.

7 World Economic Forum Reports on Sustainable Growth, NITI Aayog Documents on Sustainable Development.

Web References

1 Resources, Environment and Sustainability
https://www.sciencedirect.com/journal/resources-environment-and-sustainability

2 Innovation and Green Development
https://www.sciencedirect.com/journal/innovation-and-green-development

3 Journal of Cleaner Production
https://www.sciencedirect.com/journal/journal-of-cleaner-production

Program: Mechanical Engineering	Final Y. B.Tech.	Semester: VII/VIII
Process Equipment Design (RCP23MCPE721)		
Process Equipment Design Laboratory (RCP23MLPE721)		

Prerequisites:

1. Fundamentals of Mechanics of Materials
2. Fundamentals of Thermodynamics and Heat Transfer
3. Fundamentals of Fluid Mechanics
4. Fundamentals of Material Properties and Corrosion
5. Fundamentals of Machine Design concepts
6. Familiarity with CAD software

Course Objectives:

1. To introduce fundamental process design principles, optimization methods, and the application of design codes and standards.
2. To enable students to design reaction vessels and their components.
3. To enable students to design storage tanks.
4. To enable students to design shell-and-tube heat exchangers.
5. To build competence in the mechanical design of distillation columns.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Apply process equipment design principles, optimization techniques, and relevant engineering design codes and standards (IS, ASME, TEMA, API, BS) in the design of process equipment.	L3	Apply
CO2	Design reaction vessels by selecting suitable agitators, jackets, sealing systems, and pressure-retaining components based on process requirements.	L6	Create
CO3	Design storage tanks, including shells, heads, roofs, bottom plates, and supporting structures, in accordance with applicable design standards.	L6	Create
CO4	Analyze process requirements and design shell-and-tube heat exchangers and their major components in accordance with TEMA standards.	L4	Analyze
CO5	Analyze process requirements and design distillation columns, tray supports, packing supports, and associated structural components using relevant design standards.	L4	Analyze

Mechanical Department R.C.P.I.T. OFFICE SEAL SHIRPUR

Process Equipment Design (RCP23MCPE721)

Course Contents

Unit-I **06 Hrs.**

Process equipment design fundamentals

Basic concepts in process design, Block diagrams for flow of processes, Material flow balance, Design pressures & temperatures, Design stresses, Factory of safety, Minimum shell thickness and corrosion allowance, Weld joints efficiency, Design loading, Stress concentration and thermal stresses, Failure criteria, Optimization technique such as Lagrange's multiplier and golden section method, Cost and profitability estimation. Introduction to design codes like IS-2825, ASME-SECT, EIGHT-DIV-II TEMA.API-650, BS-1500 & 1515.

Unit-II **10 Hrs.**

Mechanical design of Reaction Vessel

Mechanical design of shell, head, Jacket, coil, agitator, nozzle, body flange, etc., Different types of agitators & their selection criteria, Different types of agitator shaft sealing system & their selection criteria, Different types of power transmission system, Determination of power required for agitation, shaft diameter, blade thickness, etc., Different types of jackets & their selection criteria.

Unit-III **08 Hrs.**

Mechanical design of Storage Tank

Classification of storage tank as per IS-803, Determination of storage tank capacity, diameter & height, Design of shell and bottom plate for storage tank, Design of conical roof, Selection of column, girders and rafters, roof curb angle and floating roof.

Unit-IV **08 Hrs.**

Mechanical design of Shell & Tube Heat Exchanger

Mechanical design of shell, tube, tube sheet, head, channel shell, etc. of shell & tube heat exchanger.

Unit-V **10Hrs.**

Mechanical design of Vertical Tall Tower (Distillation Column)

Mechanical design of shell, head, tray support, nozzle, body flange for vertical tall tower, Determination of shell thicknesses at various heights for tray tower & packed tower in case of internal & external pressure, Different types of tray supports & their selection criteria, Design of horizontal structural member with periphery ring type packing support.

Process Equipment Design Laboratory (RCP23MCPE721)

Experimental Title

A Following assignments are to be solved in the lab sessions in the form of tutorial or any software-based exercises (Minimum six):

1. Fundamentals of Process Equipment Design – Design Codes, Stress Analysis, and Optimization
2. Influence of Pressure, Temperature, and Safety Factors on Equipment Design
3. Mechanical Design of Reaction Vessel – Shell, Head, and Nozzle
4. Mechanical Design of Reaction Vessel – Jacket, Agitator, and Power Requirement
5. Design of Storage Tank
6. Design of Shell & Tube Heat Exchanger
7. Design of Distillation Column
8. Design of Piping & Fittings

B Prepare a layout for the following using any CAD software (Minimum two):

1. Layout of Reaction Vessel with Jacket & Agitator of Storage Tank with Roof & Supports of Shell & Tube Heat Exchanger of Vertical Tall Tower with Tray Supports

A minimum of 8 experiments from the above-suggested list or any other experiment based on the syllabus will be included, helping the learner apply the concept.

Books Recommended

Textbooks

1. V. V. Mahajani, Joshi's Process Equipment Design, Macmillan Publishers India Ltd., New Delhi, 2009.
2. B. C. Bhattacharya, Introduction to Chemical Equipment Design (Mechanical Aspects), CBS Publishers & Distributors, New Delhi, 2020.

Reference Books

1. Bureau of Indian Standards, Code for Unfired Pressure Vessels (IS: 2825), BIS, New Delhi, 1969.
2. D. R. Moss and M. M. Basic, Pressure Vessel Design Manual, Elsevier Butterworth-Heinemann, Oxford, 2013.
3. E. F. Megyesy, Pressure Vessel Handbook, Pressure Vessel Publishing, Tulsa, 2008.
4. L. E. Brownell and E. H. Young, Process Equipment Design, John Wiley & Sons, New York.

Web References

1. Process Equipment Design
https://nptel.ac.in/courses/103107207
2. Principles and Practices of Process Equipment and Plant Design
https://onlinecourses.nptel.ac.in/noc21_ch52/preview
3. Equipment Design: Mechanical Aspects
https://onlinecourses.nptel.ac.in/noc20_ch17/preview

Program: Mechanical Engineering	Final Y. B.Tech.	Semester: VII/VIII
Computational Fluid Dynamics (RCP23MCPE722)		
Computational Fluid Dynamics Laboratory (RCP23MLPE722)		

Prerequisites:

1. Fundamentals of Engineering Mechanics and Applied Mathematics
2. Fundamentals of Fluid Mechanics
3. Fundamentals of Heat Transfer

Course Objectives:

1. To introduce the fundamental concepts, scope, and applications of Computational Fluid Dynamics (CFD)
2. To develop understanding of governing equations and mathematical classification of fluid flow problems
3. To impart knowledge of numerical discretizations techniques with emphasis on the finite volume method
4. To analyze convection–diffusion and heat transfer problems using appropriate numerical schemes
5. To understand and apply pressure–velocity coupling algorithms for solving fluid flow problems.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Explain the fundamental concepts of Computational Fluid Dynamics (CFD), governing equations, solution methodology, grid generation, and discretization techniques.	L2	Understand
CO2	Analyze governing equations of fluid flow and heat transfer, classify partial differential equations based on mathematical characteristics and boundary conditions, and interpret turbulence modeling concepts.	L4	Analyze
CO3	Apply the Finite Volume Method (FVM) to solve one-dimensional and two-dimensional steady and unsteady diffusion and heat conduction problems.	L3	Apply
CO4	Evaluate discretization schemes for convection–diffusion problems based on stability, accuracy, boundedness, transportiveness, and numerical diffusion.	L5	Evaluate
CO5	Apply pressure–velocity coupling algorithms such as SIMPLE, SIMPLEC, and SIMPLER to solve steady incompressible fluid flow problems.	L3	Apply

Computational Fluid Dynamics (RCP23MCPE722)

Course Contents

Unit-I **05 Hrs.**

Introduction to Computational Fluid Dynamics (CFD)

- Computational Fluid Dynamics: What, When and Why?
- Scope and applications of CFD.
- Advantages and Limitations of CFD.
- Methods of predictions like experimental, numerical and theoretical.
- CFD Solution Methodology: Steps involved in CFD analysis, computational domain and grid generation, types of grids, grid quality and grid independence.
- Fundamentals of Discretization: An overview of finite difference, finite element, and finite volume methods (FDM/FEM/FVM).
- Introduction to open source/commercial CFD tool: Working in commercial CFD software (Pre-processor, Solver, Post-processor).

Unit-II **12 Hrs.**

Governing Equations and Mathematical Modeling of Fluid Flow

- Fundamental Principles of Conservation.
- Conservation of mass: Continuity Equation.
- Conservation of linear momentum: Navier-Stokes Equation.
- Conservation of Energy: Energy Equation.
- General Scalar Transport Equation: Conservative and non-conservative forms of the equations, discussion of physical meanings and significance.
- Mathematical nature of PDEs and flow equations.
- Classification of PDEs and pertinent physical behaviour, parabolic, elliptic and hyperbolic equations, role of characteristics.
- Possible types of boundary conditions, essential and natural boundary conditions, well-posed Boundary Value Problem.
- Introduction to Turbulence Modeling: The Time-Averaged Equations for Turbulent Flow, Turbulence Models.
- Discrete Element Method (DEM) fundamentals: Introduction to CFD-DEM coupling.

Unit-III **09 Hrs.**

Finite Volume Method for Diffusion Problems and Numerical Solution Techniques

- Finite Volume discretization of one-dimensional steady-state diffusion.
- Interface Conductivity.
- Non-linearity and Source-term linearization.
- Finite Volume discretization of one-dimensional unsteady-state heat conduction (Explicit scheme, The Fully Implicit scheme).
- Introduction to multi-dimensional diffusion problems (2D and 3D situations).

- Direct solution methods for linear algebraic equation systems, with emphasis on the Tri-Diagonal Matrix Algorithm (TDMA) for tridiagonal matrices.
- Overrelaxation and Underrelaxation.

Unit-IV **08 Hrs.**

Finite Volume Method for Convection-Diffusion Problems

- The Central Differencing Scheme (CDS).
- The Upwind Differencing Scheme (UDS).
- False Diffusion: The common view, The proper view.
- The Hybrid Differencing Scheme.
- Quadratic Upwind Interpolation for Convective Kinetics (QUICK) Scheme.
- Properties of discretization schemes (Conservativeness, Boundedness, Transportiveness).
- Comparative assessment of schemes (CDS vs UDS vs QUICK vs Hybrid).

Unit-V **08 Hrs.**

Solution Algorithms for Pressure-Velocity Coupling in Steady Incompressible Flows

- Need for Pressure-Velocity coupling.
- Difficulties in Incompressible flow solution.
- The Staggered grid.
- Pressure and Velocity corrections.
- The SIMPLE algorithm.
- The SIMPLER algorithm.
- The SIMPLEC algorithm.
- Convergence criteria and role of under-relaxation.

Computational Fluid Dynamics Laboratory (22PEME7035L)

Suggested Experiments

A Simulation using CFD software (ANSYS Workbench) :

1 Grid Independence study of Laminar fully developed flow in pipes
2 Investigation of flow mixing in a pipe elbow under steady incompressible turbulent flow
3 Compressible flow through a nozzle
4 Thermal analysis of a double pipe counter flow heat exchanger under steady state conditions
5 Turbulent flow over an aerofoil at different angles of attack
6 Heat transfer analysis in a solar flat plate collector
7 Simulation of the motion of a single spherical particle released in a stationary fluid domain under gravity using CFD–DEM coupling

B Numerical Analysis (Implementation using Python/MATLAB/C++/C):

1 Develop and implement a computational program to classify second-order partial differential equations based on their coefficients and to determine their mathematical nature as elliptic, parabolic, or hyperbolic
2 Develop and implement the Tri-Diagonal Matrix Algorithm (TDMA) for efficiently solving systems of linear algebraic equations arising from the discretization of one-dimensional transport equations
3 Develop and implement a numerical solver for the one-dimensional steady convection–diffusion equation using the finite volume method, employing the QUICK scheme for accurate discretization of convective fluxes
4 Develop a numerical solver for analyzing one-dimensional unsteady-state heat conduction using an explicit finite volume scheme
5 Develop a numerical solver for analyzing one-dimensional unsteady-state heat conduction using an implicit finite volume scheme
6 Develop and implement a numerical solver employing the SIMPLE algorithm for pressure–velocity coupling to simulate one-dimensional incompressible flow through a porous medium using the finite volume method

A minimum of eight experiments from the above-suggested list or any other experiment based on the syllabus will be included, which would help the learner to apply the concept.

Books Recommended

Textbooks

1 S. Versteeg and W. Malalasekera, An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Pearson Education, London, 2020.

2 S. V. Patankar, Numerical Heat Transfer and Fluid Flow, CRC Press, Boca Raton, 2021.

3 C. Hirsch, Numerical Computation of Internal and External Flows: The Fundamentals of Computational Fluid Dynamics, Volumes 1 & 2, Butterworth Heinemann, Oxford, 2020.

4 T. J. Chung, Computational Fluid Dynamics, 3rd Edition, Cambridge University Press, Cambridge, 2019.

5 R. Mittal and G. Iaccarino, Fundamentals of Numerical Turbulence Modeling for CFD, Springer, Cham, 2021.

Reference Books

1 John D. Anderson, Jr., Computational Fluid Dynamics: The Basics with Applications, McGraw Hill Education, New York, 2023.

2 C. J. K. Knight, Multiphase Computational Fluid Dynamics: Methods and Applications, Academic Press, Boston, 2020.

3 R. H. Pletcher, J. C. Tannehill, and D. Anderson, Computational Fluid Mechanics and Heat Transfer, 4th Edition, CRC Press, Boca Raton, 2019.

4 O. C. Zienkiewicz and R. L. Taylor, The Finite Volume Method for Fluid Dynamics with Multigrid and Multilevel Techniques, Elsevier, Amsterdam, 2020.

5 P. Niyogi and P. Chatterjee, Computational Fluid Dynamics with Recent Applications: A Systematic Approach, CRC Press, Boca Raton, 2021.

6 K. Muralidhar and T. Sundararajan, Computational Fluid Flow and Heat Transfer, 3rd Edition, Narosa Publishing House, New Delhi, 2020.

7 D. A. Caughey and D. A. Shepherd, Computational Methods for Fluid Dynamics: Practical Workflow and Case Studies, Elsevier, Amsterdam, 2022.

8 M. Griebel, T. Dornseifer, and T. Neunhoeffer, Numerical Simulation in Fluid Dynamics: A Practical Introduction, SIAM, Philadelphia, 2020.

9 S. B. Pope, Turbulent Flows: Advanced Topics and Modelling Extensions, Cambridge University Press, Cambridge, 2020.

Web References

1 Computational Fluid Dynamics https://nptel.ac.in/courses/112105045

2 Computational Fluid Dynamics and Heat Transfer https://nptel.ac.in/courses/112104302

3 Computational Fluid Dynamics using Finite Volume Method https://nptel.ac.in/courses/112106294

4 Computational Fluid Dynamics for Incompressible Flows https://nptel.ac.in/courses/112103289

5 Foundations of Computational Fluid Dynamics https://nptel.ac.in/courses/112106186

Program: Mechanical Engineering	Final Y. B.Tech.	Semester: VII/VIII
Sustainable Manufacturing (RCP23MCPE723)		
Sustainable Manufacturing Laboratory (RCP23MLPE723)		

Prerequisites:

1. Fundamentals of manufacturing processes, materials science, and energy systems.
2. Basics of sustainability principles, optimization techniques, and data analysis.

Course Objectives:

1. Introduce the fundamental concepts of sustainable manufacturing and its significance in modern industry.
2. Analyze the environmental, economic, and social impacts of manufacturing processes.
3. Equip students with tools and methodologies for assessing and improving the sustainability of products and processes.
4. Explore advanced topics such as life cycle analysis, green supply chain management, and sustainable product design.
5. Encourage critical thinking and problem-solving skills to develop innovative solutions for sustainable manufacturing challenges.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Explain the principles, concepts, and significance of sustainable manufacturing in achieving environmental, economic, and social sustainability.	L2	Understand
CO2	Apply Life Cycle Assessment (LCA), carbon footprint analysis, and environmental assessment tools to evaluate the sustainability of manufacturing products and processes.	L3	Apply
CO3	Apply sustainable product design principles, material selection strategies, product life cycle optimization, and end-of-life management techniques for environmentally responsible product development.	L3	Apply
CO4	Analyze manufacturing processes to improve resource efficiency through energy optimization, waste minimization, cleaner production techniques, and sustainable manufacturing technologies.	L4	Analyze
CO5	Evaluate sustainable and circular supply chain practices, including green logistics, ethical sourcing, reverse logistics, and digital technologies for sustainable operations.	L5	Evaluate
CO6	Evaluate sustainability performance using appropriate metrics, standards, regulations, and emerging technologies for continuous improvement in sustainable manufacturing.	L5	Evaluate

Sustainable Manufacturing (22PEME8013T)

Course Contents

Unit-I **06 Hrs.**

Introduction to Sustainable Manufacturing

Definition and significance, three pillars of sustainability: environmental, economic, and social. Comparison between traditional and sustainable manufacturing practices. global trends and drivers for adopting sustainable manufacturing, role of Industry 4.0 and digitalization in sustainability, sustainability challenges, and future scope.

Unit-II **06 Hrs.**

Environmental Impact Assessment and Life Cycle Analysis (LCA)

Introduction to environmental impact assessment methodologies. Life cycle analysis (LCA): principles, phases, types, and applications. Tools and software for conducting LCA, carbon footprint analysis, and case studies on LCA in manufacturing industries

Unit-III **08 Hrs.**

Sustainable Product Design and Development

Eco-design principles, integration of Circular Economy principles in product design, biomimicry, and material innovation. Design for Environment (DFE), design for disassembly (DFD), and remanufacturing strategies. Application of additive manufacturing in sustainable design, extended producer responsibility (EPR) and regulatory aspects, and case studies on sustainable product innovations.

Unit-IV **08 Hrs.**

Green Manufacturing Processes and Technologies

Energy-efficient and waste-minimization techniques, lean and six sigma for sustainability, renewable energy integration in manufacturing, advanced and hybrid manufacturing approaches, metrics and key performance indicators, case studies on sustainable manufacturing implementation.

Unit-V **08 Hrs.**

Sustainable Supply Chain and Operations Management

Green procurement, sourcing strategies, circular economy principles, recycling, and reuse of finished products. Reverse logistics and end-of-life product management. Sustainable logistics, digital transformation, and blockchain for supply chain transparency. Corporate social responsibility in manufacturing. Industry case studies on sustainable supply chain models.

Unit-VI **06 Hrs.**

Sustainable Manufacturing Metrics, Policies, and Future Trends

Key performance indicators, standards, and sustainability assessment methods, government policies, industry regulations, incentives, role of AI, IoT, and digital twins.

Sustainable Manufacturing Laboratory (RCP23MLPE723)

Experiment Title

A Study / Case Study-based Experiments (Any four):

1 Study of environmental impact assessment methodologies and standards
2 Implementation of the eco-design principle for a product
3 Implementation of sustainable design principles for additive manufacturing
4 Assessment of a manufacturing process's sustainability through key performance indicators.
5 Case study–based evaluation of a manufacturing process using Life Cycle Assessment (LCA).

B Simulation / Software-based Experiments (Any four):

1 Application of life cycle assessment (LCA) tools for the manufacturing process
2 Design of a product using Quality Function deployment for Design for the Environment (DFE)
3 Design of a product using Quality Function deployment for design for disassembly (DFD)
4 Development of a Six Sigma framework for waste minimization in manufacturing
5 Development of a sustainable product-service system.

Books Recommended

Textbooks

1 Umeda, Y., Fukushige, S., & Kondoh, S., Sustainable Manufacturing: An Introduction, Springer, 2022.

2 Jawahir, I. S., & Dillon, O. W. (Eds.), Sustainable Manufacturing: The Path to a Circular Economy, Springer, 2019.

3 Jayal, A. D., Badurdeen, F., Dillon, O. W., & Jawahir, I. S., Sustainable Manufacturing: Modeling and Optimization Challenges at the Product, Process and System Levels, Springer, 2013.

4 Sutherland, J. W., Jawahir, I. S., & Brocchi, E. (Eds.), Progress in Sustainable Manufacturing, Springer, 2018.

5 Low, J. S. C., & Ong, S. K. (Eds.), Sustainable Manufacturing and Remanufacturing Management: Enhancing Knowledge through Lifecycle Thinking, Springer, 2014.

6 Dornfeld, D. A. (Ed.), Green Manufacturing: Fundamentals and Applications, Springer Science & Business Media, 2012.

7 Ashby, M. F., Materials and the Environment: Eco-informed Material Choice, Elsevier, 2012.

Reference Books

1 Hauschild, M. Z., Rosenbaum, R. K., & Olsen, S. I. (Eds.), Life Cycle Assessment: Theory and Practice, Springer, 2018.

2 Seidel, M. (Ed.), Green Supply Chain Management: Product Life Cycle Approach, Springer, 2017.

3 Allwood, J. M., & Cullen, J. M., Sustainable Materials: With Both Eyes Open, UIT Cambridge, 2012.

4 Atkinson, G., Dietz, S., & Neumayer, E., Handbook of Sustainable Manufacturing, Edward Elgar Publishing Limited, 2007.

5 Fiksel, J., Design for Environment: A Guide to Sustainable Product Development, McGraw Hill, 2009.

Web References

1 Sustainability through Green Manufacturing Systems: An Applied Approach, IIT Kanpur
https://nptel.ac.in/courses/112104225

2 System Design for Sustainability, IIT Guwahati
https://nptel.ac.in/courses/107103081

Mechanical Department R.C.P.I.T. OFFICE SEAL SHIRPUR

Program: Mechanical Engineering	Final Y. B.Tech.	Semester: VII/VIII
Motorsports Engineering (RCP23MCPE724)		
Motorsports Engineering Laboratory (RCP23MLPE724)		

Prerequisites:

1. Knowledge of materials technology (metallic and non-metallic materials).
2. Basics of Finite Element Analysis (FEA) and Computational Fluid Dynamics (CFD).
3. Fundamentals of automotive prime movers.
4. Fundamentals of electronics devices and sensors.

Course Objectives:

1. To provide knowledge of advanced materials and their manufacturing techniques applied in motorsport vehicles.
2. To enable learners to understand and apply scientific and engineering principles that govern high performance in motorsports.
3. To develop skills in design, structural analysis, and optimization techniques for competition vehicles.
4. To impart analysis and optimization skills for vehicle powertrain, transmission, aerodynamics and data acquisition technologies relevant to motorsport engineering.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Explain the classification of competition vehicles, advanced engineering materials, and manufacturing techniques used in motorsport applications.	L2	Explain
CO2	Apply engineering design principles, CAD/CAE tools, and simulation techniques for the design and structural analysis of motorsport vehicle components.	L3	Apply
CO3	Analyze vehicle handling and stability using tire characteristics, suspension geometry, steering systems, and vehicle dynamics principles.	L4	Analyze
CO4	Analyze the performance of motorsport powertrain systems, including engines, transmission systems, and driveline components for high-performance applications.	L4	Analyze
CO5	Analyze aerodynamic characteristics of motorsport vehicles and evaluate the influence of aerodynamic components on vehicle performance and stability.	L4	Analyze
CO6	Apply data acquisition systems and performance analysis techniques for monitoring, interpreting, and improving motorsport vehicle performance.	L3	Apply

Motorsports Engineering (RCP23MCPE724)

Course Contents

Unit-I **09 Hrs.**

Introduction to Advanced Materials, Application, and Manufacturing

History of motorsport and its development; Competition vehicle categories; sporting and technical regulations.
The physical and metallurgical properties of high-strength steels, stainless steels, metal matrix composites, aluminium, titanium alloys, rubbers, elastomers, plastics, and honeycomb structures.
Case studies on the application of advanced materials in the motorsport industry, which includes material forms, performance, selection, advanced manufacturing technologies, and joining techniques in the context of motorsports.

Unit-II **08 Hrs.**

Design, Analysis, and Optimization of Competition Vehicles

Introduction to structural design principles for competition vehicles; finite element modelling and simulation for structural analysis; shape and topology optimization methods; identification and analysis of common structural failure modes; non-destructive testing (NDT) techniques.

Unit-III **09 Hrs.**

Vehicle Stability

Concept of vehicle stability and controllability; tire mechanics and force generation, slip angle, cornering stiffness, and tire models; suspension geometry and chassis interactions; role of springs, dampers, and anti-roll bars in stability; longitudinal and lateral stability including understeer, oversteer, rollover, and load transfer; stability control systems (ABS, TCS, ESP, active suspension and steering); introduction to differentials and brake balancing simulation tools.

Unit-IV **08 Hrs.**

Powertrains in Motorsport

Role and evolution of powertrain, features of high performance of SI, CI engines, performance optimizations, tuning of intake, exhaust, fuel systems, turbocharging, combustion, etc, importance of dyno and simulation data analysis.
Transmission systems, gear ratios analysis and optimization, engine matching, shift point, and max. top speed estimation.
Hybrid and electric powertrains employed in motorsports. Sustainable and future technologies.

Unit-V **08 Hrs.**

Motorsport Aerodynamics and Data Acquisition

Motorsport Aerodynamics: Role of aerodynamics in motorsports, evolution of aero components, boundary layers, flow regimes, pressure distribution, lift/downforce, drag, side forces, and their analysis. Aerodynamic devices: Airfoil design, characteristics, function and tuning, drag and downforce optimization, DRS, vortex generators, and active aero.

Introduction to CFD tools, importance, meshing strategies, modeling, and simulation setup for motorsport applications, wind tunnels, flow visualization techniques, and motorsport regulations.
Data Acquisition and Analysis in Motorsports : Role of data in modern racing, system overview of ECUs, sensors, data loggers and telemetry, sensor calibration, data logging software, signal conditioning and filters, data analysis of powertrain, vehicle dynamics, driver performance, importance of real-time data and telemetry in race strategy optimization and live tuning.

Motorsports Engineering Laboratory (RCP23MLPE724)

Experiment/Case study

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1. Case study on the application of Carbon Fiber Composites and Honeycomb Sandwich Structures in motorsports vehicles.
2. Case study on the application of Titanium and Aluminum in motorsports vehicles.
3. Case study on the application of Rubbers and Elastomers in motorsports.
4. Fatigue analysis of automobile components (connecting rod/crankshaft/piston) using Finite Element Analysis (FEA) software.
5. Crash analysis of the impact attenuator using FEA.
6. Analysis of an automobile chassis using FEA.
7. Analysis of the steering and suspension system using suitable software.
8. Analysis and optimization of transmission gear ratios for any motorsport vehicle using MS Excel or Python.
9. Comparative analysis of the gradeability of any two vehicles using MS Excel or Python.
10. Simulations on airfoil optimization and drag force estimation using ANSYS or SimScale.
11. Comparative simulations of different aerodynamic devices using ANSYS or SimScale.

A minimum of seven experiments/exercises from the above-suggested list or any other experiment based on the syllabus will be included, which would help the learner to apply the concept.

Books Recommended

Reference Books

1 Andrew Livesey, Advanced Motorsport Engineering, Routledge, London, 2012.

2 Simon McBeath, Competition Car Composites: A Practical Handbook, Veloce Publishing, Dorchester, 2016.

3 John C. Dixon, Suspension Geometry and Computation, John Wiley & Sons, Hoboken (NJ), 2009.

4 William F. Milliken and Douglas L. Milliken, Race Car Vehicle Dynamics, SAE International, Warrendale (PA), 1995.

5 Herb Adams, Chassis Engineering: Chassis Design, Building & Tuning for High Performance Cars, HP Books/Penguin Publishing Group, London, 1993.

6 Michael F. Ashby, Materials Selection in Mechanical Design, Butterworth-Heinemann, Burlington, MA, 2005.

Program: Mechanical Engineering	Final Y. B.Tech.	Semester: VII/VIII
Flexible Manufacturing Systems (RCP23MCPE725)		
Flexible Manufacturing Systems Laboratory (RCP23MLPE725)		

Prerequisites:

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Course Objectives:

1. To introduce the basic concepts of flexible manufacturing system (FMS) like material handling, loading, scheduling, storage etc.
2. Developing skills to design and optimize manufacturing cells.
3. Incorporate advanced tools like Petri nets enabling students for modeling manufacturing processes, enhancing system analysis and decision-making.

Course Outcomes:

On completion of the course:

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Explain the evolution, principles, components, and economic justification of Flexible Manufacturing Systems (FMS), the role of Computer Integrated Manufacturing (CIM), and differentiate between job shop, batch, and mass production systems.	L2	Understand
CO2	Apply the principles of FMS by selecting appropriate workstations, automated material handling systems (AGVS and ASRS), and work-in-progress (WIP) storage techniques for manufacturing applications.	L3	Apply
CO3	Apply group technology principles to form part families, utilize part classification and coding systems, design manufacturing cells, and implement clustering algorithms for improved manufacturing efficiency.	L3	Apply
CO4	Analyze the flexibility of manufacturing systems using appropriate evaluation algorithms and determine the machine, tooling, and resource requirements for manufacturing cells.	L4	Analyze
CO5	Analyze manufacturing systems using Petri nets for modeling, performance evaluation, production planning, system coordination, and effective resource utilization.	L4	Analyze

Flexible Manufacturing Systems (RCP23MCPE725)

Course Contents

Unit-I **09 Hrs.**

Introduction

Introduction – FMS evolution, need for flexibility, economic justification of FMS, role of CIM in FMS, case studies.
Production systems in FMS - Types of Production-Job Shop, Batch and Mass production; Organization and information processing in manufacturing - Plant layout - Batch production – Work in progress inventory.

Unit-II **09 Hrs.**

FMS components

Workstations, Computer control system (data file, reports, hardware and software development), types of automated guided vehicle system (AGVS)and automated storage retrieval system (ASRS), carousel storage system,
WIP storage, analysis of AGV and AS/RS systems.

Unit-III **10 Hrs.**

Cellular manufacturing

Formation of part families, Part classification, Coding system optiz, Machine cells design, clustering methods, modern algorithms, benefits of GT, system planning, cell characteristic - system definition and sizing, human resources and its objective, staffing, supervisor role.

Unit-IV **04 Hrs.**

Evaluation of FMS

Algorithms for cell evaluations, measure of flexibility.

Unit-V **10 Hrs.**

Production control in FMS and Inventory control in FMS

Production control in FMS – Value Stream Mapping (VSM), Heijunka (level scheduling and load balancing), Heijunka planning and control, standardized work in manufacturing cells.
Inventory control in FMS - pull-based scheduling (Kanban concept), reduction of WIP through Just-in-Time (JIT) approach.
Applications of Petri net methodology to manufacturing systems.

Flexible Manufacturing Systems Laboratory (RCP23MLPE725)

Experiment Title

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1 Determine the components and configuration of the FMS to simulate machines, robots, conveyors, automated Guided Vehicles (AGVs), and storage.

2 Define various inputs to be given to FMS system - product types, production rates, machine setup times, processing times.

3 Simulation on software (Arena, Simul8, FlexSim) , create a digital model of the flexible manufacturing system and set up various operational parameters.

4 Analyze system performance measures with given production schedules.

5 Optimize the material handling system by testing different transport methods (e.g., conveyor vs. AGVs), using simulation software

6 Implement scheduling algorithms such as First-Come-First-Served (FCFS), Shortest Job First (SJF), or Priority Scheduling in a simulated FMS setup.

7 Use Value Stream Mapping (VSM) to identify and eliminate waste in the FMS setup.

All seven experiments from the above list or any other experiment based on the syllabus will be included, which would help the learner apply the concept.

Books Recommended

Reference Books

1 B. S. Nagendra Parashar, Cellular Manufacturing System – An Integrated Approach, PHI Learning Private Ltd., 2009.

2 Mikell Groover, Automation, Production Systems & Computer Integrated Manufacturing, PHI, 4th Edition, 2016.

3 H. K. Shivananda, Flexible Manufacturing Systems, Dhanpat Rai Publications, New Delhi.

4 Jha N. K., Handbook of Flexible Manufacturing Systems, Academic Press Inc., 1991.

5 William W. Luggen, Flexible Manufacturing Cells and Systems, Prentice Hall, NJ, 1991.

Program: Mechanical Engineering	Final Y. B.Tech.	Semester: VII/VIII
Business Analytics (RCP23MCPE726)		
Business Analytics Laboratory (RCP23MLPE726)		

Prerequisites:

1. Basic knowledge of Engineering Mathematics (linear algebra, calculus, optimization concepts)
2. Fundamentals of Probability and Statistics
3. Introductory understanding of Programming (Python/MATLAB)
4. Basic concepts of Artificial Intelligence / Data Analytics

Course Objectives:

1. To understand data-driven decision-making in industrial and engineering business contexts.
2. To apply advanced analytics techniques for strategic and operational decision-making.
3. To integrate AI-driven analytics methods in business processes of mechanical industries.
4. To analyze engineering business problems using modern computational intelligence techniques.
5. To evaluate emerging AI paradigms for enhancing business analytics capabilities.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Analyze business analytics frameworks and evaluate their role in decision-making within mechanical engineering industries	L4	Analyze
CO2	Apply advanced predictive and prescriptive analytics techniques to solve engineering business problems involving uncertainty and risk	L3	Apply
CO3	Evaluate and implement advanced AI techniques such as GANs, Transfer Learning, Neuroevolution, and Agentic AI for business analytics applications	L5	Evaluate
CO4	Analyze and interpret results from Explainable AI (XAI) methods to support transparent and ethical decision-making in engineering business systems	L4	Analyze
CO5	Evaluate the application of Quantum AI, Hybrid AI, and Industry 5.0 technologies in developing effective business analytics strategies for mechanical industries.	L5	Evaluate

Business Analytics (RCP23MCPE726)

Course Contents

Unit-I **08 Hrs.**

Business Analytics Foundations and Engineering Context

- Role of business analytics in mechanical engineering industries.
- Types of analytics: descriptive, diagnostic, predictive, prescriptive (advanced focus).
- Data-driven decision-making frameworks in engineering enterprises.
- Key business metrics: productivity, efficiency, reliability, lifecycle cost.
- Data pipelines in industrial organizations (ERP, SCM, PLM integration).
- Optimization of business processes in manufacturing systems.
- Case studies: automotive, energy systems, and heavy industries.

Unit-II **08 Hrs.**

Advanced Predictive and Prescriptive Analytics

- Advanced forecasting methods (beyond regression) for engineering systems.
- Simulation-based analytics for business decision-making.
- Scenario analysis and sensitivity analysis.
- Prescriptive analytics using optimization and simulation integration.
- Risk analytics in engineering business systems.
- Demand forecasting and inventory optimization in mechanical industries.
- Reliability-centered business analytics (cost vs performance trade-offs).

Unit-III **10 Hrs.**

AI-Driven Business Analytics

- Generative Adversarial Networks (GANs): Concept, architecture, and synthetic data generation for engineering/business data.
- Transfer Learning: Domain adaptation for engineering datasets and business predictions.
- Neuroevolution: Evolutionary optimization of neural networks for business analytics problems.
- Multimodal AI: Integration of sensor data, text, images in engineering business systems.
- Agentic AI: Autonomous decision-making agents in industrial operations and supply chains.

Unit-IV **08 Hrs.**

Explainable and Trustworthy AI in Business Analytics

- Need for interpretability in industrial decision-making.
- Explainable AI (XAI): Model transparency, feature importance, SHAP/LIME concepts.
- Bias, fairness, and ethical considerations in analytics.
- Decision intelligence systems.
- AI governance in engineering enterprises.

- Human-in-the-loop decision-making systems.
- Case studies: Maintenance decision systems; Supplier selection; Risk management.

Unit-V **08 Hrs.**

Emerging Trends: Quantum AI and Advanced Applications

- Introduction to Quantum AI: Quantum computing basics (conceptual); Quantum machine learning in business analytics.
- Hybrid AI systems for large-scale decision-making.
- Digital transformation and Industry 5.0.
- Advanced applications: Smart manufacturing analytics; Supply chain resilience; EV ecosystem analytics; Energy market analytics.
- Integration of AI with business strategy.
- Future trends in business analytics for mechanical engineers.

Note : Applications, numerical, and case studies should be related to mechanical and allied engineering domains only.

Business Analytics Laboratory (RCP23MLPE726)

Suggested Experiments

Any 8 experiments:

1. Perform business data preprocessing and cleaning for engineering datasets.
2. Analyze production and operational data for performance evaluation.
3. Develop key performance indicators (KPIs) for mechanical systems.
4. Perform cost analysis and optimization for manufacturing processes.
5. Analyze supply chain data for mechanical industries.
6. Develop demand forecasting models for engineering products.
7. Perform scenario-based business decision analysis for industrial systems.
8. Analyze maintenance and downtime data for cost optimization.
9. Develop dashboards for business analytics in mechanical systems.
10. Perform lifecycle cost analysis of mechanical components.
11. Analyze inventory and logistics data for optimization.
12. Perform risk analysis in engineering business operations.
13. Develop predictive models for business performance in manufacturing.
14. Perform customer and market analytics for engineering products.
15. Analyze energy consumption data for cost and efficiency optimization.
16. Perform supplier selection analysis using decision-making techniques.
17. Develop business analytics models for reliability-based decision-making.
18. Analyze financial and operational data for engineering project evaluation.

19. Perform multimodal data analysis combining sensor and business data.
20. Develop AI-driven decision support systems for mechanical engineering businesses.

A minimum of 8 experiments from the above-suggested list or any other experiment based on the syllabus will be included, helping the learner apply the concept.

Books Recommended

Textbooks

1 Foster Provost and Tom Fawcett, Data Science for Business: What You Need to Know about Data Mining and Data-Analytic Thinking, O'Reilly Media, Sebastopol, USA, 2nd Edition, 2013.

2 S. Christian Albright and Wayne L. Winston, Business Analytics: Data Analysis & Decision Making, Cengage Learning, Boston, USA, 6th Edition, 2016.

3 Ramesh Sharda, Dursun Delen and Efraim Turban, Business Intelligence, Analytics, and Data Science: A Managerial Perspective, Pearson, London, UK, 5th Edition, 2024.

4 Galit Shmueli, Peter C. Bruce, Nitin R. Patel and Mia Stephens, Machine Learning for Business Analytics, Wiley, Hoboken, USA, 2nd Edition, 2023.

5 James Evans, Business Analytics: Methods, Models, and Decisions, Pearson, London, UK, 2nd Edition, 2015.

Reference Books

1 Wes McKinney, Python for Data Analysis: Data Wrangling with Pandas, NumPy, and Jupyter, O'Reilly Media, Sebastopol, USA, 2nd Edition, 2017.

2 Trevor Hastie, Robert Tibshirani and Jerome Friedman, The Elements of Statistical Learning: Data Mining, Inference, and Prediction, Springer, New York, USA, 2nd Edition, 2009.

3 Dean Abbott, Applied Predictive Analytics: Principles and Techniques for the Professional Data Analyst, Wiley, Hoboken, USA, 1st Edition, 2014.

4 Hadley Wickham and Garrett Grolemund, R for Data Science: Import, Tidy, Transform, Visualize, and Model Data, O'Reilly Media, Sebastopol, USA, 1st Edition, 2017.

5 Ian H. Witten, Eibe Frank and Mark A. Hall, Data Mining: Practical Machine Learning Tools and Techniques, Morgan Kaufmann, Burlington, USA, 4th Edition, 2016.

Web References

1 Business Analytics For Management Decision
https://nptel.ac.in/courses/110105089

2 Business Intelligence & Analytics
https://nptel.ac.in/courses/106106361

3 Business Analytics & Text Mining Modeling Using Python
https://nptel.ac.in/courses/110107129

4 Business Analytics & Data Mining Modeling Using R Part II
https://nptel.ac.in/courses/110107095

5 Introduction to Business Analysis for Engineers
https://nptel.ac.in/courses/110106050

6 Business Statistics
https://nptel.ac.in/courses/110107114

7 Business Analytics and Data Mining Modeling Using R
https://nptel.ac.in/courses/110107092

Program: Mechanical Engineering	**Final Y. B.Tech.**	**Semester: VII/VIII**
Startup Compliances and Exit Strategies (RCP23MCPE727)		
Startup Compliances and Exit Strategies Laboratory (RCP23MLPE727)		

Prerequisites:

1. Fundamentals of Business Development
2. Entrepreneurial Business Models
3. Startup Registration and Development

Course Objectives:

1. To provide a comprehensive understanding of legal, regulatory, and statutory compliance required for startups in India, with special focus on engineering ventures.
2. To equip learners with practical knowledge of company formation, IPR, taxation, labor law, and ongoing compliance frameworks.
3. To develop a clear understanding of different exit strategies and their legal and financial implications for founders and investors.
4. To enable students to prepare necessary documentation and processes for smooth compliance management and successful exit.
5. To build practical skills for handling compliance and creating an effective compliance-cum-exit roadmap for mechanical/product-based startups.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Apply statutory, legal, and regulatory compliance requirements for startups in India.	L3	Apply
CO2	Apply intellectual property, taxation, labor, and technology compliance requirements for engineering startups.	L3	Apply
CO3	Evaluate suitable startup exit strategies based on business valuation, growth stage, and stakeholder objectives.	L5	Evaluate
CO4	Prepare compliance documentation and due diligence processes required for startup exits.	L3	Apply
CO5	Develop a comprehensive compliance and exit roadmap for a mechanical engineering startup.	L6	Create

Startup Compliances and Exit Strategies (RCP23MCPE727)

Course Contents

Unit-I **10 Hrs.**

Introduction to Startup Compliances and Legal Structure

Overview of the regulatory environment for startups in India, including the Startup India Action Plan and its benefits. Key regulatory bodies such as MCA, DPIIT, RBI, and SEBI. The difference between compliance for startups versus established companies. Choosing the right legal structure, such as a Private Limited company, LLP, or Partnership. Company registration processes, including DIN, DSC, PAN, TAN, and GST registration. Shops and Establishments registration, EPF, ESI, and Professional Tax, along with compliance calendar and annual filing requirements. Case studies of compliance failures and successes.

Unit-II **08 Hrs.**

Intellectual Property and Technology Compliance.

IPR strategy for mechanical and engineering innovations, including Patents, Designs, Trademarks, and Copyrights. Patent filing process and maintenance. Technology transfer and licensing agreements. Data protection, cybersecurity, and IT compliance.

Unit-III **08 Hrs.**

Taxation, Financial, and Labor Compliance

Direct and Indirect tax compliance, including Income Tax, GST, and TDS. Angel tax and Section 80-IAC benefits. Labor laws covering the Factories Act, Contract Labor, POSH, and Wage Code. Accounting standards and financial reporting requirements for startups.

Unit-IV **08 Hrs.**

Exit Strategies – Concepts and Options

Types of exits include IPOs, acquisitions (M&A), Strategic Sales, Buybacks, Secondary Sales, and Liquidations. Valuation methods for exit. Role of investors and shareholders' agreements. Preparing the startup for exit, including cleaning up the cap table and due diligence readiness.

Unit-V **08 Hrs.**

Execution of Exit and Post-Exit Considerations

Due diligence process and documentation. Negotiation strategies in exits. Tax implications of different exit routes. Founder transition and wealth management. Final Project on Compliance and Exit Strategy Presentation along with course review and reflection.

Mechanical Department R.C.P.I.T. OFFICE SEAL SHIRPUR

Startup Compliances and Exit Strategies Laboratory (RCP23MLPE727)

Exercise Title

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1. Startup Registration Simulation: Complete step-by-step virtual registration of a Private Limited Company or LLP for a mechanical engineering product-based startup using MCA portal simulation.
2. Compliance Calendar Development: Prepare a 3-year compliance calendar covering all statutory filings, taxes, labor laws, and IPR maintenance for an engineering startup.
3. IPR Strategy and Patent Drafting Exercise: Identify patentable innovation from a mechanical, automotive, or manufacturing idea and prepare a basic patent application outline.
4. Tax and Financial Compliance Mapping: Analyze GST, Income Tax, and angel tax implications for a given startup scenario and suggest optimization strategies.
5. Exit Strategy Evaluation: Evaluate multiple exit options, such as IPO, acquisition, and strategic sale, for a sample mechanical engineering startup and recommend the best route with justification.
6. Due Diligence Checklist Preparation: Create a comprehensive due diligence checklist covering legal, financial, operational, and IPR aspects that a startup must fulfill before exit.
7. Shareholders Agreement and Term Sheet Analysis: Review and suggest improvements in a sample term sheet and shareholders agreement from an investor perspective.
8. Final Project: Comprehensive Compliance and Exit Roadmap: Develop and present a comprehensive compliance management plan, along with a chosen exit strategy, for a chosen mechanical engineering startup idea, including a timeline and risk mitigation.

Books Recommended

Textbooks

1 India Business Guide – Startup to Set-up, Vinay Vaish (Vaish Associates).

2 Bloomsbury's Handbook for Start-Ups – A Tax and Regulatory Guide, CA Radhika Jain.

3 Beyond the Incorporation: A Startup Guide to Navigating Taxation, Registrations, and Compliances in India, CA Megha Jain.

4 MSME & Start Ups Law & Practice, 2024, CS Amit Baxi, FCA Nisha Bhandari and FCA Satyadev Purohit.

5 Taxmann's Company Law & Practice, G. K. Kapoor and Sanjay Dhamija.

6 Intellectual Property Rights, N. K. Acharya.

7 Handbook of Legal Aspects of Startups in India, GNLU Publication.

8 India Startup Law & Policy Guidebook 2025, FICCI / Khaitan & Co.

Web References

1 Journal of Business Strategy
https://www.sciencedirect.com/org/journal/journal-of-business-strategy

2 Innovation and Green Development
https://www.sciencedirect.com/journal/innovation-and-green-development

3 Journal of Cleaner Production
https://www.sciencedirect.com/journal/journal-of-cleaner-production

4 Journal of Business Venturing
https://www.sciencedirect.com/journal/journal-of-business-venturing

Program: Mechanical Engineering	**Final Y. B.Tech.**	**Semester: VII/VIII**
Industrial Engineering and Management (RCP23MCMD701)		

Prerequisites:

1. Basic knowledge of Manufacturing processes.
2. Basic knowledge of various manufacturing systems.

Course Objectives:

1. To introduce Industrial Engineering foundations, productivity concepts, and value engineering for efficiency improvement.
2. To build skills in work study, ergonomics, and system design for optimizing human–machine interaction and workplace performance.
3. To provide knowledge of facility planning, layout design, line balancing, and agile/lean practices for sustainable resource utilization.
4. To understand the principles and practices of Quality Management, including Quality Circles, TQM, and Quality 4.0, and apply them in real-world scenarios.
5. To introduce Industry 4.0 concepts, including Digital Twin, simulation-based decision making, and smart manufacturing systems.

Course Outcomes:

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

CO	**Course Outcomes**	**Bloom's Level**	**Bloom's Description**
CO1	Explain Industrial Engineering concepts, productivity measures, and value engineering principles.	L2	Understand
CO2	Apply work study techniques using modern tools such as AI-based motion and time analysis.	L3	Apply
CO3	Analyze work systems considering ergonomics, human factors, and organizational behaviour.	L4	Analyze
CO4	Design efficient facility layouts and production systems using digital and optimization techniques.	L5	Create
CO5	Evaluate agile, lean, and smart manufacturing systems for productivity improvement.	L6	Evaluate

Industrial Engineering and Management (RCP23MCMD701)

Course Contents

Unit-I **08 Hrs.**

Introduction to Industrial Engineering

- Evolution: Industry 1.0 - 4.0 and contribution of Industrial Engineering.
- Productivity: concept, types (partial, total, multifactor), measurement.
- Productivity improvement using analytics and digital tools.
- Value Engineering and Value Analysis: Concept and distinction, Steps and applications, AI-assisted cost optimization and simulation-based evaluation.
- Cyber-Physical Systems (CPS).
- Smart factories & digital integration (Introduction).

Unit-II **08 Hrs.**

Method Study and Work Measurement

- Method study: objectives, steps, process analysis.
- Motion study: concept (Therbligs – overview only).
- Work measurement: Time study (digital and automated), Work sampling (modern data collection), PMTS and MOST (concept + digital tools), Motion capture & wearable sensors AI-based time study.
- Digital Work Study.

Unit-III **08 Hrs.**

Ergonomics

- Definition of Ergonomics.
- Objectives of Ergonomics.
- Importance of Ergonomics.
- History and Development.
- Latest trends of Ergonomics in Different Industries.
- Types of Ergonomics.
- Benefits of Ergonomics.

Unit-IV **08 Hrs.**

Facility Planning

- Factors affecting location decisions, Evaluation of alternative locations.
- Plant layout: Types of layouts (product, process, fixed-position, cellular, hybrid), Computer-aided layout design techniques.
- Line Balancing: Objectives and constraints, Terminology in assembly line. Numerical on Line Balancing.
- Materials handling systems: principles, equipment, and Automated Guided Vehicles (AGVs).
- Group Technology (GT) and Cellular Manufacturing concepts.
- Digital Twin for facility optimization.
- Smart warehouses and logistics systems.

Unit-V **10 Hrs.**

Lean Manufacturing and Agile Manufacturing

- Lean Manufacturing:
  - History of Lean (Toyota Production System)
  - Lean vs Traditional Manufacturing
  - Lean Principles
  - Lean Thinking Philosophy
  - Just-In-Time Production
- Agile Manufacturing:
  - Definition of Agile Manufacturing
  - Need for Agile Manufacturing
  - Evolution of Agile Manufacturing
  - Agile vs Lean vs Mass Production
  - Characteristics of Agile Manufacturing
  - Computer Integrated Manufacturing (CIM)
  - Flexible Manufacturing Systems (FMS)

Case studies based on syllabus can be included, which would help the learner to apply the concept learnt.

Books Recommended

Textbooks

1 Ravi Shankar, Industrial Engineering and Management, Galgotia Publications Pvt Ltd ,June 2000

Reference Books

1 Apple, James M., Plant Layout and Material Handling, John Wiley & Sons, New York, 1977.

2 Besterfield, Dale H. et al., Total Quality Management, Prentice Hall, New Jersey, 2011.

3 Elion, Samuel, Production Planning and Control, Prentice Hall, New Jersey, 1987.

4 Francis, Richard L. & White, John A., Facility Layout and Location – An Analytical Approach, Prentice Hall, New Jersey, 1974.

5 International Labour Organization (ILO), Introduction to Work Study, Oxford & IBH Publishing Co. Pvt. Ltd., Geneva/New Delhi, 1978.

6 Juran, J. M. & Gryna, F. M., Quality Planning and Analysis, Tata McGraw-Hill, New Delhi, 1993.

7 Menon, H. G., TQM in New Product Manufacturing, Tata McGraw-Hill, New Delhi, 1992.

8 Monks, Joseph G., Production and Operations Management, McGraw-Hill, New York, 1982.

9 Murrell, K. F. H., Ergonomics at Work, Taylor & Francis, London, 1965.

10 Industrial Engineering in the Industry 4.0 Era

11 Simulation Modeling and Analysis – Law & Kelton

12 Process Simulation using Witness including lean and six sigma applications by Raid Al-Aomar, Edward J. Williams, Onur M. Ulgen

13 Rational Process Design & Simulation Modelling using Witness Horizon by Dr. Neil G, Murray

Web References:

1. www.nptel.ac.in
2. Introduction to Industrial Engineering – NPTEL https://nptel.ac.in/courses/110107089
3. Industry 4.0 and Industrial IoT – NPTEL https://nptel.ac.in/courses/106105195
4. Lean Manufacturing – NPTEL https://nptel.ac.in/courses/110107141
5. Human Factors Engineering – NPTEL https://nptel.ac.in/courses/112106225
6. Work System Design and Ergonomics – NPTEL https://nptel.ac.in/courses/112107142
7. https://www.smartzworld.com/notes/management-and-enterpreneurship-notes-me-vtu/
8. https://www.maggubhai.com/management-process-organising-and-staffing/
9. https://tutorstips.com/difference-between-directing-and-controlling/

Program: Mechanical Engineering	Final Y. B.Tech.	Semester: VII/VIII
Research Ecosystem (RCP23ITELX08)		

Prerequisites:

1. Basic understanding of Engineering concepts and problem-solving techniques.
2. Fundamental knowledge of project-based learning, data analysis, and domain-specific tools.
3. Basic exposure to project development, technical report writing, and emerging technologies.

Course Objectives:

1. To understand and identify complex engineering, societal, and industrial problems suitable for research through structured analysis of literature, patents, and real-world needs.
2. To learn and apply advanced research methodologies—including experimental, simulation-based, and data-driven approaches—for designing and validating engineering solutions.
3. To gain proficiency in selecting and using appropriate tools, software, and platforms (AI/ML, simulation, CAD, IoT, etc.) for experiment design, data acquisition, and performance evaluation.
4. To transform research insights into innovative prototypes, products, or startup concepts by engaging with innovation ecosystems, TRLs, and funding mechanisms.
5. To analyze socio-technical systems, ethics, and sustainability implications of engineering solutions, ensuring responsible and impactful outcomes.
6. To integrate systems thinking, multidisciplinary perspectives, policy awareness, future technology trends, and technical documentation skills to develop comprehensive research proposals and outputs (papers, patents, reports).

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description

Research Ecosystem (RCP23ITELX08)

Course Contents

Unit-I **05 Hrs.**

Research Gap Identification & Advanced Problem Formulation

- Identifying high-impact problems from: Industry and Society; Emerging technologies (AI, IoT, Blockchain, EV, etc.)
- Research gap identification techniques: Systematic Literature Review (SLR); Patent analysis
- Defining objectives, scope, constraints, and feasibility of the identified problem
- Writing problem statement for: Research paper; Product/Startup idea
- Activities: Convert Industry/ Societal problem into research problem; Analyze research articles and extract research gaps.

Unit-II **06 Hrs.**

Experimental Design, Tools & Validation Techniques

- Advanced research methodologies: Experimental, simulation, data-driven, design thinking
- Tool selection: Computational tools and software, simulation and analysis platforms, system prototyping and testing platforms
- Data acquisition: Data collection interfaces, Principles of data cleaning and organization (primary / secondary data)
- Validation techniques: Accuracy and performance metrics; Benchmarking with existing solutions
- Result interpretation & visualization
- Activities: Selection of Research Design for final year project; Apply evaluation metrics (e.g., ML model accuracy, system efficiency).

Unit-III **05 Hrs.**

Research to Innovation, Product & Startup Ecosystem

- Research → Prototype → Product → Startup lifecycle
- Intellectual Property Rights (IPR), patents, copyrights
- Technology readiness levels (TRL)
- Case studies: AI startups, EV ecosystem, Smart Cities
- Industry-academia collaboration models
- Funding opportunities (grants, incubation, government schemes - Anusandhan National Research Foundation (ANRF))
- Activities: Convert project into startup idea or product pitch; Analyze failure of a technology/product.

Unit-IV **06 Hrs.**

Socio-Technical Systems, Ethics & Sustainability

- Socio-technical systems: Interaction of people, technology and environment
- Ethical issues: Plagiarism, AI bias, data privacy
- Sustainability in Engineering: Green practices, resource optimization and lifecycle considerations
- Impact assessment: Social, economic, environmental
- Policies and governance (data protection laws, standards and compliance requirements)
- Activities: Case study: Facial recognition ethics / smart surveillance; Impact analysis of student's own project.

Unit-V **06 Hrs.**

Integrated Research, Policy and Future Engineering Challenges

- Systems thinking and holistic analysis
- Multidisciplinary problem solving: Healthcare tech, climate tech, smart mobility
- Writing research proposals: Problem → Methodology → Expected outcomes
- Future trends: AI ethics, Quantum computing, Industry 5.0 / 6.0
- Scaling solutions from lab to society
- Activities: Capstone Task: Identify real-world problem; Apply research methodology; Propose: Technical solution, Societal impact, Possible commercialization.

Term Work Guidelines

The Term Work (TW) shall consist of continuous assessment based on tutorials activities and a final group presentation.

- Part A (25 Marks): Each student shall complete a minimum of five tutorials based on the syllabus topics during the semester. The tutorials may include activities such as research gap identification, literature survey, case study analysis, tool-based experimentation, impact analysis, technical report writing, and innovation-oriented problem solving.
- Part B (25 Marks) : Students shall work in groups and select a project/research topic based on emerging engineering, industrial, or societal challenges. The group presentation shall include:
  i. Identification of a real-world problem
  ii. Application of appropriate research methodology
  iii. Proposed technical solution
  iv. Analysis of societal impact
  v. Possible commercialization/startup opportunities

Books Recommended

Reference Books

1 Booth, W. C., Colomb, G. G., Williams, J. M., Bizup, J., & FitzGerald, W. T., The Craft of Research, University of Chicago Press, Chicago, 2024.

2 Montgomery, D. C., Design and Analysis of Experiments, Wiley, New York, 2020.

3 Singh, Pooja, Katiyar, Aman, Rawat, Shalini, Dhuri, Archana, Research Methodology and IPR, RK

4 Blok, Vincent (Ed.), Putting Responsible Research and Innovation into Practice: A Multi-Stakeholder Approach, Springer Cham, Switzerland, 2022.

Web References:

1. Research Methodology: Quantitative Methods and Computer Application
https://onlinecourses.swayam2.ac.in/e-learning/preview/ini26_ma02
2. Research Methodology and IPR
https://onlinecourses.swayam2.ac.in/e-learning/preview/ntr26_ed28
3. Research and Publication Ethics
https://onlinecourses.swayam2.ac.in/e-learning/preview/nou26_ge46
4. Research Ethics and Plagiarism
https://onlinecourses.swayam2.ac.in/e-learning/preview/nou26_ge26
5. Quantitative and Mixed Methods Research for Management
https://onlinecourses.swayam2.ac.in/e-learning/preview/imb26_mg21
6. Doing Qualitative Research
https://onlinecourses.swayam2.ac.in/e-learning/preview/nou26_ge61

Program: Mechanical Engineering	Final Y. B.Tech.	Semester: VII/VIII
Disaster Management and Preparedness (RCP23ICHSX09)		

Prerequisites:

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Course Objectives:

1. To provide a basic understanding of hazards, disasters, and various types and categories of disasters occurring around the world.
2. To identify the extent and damaging capacity of a disaster.
3. To study and understand the means of losses and methods to overcome /minimize them.
4. To understand the roles and responsibilities of individuals and various organizations during and after a disaster.
5. To appreciate the significance of GIS, GPS in the field of disaster management.
6. To understand the emergency government response structures before, during, and after a disaster.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Apply disaster management principles & guidelines.	L3	Apply
CO2	Analyze risk assessments.	L4	Analyze
CO3	Demonstrate community awareness & participation.	L3	Apply
CO4	Use Science & Technology tools (GIS, GPS).	L3	Apply
CO5	Prepare disaster management plans.	L3	Apply

Disaster Management and Preparedness (RCP23ICHSX09)

Course Contents

Unit-I **06 Hrs.**

Understanding Disasters & Hazards

- Definition and types of disasters: Natural, Man-made and hybrid disasters, Study of Natural disasters: Flood, drought, cloud burst, Earthquake, Landslides, Avalanches, Volcanic eruptions, Mudflow, Cyclone, Storm, Storm Surge, climate change, global warming, sea level rise, ozone depletion etc.
- Study of Human/Technology Induced Disasters: Chemical, Industrial and Nuclear disasters, internally displaced persons, road and train accidents Fire Hazards, terrorism, militancy,
- Hazard & Vulnerability profiles of India (seismic zones, flood-prone areas).
- India's vulnerability to disasters, and the impact of disasters on National development.

Unit-II **06 Hrs.**

Disaster Risk Reduction (DRR) & Mitigation

- Disaster Management Cycle: Prevention, Mitigation, Preparedness, Response, Recovery. Need for disaster prevention and mitigation, mitigation guiding principles, challenging areas, structural and non-structural measures for disaster risk reduction.
- Risk Assessment & Vulnerability Analysis.
- Science & Technology: Use of information management, Geo informatics like RS, GIS, GPS and remote sensing mitigation measure.

Unit-III **04 Hrs.**

Disaster Preparedness & Response

- Preparedness Planning, Early Warning Systems (EWS), & Communication.
- Emergency Response: Search & Rescue, Logistics, Medical Aid.
- Psychological Response & Management (Trauma, Stress).
- Role of IT, Media, Govt., NGOs, & Community.

Unit-IV **04 Hrs.**

Recovery, Rehabilitation & Reconstruction

- Post-disaster damage assessment.
- Rehabilitation, Reconstruction, & Livelihood Restoration.
- Sanitation, Hygiene, & Waste Management.

Unit-V **04 Hrs.**

Policy, Governance, Capacity Building & Case Studies

- Policy, Governance & Capacity Building
  - National Disaster Management Authority (NDMA) & Legislation.
  - Institutional Mechanisms & Community Mobilization. Non-Structural Mitigation: Community-based disaster preparedness, capacity development and training, awareness and education, contingency plans.
- Case studies on disaster (National /International):
  - Case study discussion of National Disasters: Tsunami (2004), Bhopal gas tragedy, Kerala and Uttarakhand flood disaster, 26th July 2005 Mumbai flood
  - Case study discussion of International Disasters: Hiroshima – Nagasaki (Japan), Cyclone Phailin (2013), Fukushima, Daiichi nuclear disaster (2011), Chernobyl meltdown

Books Recommended

Reference Books and Reports

1 Disaster Management, by Harsh K. Gupta, Universities Press Publications (2003).

2 Disaster Management: An Appraisal of Institutional Mechanisms in India, by O. S. Dagur, published by Centre for Land Warfare Studies, New Delhi, 2011.

3 Introduction to International Disaster Management, by Damon Copolla, Butterworth Heinemann Elsevier Publications (2015).

4 Disaster Management Handbook, by Jack Pinkowski, CRC Press, Taylor and Francis group (2008).

5 Disaster management & rehabilitation, by Rajdeep Dasgupta, Mittal Publications, New Delhi (2007).

6 Natural Hazards and Disaster Management, Vulnerability and Mitigation, by R B Singh, Rawat Publications (2006).

7 Concepts and Techniques of GIS, by C. P. Lo Albert, K.W. Yonng, Prentice Hall (India) Publications (2006).

8 Risk management of natural disasters, by Claudia G. Flores Gonzales, KIT Scientific Publishing (2010).

9 Disaster Management – a disaster manager's handbook, by W. Nick Carter, Asian Development Bank (2008).

10 Disaster Management in India, by R. K. Srivastava, Ministry of Home Affairs, GoI, New Delhi (2011)

11 The Chernobyl Disaster: Legacy and Impact on the Future of Nuclear Energy, by Wil Mara, Marshall Cavendish Corporation, New York, 2011.

12 The Fukushima 2011 Disaster, by Ronald Eisler, Taylor & Francis, Florida, 2013.

(Learners are expected to refer to reports published at the national and international levels and updated information available on authentic websites.)

Program: Mechanical Engineering	Final Y. B.Tech.	Semester: VII/VIII
Project Stage - II (RCP23IPELX10)		

Prerequisites:

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Course Objectives:

1. To implement the solution as per the problem statement
2. To develop the team building, writing, logical reasoning and management skills.
3. To provide the connections between the designs and concepts across different disciplinary boundaries.
4. To encourage students to become independent personnel, critical thinkers and lifelong learners.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Analyze the problem statement and produce solution of the problem considering cultural, social, environmental and economic factors using appropriate tool and method.	L4	Analyze
CO2	Interpret project based learning that allows students to transfer existing ideas into new applications.	L2	Understand
CO3	Apply the ability to work in teams and manage to conduct the project development activity.	L3	Apply
CO4	Use different perspectives from relevant disciplines which help them to get internships, jobs, and admission for higher studies.	L3	Apply
CO5	Explain the project development in the form of technical writing, and interpret what constitutes plagiarism and the use of proper referencing styles.	L2	Understand

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Project Stage - II (RCP23IPELX10)

Project-I work done in VI semester shall be continued as Project-II in semester VII. Students should complete remaining implementation of ideas given in synopsis/Abstract of semester VII
Students / group must plan their execution of project, so that project work should be completed before end of semester.
Project-II involves fabrication, design, experimentation, data analysis within realistic constraints such as economic, environmental, social, ethical, health and safety, manufacturability, and sustainability. The stage also includes testing, possible results and report writing.
Each project group is required to maintain log book for documenting various activities of Project-II and submit group project report at the end of Semester-VII in the form of Hard bound.
Domain knowledge (any beyond) needed from the various areas in the field of mechanical engineering for the effective implementation of the project.
The above areas can be updated based on the technological innovations and development needed for specific project.

Guidelines

The main purpose of this activity is to improve the students technical skills, communication skills by integrating writing, presentation and teamwork opportunities.

- Each group will be reviewed twice in a semester and marks will be allotted based on the various points mentioned in the evaluation scheme.
- In the first review of this semester, each group is expected to complete 30% of project.
- In the second review of this semester, each group is expected to complete 50% of project.
- Interaction with alumni mentor will also be appreciated for the improvement of project.

Student is expected to :

- Select an appropriate project title based on acquired knowledge from subjects.
- Maintain a Log Book of weekly work done (Log Book Format will be as per Table 1).
- Report weekly to the project guide along with the log book.

Table 1: Log Book Format

Sr	Week (Start Date:End Date)	Work Done	Sign of Guide	Sign of Coordinator
1				

Assessment Criteria

- At the end of the semester, after confirmation by the project guide, each project group will submit a project completion report in the prescribed format for assessment to the departmental committee (including project guide).
- Assessment of the Project Stage-II (at the end of the semester) will be done by the departmental committee (including project guide).
- Oral examination should be conducted by Internal and External examiners. Students have to give presentation and demonstration based on their project.

Prescribed project report guidelines

The size of the report shall be a minimum of 25 pages. The Project Report should include appropriate content for:

- Introduction
- Literature Survey
- Related Theory
- Implementation details
- Project Stage-II Outcomes
- Conclusion
- References

Assessment criteria for departmental committee (including project guide) for Continuous Assessment:

Guide will monitor weekly progress, and marks allocation will be as per Table 2.

Table 2: Continuous Assessment table

Sr	PRN	Name of Student	Student Attendance	Log Book Maintain	Literature Review	Depth of Understanding	Report	Total
			5	5	5	5	5	25

Each group will be reviewed twice in a semester by faculty guide and faculty coordinator based on the following criteria;

- Project progress
- Documentation/Technical paper writing
- Key findings
- Validation of results

Each review consists of 50 marks. Average of the marks scored in both the two reviews will be considered for final grading. The final certification and acceptance of TA ensures the satisfactory performance on the above aspects.

Assessment criteria for departmental committee (including project guide) for End Semester Exam:

evaluate the project as per Table 3.

Table 3: Evalution Table

Sr	PRN	Name of Student	Project Selection	Design/ Simulation	model/ programming	Result Verification	Presentation	Total
			5	5	5	5	5	25

Each group shall present/publish a paper based on the project in reputed/peer-reviewed Conference/Journal/TechFest/Magazine before the end of the semester.

Program: Mechanical Engineering	Final Y. B.Tech.	Semester: VII/VIII
Data Science for Mechanical Engineers (RCP23MCSC701)		

Prerequisites:

-

Course Objectives:

1. To understand the fundamentals of engineering data science and industrial analytics.
2. To analyze engineering datasets using statistical and visualization techniques.
3. To perform pre-processing and cleaning of industrial data.
4. To create meaningful visualizations and dashboards for engineering decision-making.
5. To apply data science concepts to mechanical engineering applications.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Explain the role of data science in mechanical engineering industries.	L2	Understand
CO2	Analyze engineering datasets using basic statistical methods.	L4	Analyze
CO3	Apply data analytics techniques to manufacturing and maintenance datasets.	L3	Apply
CO4	Create visualizations and dashboards for engineering interpretation.	L6	Create
CO5	Perform preprocessing and cleaning of industrial datasets.	L3	Apply

Data Science for Mechanical Engineers (RCP23MCSC701)

Course Contents

Unit-I **01 Hrs.**

Introduction to Engineering Data Science

- Introduction to data science;
- Role of data science in engineering industries;
- Data-driven decision-making;
- Data science workflow;
- Applications of data science in mechanical engineering;
- Introduction to industrial analytics.

Unit-II **02 Hrs.**

Engineering Data and Industrial Datasets

- Types of engineering data:
- Structured data, Unstructured data, Sensor data, Time-series data;
- Introduction to industrial datasets;
- Characteristics of engineering data;
- Data collection and management in industries.

Unit-III **02 Hrs.**

Engineering Statistics and Data Interpretation

- Introduction to engineering statistics;
- Measures of central tendency;
- Measures of dispersion;
- Histograms and frequency distribution;
- Probability basics for engineering applications;
- Engineering data interpretation.

Unit-IV **02 Hrs.**

Correlation, Regression, and Engineering Analytics

- Correlation analysis;
- Introduction to regression analysis;
- Trend identification;
- Data relationships and engineering insights;
- Applications of correlation and regression in mechanical engineering.

Unit-V 02 Hrs.

Data Preprocessing and Data Cleaning Techniques

- Importance of data preprocessing;
- Handling missing data;
- Data cleaning techniques;
- Duplicate data handling;
- Outlier detection basics;
- Introduction to engineering data preparation workflows.

Unit-VI 02 Hrs.

Data Transformation and Feature Engineering

- Data normalization and standardization;
- Feature selection basics;
- Data transformation techniques;
- Preparing engineering datasets for analysis;
- Improving data quality for predictive applications.

Unit-VII 01 Hrs.

Data Visualization and Dashboard Development

- Importance of visualization in engineering;
- Principles of effective data visualization;
- Introduction to visualization tools;
- Plotting techniques (Line plots, Scatter plots, Histograms, Box plots, Heat maps);
- Introduction to dashboards;
- Interactive visualization concepts;
- Introduction to Power BI;
- Data storytelling for engineering systems.

Unit-VIII 02 Hrs.

Engineering Data Science Applications

- Introduction to predictive analytics;
- Engineering trend analysis;
- Quality control analytics;
- Maintenance analytics;
- Energy system analytics;
- Industrial IoT data interpretation;
- Case studies on smart manufacturing;
- Introduction to AI-enabled industrial analytics;
- Mini-project development using engineering datasets.

Suggested Coursera Mapping

Module	Suggested Coursera Content Provider
Introduction to Data Science	IBM Data Science, Google
Engineering Statistics	University of Michigan, Stanford
Visualization and Dashboards	IBM, Microsoft
Data Analytics and Visualization	Google Data Analytics, Microsoft Power BI
Industrial Analytics Applications	AWS, DeepLearning, AI

Shirpur Education Society's

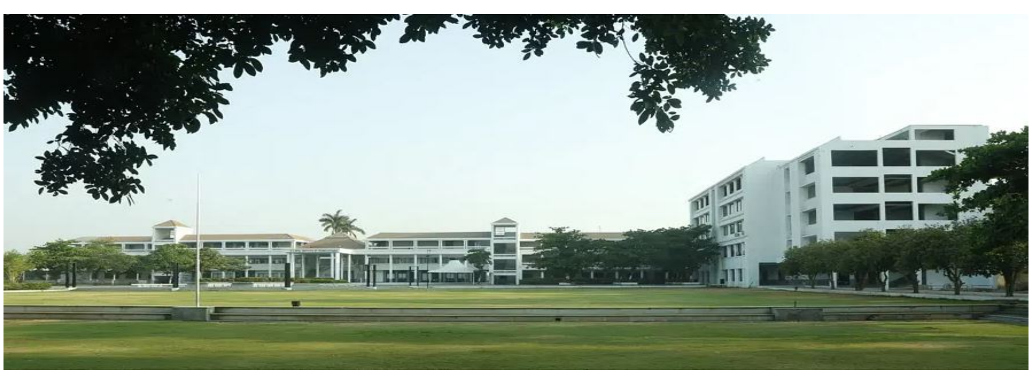
R. C. Patel Institute of Technology, Shirpur

(An Autonomous Institute)

Syllabus Details of Semester-VIII

Final Year B.Tech in Mechanical Engineering

(RCP23 NEP Scheme) with effect from Year 2026-27



Shahada Road, Near Nimzari Naka, Shirpur, Maharashtra 425405 Ph: 02563 259 802,

Web: www.rcpit.ac.in/mechanical-engineering-syllabus

Program: Mechanical Engineering	Final Y. B.Tech.	Semester: VII/VIII
Design for X (RCP23MCPE811)		

Prerequisites:

1. Fundamentals of Mechanical Engineering.
2. Fundamentals of Design, Manufacturing, and Assembly

Course Objectives:

1. To understand the fundamental principles of Design for X (DfX) and its role in product development.
2. To gain knowledge about DfX methodologies to optimize designs for manufacturability, cost, reliability, sustainability, safety, and maintainability.
3. To develop analytical skills to assess trade-offs between different DfX factors and make informed design decisions.
4. To gain knowledge of industry best practices, tools, and techniques used in DfX.
5. To explore emerging trends and future advancements in DfX, including additive manufacturing, IoT integration, and sustainability-driven designs.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Explain the fundamental principles of DfX and its role in optimizing product design for various factors such as manufacturability, reliability, cost, and sustainability.	L2	Explain
CO2	Apply Design for Manufacturability (DfM) principles to optimize material selection, process constraints, and design simplification for efficient manufacturing.	L3	Apply
CO3	Analyze product designs to minimize assembly complexity, reduce part count, and optimize cost through effective DfA and DfC strategies.	L4	Analyze
CO4	Evaluate reliability and sustainability factors in product design using techniques such as Failure Modes and Effects Analysis (FMEA) and Life Cycle Assessment (LCA).	L5	Evaluate
CO5	Evaluate, safety, maintainability, and serviceability considerations into product design to enhance usability, longevity, and compliance with industry standards.	L5	Evaluate
CO6	Develop an optimized product design by integrating multiple DfX principles and using digital tools such as CAD, simulation, and AI-driven optimization.	L6	Develop

Design for X (RCP23MCPE811)

Course Contents

Unit-I **07 Hrs.**

Introduction to Design for X

Definition and Philosophy of DfX: Understanding “X” as a variable representing key design considerations, Holistic and proactive approach to engineering design, Emphasis on life-cycle thinking. Importance of DfX in Product Development: Duration 8 Enhancing product quality, usability, and competitiveness, Reducing time-to-market and development cost, Supporting innovation while mitigating risks. Role of DfX in the Product Development Cycle: Integrating DfX early in the concept and design stages. Cross-functional collaboration (design, manufacturing, supply chain, sustainability, etc.). Aligning with customer requirements and business goals.
Overview of Key DfX Disciplines: Design for Manufacturability (DfM), Design for Assembly (DfA), Design for Cost (DfC), Design for Reliability (DfR), Design for Sustainability (DfS) , Design for Safety (DfSa), Design for Maintainability & Serviceability (DfM&S).
Case studies on successful DfX applications: Real-world examples of successful DfX applications from industries like automotive, aerospace, electronics, and consumer goods. Analysis of the impact of DfX on cost, quality, time, and environmental performance.

Unit-II **08 Hrs.**

Design for Manufacturability (DfM)

Principles of Manufacturability:
Designing products for ease, efficiency, and cost-effectiveness in manufacturing, Avoiding overly complex geometry and unnecessary features, Material Selection and Process Constraints: Matching materials to manufacturing processes and product requirements, Consideration of formability, machinability, weldability, etc. Tolerance Analysis and Design Simplification: Importance of tolerancing in manufacturability and quality, GD&T basics and statistical tolerance stacking, Simplifying part geometry to reduce processing steps.
Design Guidelines for Key Manufacturing Processes:
Casting: Uniform wall thickness, draft angles, and riser design. Machining: Tool access, fixturing, and reducing setup changes. Injection Molding: Parting lines, flow paths, undercuts, and sink marks. Sheet Metal: Bend radii, material usage, and nesting. Additive Manufacturing: Layer orientation, support structures, and topology optimization.
Tools and Techniques: DFM/DFA software tools (DFMPro, DesignSpark, etc.), Case examples of design changes that improved manufacturability.

Unit-III **0 Hrs.**

Design for Assembly (DfA) and Design for Cost (DfC):

Design for Assembly (DfA)
Principles of Assembly Efficiency: Minimizing assembly time, tools, and labor, Reducing orientation sensitivity. Minimizing Part Count and Fasteners:
Use of multifunctional and self-locating parts, Snap-fits, interlocking components, and integrated designs.
Modular Design and Standardization: Plug-and-play components, Reusability across product lines and platforms.
Automated Assembly Considerations: Robotics and automation-friendly design, Avoiding small, fragile, or asymmetrical parts.
Design for Cost (DfC):

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Cost Modelling Techniques: Parametric costing, activity-based costing. Material and Process Cost Trade-offs: Evaluating performance vs. cost. Design Simplifications for Cost Reduction: Standard components, simplified assemblies.
Life Cycle Cost Analysis: CAPEX, OPEX, maintenance, and end-of-life.

Unit-IV **09 Hrs.**

Design for Reliability (DfR) and Design for Sustainability (DfS):

Design for Reliability (DfR)
Failure Modes and Effects Analysis (FMEA): Systematic identification and ranking of potential failure modes, Risk Priority Number (RPN) and mitigation strategies.
Reliability Prediction and Testing Methods: MTBF (Mean Time Between Failures), Weibull analysis, Accelerated life testing, environmental testing.
Fatigue, Wear, and Durability: Stress-life and strain-life approaches, Material selection and design against degradation.
Redundancy and Fault-Tolerant Design: Backup systems, graceful degradation, Criticality analysis and design for safe failure.
Design for Sustainability (DfS):
Environmental Impact (Energy consumption, emissions, waste), Life Cycle Assessment (LCA) (Cradle-to grave and cradle-to-cradle models), Sustainable Materials and Processes (Bio-based materials, green manufacturing), Circular Economy (Reuse, remanufacturing, recycling, and take-back systems).

Unit-V **09 Hrs.**

DfS, DfM&s, and Industry Trends

Design for Safety (DfS): Compliance with Safety Standards (ISO, OSHA, CE marking, etc.), Human Factors & Ergonomics (User interaction, comfort, and errors), Hazard Analysis Techniques (HAZOP, FTA (Fault Tree Analysis), ETA (Event Tree)), Fail-Safe and Foolproof Design (Interlocks, alarms, and error-proofing (Poka-yoke)).
Design for Maintainability & Serviceability (DfM&S): Ease of Inspection and Diagnostics (Access to critical components, onboard diagnostics), Modularity and Repairability (Plug-and-play modules, standardized connectors), Spare Parts and Accessibility Considerations (Common fasteners, openable enclosures), Predictive Maintenance and IoT Integration (Real-time monitoring, analytics-driven alerts).
Integrated DfX Approach: Cross-functional Optimization (Balancing manufacturability, cost, reliability, and sustainability), Trade-off and Decision-Making Techniques (Pareto analysis, QFD, TRIZ, multicriteria decision analysis).
Digital Tools and Software: CAD/CAM/CAE integration for DfX analysis, PLM (Product Lifecycle Management) platforms, AI, and machine learning in design optimization.
Industry Trends and Future Directions: Smart manufacturing, Industry 4.0, digital twins, DfX in circular economy and netzero goals, Role of generative design and design automation.

Books Recommended

Reference Books

1 George Q. Huang, Design for X: Concurrent Engineering Imperatives, Springer London, 1996.

2 Geoffrey Boothroyd, Peter Dewhurst, and Winston Knight, Product Design for Manufacture and Assembly, CRC Press, 2010.

3 Gerhard Pahl and Wolfgang Beitz, Engineering Design: A Systematic Approach, Springer London, 2007.

4 David M. Anderson, Design for Manufacturability: How to Use Concurrent Engineering to Rapidly Develop Low-Cost, High-Quality Products for Lean Production, CRC Press, 2014.

5 Bryan R. Fischer, Mechanical Tolerance Stackup and Analysis, CRC Press, 2011.

6 Peter Sandborn, Cost Analysis of Electronic Systems, World Scientific Publishing, 2013.

7 E. E. Lewis, Reliability Engineering, Dover Publications, 1996.

8 Patrick D. T. O'Connor and Andre Kleyner, Practical Reliability Engineering, Wiley, 2012.

9 David T. Allen and David R. Shonnard, Sustainable Engineering: Principles and Practice, Pearson Education, 2011.

10 Louis J. Gullo and Jack Dixon, Design for Safety, Wiley, 2018.

11 Mark S. Sanders and Ernest J. McCormick, Human Factors in Engineering and Design, McGraw-Hill, 1993.

12 B. S. Dhillon, Maintainability, Maintenance, and Reliability for Engineers, CRC Press, 2006.

13 Andrew Kusiak, Concurrent Engineering: Contemporary Issues and Modern Design Tools, Wiley, 1993.

Web References

1 Dassault Systèmes https://www.3ds.com/store/cad/design-for-x

2 ANSYS https://www.ansys.com/en-in/blog/what-is-dfx

Program: Mechanical Engineering	Final Y. B.Tech.	Semester: VII/VIII
Air Handling Units (RCP23MCPE812)		

Prerequisites:

1. Fundamentals of mechanical, electronics, and electrical engineering.
2. Fundamentals of Fluid Mechanics, Thermodynamics, and Heat Transfer.

Course Objectives:

1. To Understand the Fundamentals of AHUs and Airflow Principles.
2. To study the Components and Construction of AHUs.
3. To gain the knowledge of AHU Design, Sizing, and Selection Criteria.
4. To explore AHU Control Systems and Automation
5. To develop Skills for AHU Installation, Commissioning, and Maintenance.
6. To develop skills to Analyze Industry Applications and Future Trends in AHUs.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Explain the fundamentals, airflow principles, classification, and functions of Air Handling Units in HVAC systems.	L2	Explain
CO2	ExplainAnalyze the construction, components, and performance characteristics of AHUs for different HVAC applications.	L4	Analyze
CO3	Apply design principles for sizing, selection, and performance optimization of AHUs based on system requirements.	L3	Apply
CO4	Apply control strategies, sensors, actuators, and automation techniques for efficient AHU operation.	L3	Apply
CO5	Apply installation, commissioning, testing, troubleshooting, and preventive maintenance procedures for AHUs.	L3	Apply
CO6	Evaluate energy-efficient technologies, industrial applications, sustainability practices, and future trends in AHUs.	L5	Evaluate

Air Handling Units (RCP23MCPE812)

Course Contents

Unit-I **09 Hrs.**

Fundamentals of Air Handling Units (AHUs) and Airflow Principles

- Introduction to Air Handling Units (AHUs): Definition, Purpose, and Importance of AHUs; Role of AHUs in HVAC Systems and Building Management; Basic Structure and Working Principle
- Principles of Airflow in AHUs: Concepts of Airflow, Static Pressure, and Velocity; Psychrometrics and Air Conditioning Processes; Ventilation: Fresh Air, Recirculated Air, and Exhaust Air; Air Distribution Systems:
- Classification and Types of AHUs: Centralized vs. Decentralized AHUs; Packaged AHUs vs. Custom-Built AHUs; Indoor vs. Outdoor AHUs; Modular vs. Integrated AHUs
- Industry Standards and Regulations: ASHRAE, ISO, and EN Standards for AHUs; Air Quality Standards and Energy Regulations

Unit-II **09 Hrs.**

AHU Components and Their Functions

- Components: AHU Casing: Materials, Insulation, and Construction; Fans and Blowers: Types, Selection Criteria, and Efficiency; Fan Laws and Performance Curves; Variable Frequency Drives (VFDs) and Energy Optimization
- Air Filtration Systems: Types of Filters: Pre-Filters, Bag Filters, HEPA, Carbon Filters; Filtration Efficiency and Pressure Drop Considerations; Filter Replacement, Cleaning, and Maintenance Strategies
- Air Treatment Components: Cooling and Heating Coils; Humidifiers and Dehumidifiers; Dampers and Louvers; Heat Recovery Systems (HRV, ERV) and Energy Efficiency

Unit-III **08 Hrs.**

Design, Sizing, and Selection of AHUs

- AHU System Design Principles: Load Calculations for AHU Sizing, Airflow Rate and Capacity Calculations, Heat Load Considerations for Cooling and Heating Coils
- AHU Selection Criteria: Application-Based AHU Selection (Commercial, Industrial, Healthcare, etc.), Sizing and Capacity Planning (CFM, ESP, Face Velocity), Fan Selection Based on System Resistance and Duct Design
- Energy Efficiency and Performance Optimization: AHU Efficiency Metrics (COP, SEER, and EER), Variable Air Volume (VAV) vs. Constant Air Volume (CAV) Systems, Energy Recovery Strategies (Heat Exchangers, Enthalpy Wheels)

Unit-IV **08 Hrs.**

A

HU Control Systems and Automation

- Control Strategies: Temperature, Humidity, and Pressure Control; Airflow Regulation and Demand-Based Ventilation

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- Sensors and Actuators: Temperature and Humidity Sensors; CO and Air Quality Sensors; Actuators for Dampers and Valves
- Smart AHUs and IoT-Enabled Control: Role of Artificial Intelligence and Machine Learning in AHUs; Predictive Maintenance using IoT

Unit-V **08 Hrs.**

Installation, Commissioning, and Applications

- Installation and Site Considerations: AHU Placement (Indoor vs. Outdoor); Ductwork Connections and Air Distribution Considerations; Condensate Drainage and Water Management
- Testing and Commissioning of AHUs: Pre-Commissioning Checklist and Procedures; Airflow Measurement and Balancing; Performance Testing and Functional Verification
- Industry Applications and Future Trends
  - Application-Specific AHU configurations: Commercial Buildings; Industrial Applications; Healthcare and Clean-room; Data Centers
  - Future Challenges and Market Trends: Market Growth and Emerging Technologies; Challenges in Retrofitting old AHUs; Impact of Regulations on Future AHU Design.

Books Recommended

Textbooks

1 Roger Legg, Air Handling Systems Design, CRC Press, 2018.

2 Ronald H. Howell, William J. Coad, Harry J. Sauer Jr., Ventilation, and Air Conditioning: ASHRAE (American Society of Heating, Refrigerating, and Air-Conditioning Engineers, 2017.

3 Stanley E. Cummings, Airflow in Ducts and Fans, Elsevier, 2018.

4 William Cory, Fans and Ventilation: A Practical Guide, 2007. . A. Wallis, Centrifugal and Axial Flow Fans: Design and Applications, John Wiley & Sons.

Reference Books

1 Frank P. Bleier, Fan Handbook: Selection, Application, and Design, McGraw-Hill, 2009.

2 Faye C. McQuiston, Jerald D. Parker, Jeffrey D. Spitler, Heating, Ventilating, and Air Conditioning: Analysis and Design, Wiley publication, 2005.

Web References

1 Refrigeration and Air-conditioning
https://onlinecourses.nptel.ac.in/noc19$_m$e58

Program: Mechanical Engineering	Final Y. B.Tech.	Semester: VII/VIII
Digital Manufacturing (RCP23MCPE813)		

Prerequisites:

1. Fundamentals of CAD/CAM.

Course Objectives:

1. To focus on equipping the students with the knowledge and skills to leverage digital technologies in the manufacturing process.
2. To gain knowledge about digital manufacturing planning process.
3. To study CAD/CAM/CAE integration in digital manufacturing.
4. To gain knowledge digital twin and industrial internet of things.
5. To study cyber security issues in digital manufacturing environment.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Explain the various steps involved in digital manufacturing and smart factory concepts.	L2	Understand
CO2	Explain the architecture of Industry 4.0 in the digital manufacturing planning process.	L2	Understand
CO3	Analyze the benefits of CAD/CAM/CAE in the digital manufacturing process.	L4	Analyze
CO4	Identify and evaluate cybersecurity issues in the digital manufacturing environment.	L5	Evalute

Digital Manufacturing (RCP23MCPE813)

Course Contents

Unit-I **08 Hrs.**

Introduction to Digital Manufacturing

Evolution of conventional manufacturing to Digital Manufacturing (DM); concept and significance of digital transformation; drivers of digital transformation in manufacturing; three dimensions of digital manufacturing; Cyber-Physical Systems (CPS); Industrial Internet of Things (IIoT); digital thread and digital twin in manufacturing; need and components of digital infrastructure; challenges in implementing digital transformation; outcomes and benefits of digital transformation for industrial enterprises.

Unit-II **10 Hrs.**

Industry 4.0 and Digital Manufacturing Planning

Overview and progression of Industry 4.0; core components and enabling technologies; integration and connectivity of cyber physical systems within manufacturing environments; current status and trends of Industry 4.0 adoption in India; six fundamental design principles of Industry 4.0; reference architectures and standard models for Industry 4.0; comparative analysis of digital manufacturing models and their adaptability; digital resource modelling and factory level simulation techniques; digital manufacturing planning methodologies; integration of ERP systems with value chain management; and the role of validation and virtual commissioning in successful digital manufacturing implementation.

Unit-III **08 Hrs.**

CAD/CAM and CAE in Digital Manufacturing

Introduction to CAD/CAM systems; geometric modelling concepts and modelling kernels; computer aided geometric modelling systems; component and assembly design methodologies; simulated motion analysis of machine components; fundamentals and procedures of finite element modelling and analysis (FEA); computer aided engineering (CAE) implementation in product and process design; application of automation in digital manufacturing environments; principles of geometric dimensioning and tolerancing (GD&T); introduction to computer aided fixture design.

Unit-IV **09 Hrs.**

Digital Twin and Industrial Internet of Things (IIoT)

Digital Twin: Introduction to digital twins and their working principles; applications of digital twins in manufacturing systems; scalability and complexity considerations in digital twin development; role of digital twins in the automotive industry; digital twins platform architecture and ecosystem; challenges, risks, and limitations associated with digital twin implementation.
IIOT: Introduction to the Industrial Internet of Things (IIoT); role of sensor technologies in industrial applications; impact of IIoT on productivity, safety, and security; fundamentals of cloud computing for industrial data management; structure and components of the IIoT ecosystem; business value proposition of IIoT in manufacturing and industrial enterprises; challenges, risks, and limitations associated with IIoT deployment.

Unit-V **07 Hrs.**

Cybersecurity/ Big Data Security in Digital Manufacturing

Introduction to cybersecurity concepts in digital manufacturing, including threats, vulnerabilities, and attacks; network and system security measures such as wireless security, firewalls, intrusion detection and prevention systems; security of industrial control systems including SCADA, PLCs, and critical ICS components; data security strategies for protecting intellectual property, customer, and operational data using encryption, access control, and data loss prevention techniques; identification and mitigation of cybersecurity risks in digital manufacturing environments.

Books Recommended

Textbooks

1 Sunil Mudumala, Leading Digital Transformation in Manufacturing Industry 4.0.

2 J. Paulo Davim , Kaushik Kumar, Divya Zindani , J. Paulo Davim, Digital Manufacturing and Assembly Systems in Industry 4.0, Taylor and Francis, 2021.

3 Mark J. Barrenechea, Tom Jenkins, Digital Manufacturing, Waterloo, 2018.

4 Y. Koren, "The Global Manufacturing Revolution", John Wiley & Sons, 2010.

5 Chandrakant D. Patel, Chun-Hsien Chen, Digital Manufacturing, Elsevier, 2024.

Reference Books

1 Andries Feikema, Digital Transformation in Procurement, Koganpage, 2025.

2 Lane Thames, Dirk Schaefer, Cybersecurity for Industry 4.0, Springer, 2017.

3 R Sujatha, G Prakash, Noor Zaman Jhanjhi, Cyber Security Applications for Industry 4.0, Chapman & Hall, 2024.

Web References

1 The Future of Manufacturing Business: Role of Digital Technologies
https://onlinecourses.nptel.ac.in/noc21_mg83

2 Industry 4.0: Managing The Digital Transformation
https://onlinecourses.nptel.ac.in/noc26_ge04/

Program: Mechanical Engineering	Final Y. B.Tech.	Semester: VII/VIII
Lean Manufacturing (RCP23MCPE814)		

Prerequisites:

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Course Objectives:

1. Develop observation and labelling skills for shop-floor safety and cleanliness.
2. Trace manufacturing evolution from craft to lean systems.
3. Understand essential factory concepts and lean operations.
4. Master flow management, time-motion study, and visual mapping.
5. Apply lean tools for muda elimination and process improvement.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Apply observation skills using 4W1H labelling to identify unsafe conditions, hazards, and risks on shop floors.	L3	Apply
CO2	Explain the evolution of manufacturing, key challenges, and core lean principles from Toyota Production System.	L2	Understand
CO3	Explain factory essentials like business cycles, procurement, production, teamwork, and self-discipline in lean contexts.	L2	Understand
CO4	Analyze lean operations, identify eight mudas, and create process flow diagrams for flow improvement.	L4	Analyze
CO5	Apply 5S, takt time, and flow attributes to optimize material, space, and information flow and prepare visual maps (VMapQ) and	L3	Apply

Lean Manufacturing (RCP23MCPE814)

Course Contents

Unit-I **8 Hrs.**

Observation Skills and Manufacturing History

Observation Skills: Safety and cleanliness in factory site visits, pre-training observation test, "Seeing vs Observing", 4W1H format (What, Where, When, Who, How), language of label writing, steps in label grouping, identifying unsafe conditions/acts, hazard-risk understanding.
Manufacturing History: History of craftsmanship and its valuable lessons/practical needs, challenges of craft production, mass manufacturing and interchangeable parts/assembly line, Ford's challenges and fall, Toyota's rise, core Lean Principles (eliminate waste, continuous improvement, respect for people), Lean vs Mass Production.
Practical: Factory site visit with 4W1H labeling exercise

Unit-II **8 Hrs.**

Factory Essentials and Lean Operations

Essential Factory Concepts: Business cycle overview, concepts in procurement/production/delivery, organization of people (men), types of material handling, self-discipline, time management, teamwork, brainstorming techniques, conflict management in shop-floor teams.
Lean Operations: Operations and functional silos (drawbacks, net negative impacts), Eight Muda (Overproduction, Waiting, Transport, Over-processing, Inventory, Motion, Defects, Unused Talent), eliminating muda through loops, Process Flow Diagram (PFD) creation, PFD case study analysis.
Practical: Teamwork exercise on brainstorming production bottlenecks.

Unit-III **9 Hrs.**

Flow Management Fundamentals

Flow Concepts: Concept of Flow vs Process, Time and Motion Study fundamentals, Takt Time calculation and significance, origination of muda in non-flow processes, characteristics of flow in manufacturing vs business processes.
Flow Attributes: Flow of material (one-piece flow principles), flow of information (pull systems intro), takt time application in line balancing, process vs flow comparison in mechanical manufacturing.
Practical: Takt time calculation exercise using mechanical assembly line data.

Unit-IV **9 Hrs.**

Visual Mapping and 5S

5S Methodology: Complete 5S implementation steps (Sort, Set-in-order, Shine, Standardize, Sustain) with mechanical engineering examples.
VMapQ Family (Visual Mapping): Introduction to VMapQ, benefits and stages of VMapQ creation, visualizing material flow, space allocation mapping, safety issues visualization. VMapQ Creation Process: Guidelines, Step 1-8 detailed process (current state mapping, proposed improvements), VMapQ Step 5-6 (waste identification), Step 7-8 (Kaizen proposals).
Practical: Hands-on VMapQ creation for a mechanical workshop.

Unit-V **8 Hrs.**

Lean Implementation and Improvement

Lean Deployment: Integrating observation, flow, VMapQ tools for Kaizen events, MIJSC case studies from automotive/SME sectors, lean leadership, and employee involvement.

Implementation Challenges: Barriers in Indian manufacturing SMEs, performance measurement (productivity, quality, delivery metrics), and shop-floor transformation roadmap.
Project Work: Complete a lean improvement proposal using VMapQ methodology on a real manufacturing process (auto-components/sheet metal preferred).
Practical: Group project presentation on VMapQ-based improvement proposal.

Books Recommended

Textbooks

1 The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer by Jeffrey K. Liker (5th Edition, McGraw-Hill, 2021).

2 Lean Thinking: Banish Waste and Create Wealth in Your Corporation by James P. Womack and Daniel T. Jones (Simon & Schuster, 2003).

3 Lean Manufacturing: Fundamentals, Tools, Approaches, and Industry 4.0 Integration by S. Vinodh (CRC Press, 2022).

Reference Books

1 Learning to See: Value Stream Mapping to Add Value and Eliminate Muda by Mike Rother and John Shook (Lean Enterprise Institute, 1999).

2 The Lean Six Sigma Pocket Toolbook: A Quick Reference Guide to Nearly 100 Tools by Michael L. George, John Maxey, David T. Rowlands, and Mark Price (McGraw-Hill, 2005).

3 Kaizen Express: Fundamentals for Becoming a Lean Enterprise by Toshiko Narusawa and Masaaki Imai (Lean Enterprise Institute, 2007).

Web References

1 SWAYAM Foundations of Lean Manufacturing Course (IMB24_MG119)
https://onlinecourses.swayam2.ac.in/imb24_mg119/preview
- Free modules on observation, VMapQ, and flow matching syllabus.

2 Mizuho India Japan Study Center (MIJSC) Lean Manufacturing Program
https://www.iimb.ac.in/mijsc/lean-manufacturing-transformation.php
- Brochures, case studies, and VLCI-aligned resources for industry application

Program: Mechanical Engineering	Final Y. B.Tech.	Semester: VII/VIII
Soft Computing and Optimization Techniques (RCP23MCPE815)		

Prerequisites:

1. Basic knowledge of Engineering Mathematics (linear algebra, calculus, optimization concepts)
2. Fundamentals of Probability and Statistics
3. Introductory understanding of Programming (Python/MATLAB)
4. Basic concepts of Artificial Intelligence / Data Analytics

Course Objectives:

1. To introduce the fundamental concepts of soft computing and intelligent systems, including uncertainty modeling and optimization principles.
2. To develop an understanding of fuzzy logic and hybrid systems for handling imprecision and real-world engineering problems.
3. To familiarize learners with evolutionary algorithms and their role in solving complex optimization problems.
4. To provide knowledge of swarm intelligence techniques and their applications in large-scale and non-linear optimization.
5. To equip learners with multi-criteria decision-making (MCDM) techniques for solving complex engineering decision problems under uncertainty.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Apply observation skills using 4W1H labelling to identify unsafe conditions, hazards, and risks on shop floors.	L3	Apply
CO2	Explain the evolution of manufacturing, key challenges, and core lean principles from Toyota Production System.	L2	Understand
CO3	Explain factory essentials like business cycles, procurement, production, teamwork, and self-discipline in lean contexts.	L2	Understand
CO4	Analyze lean operations, identify eight mudas, and create process flow diagrams for flow improvement.	L4	Analyze
CO5	Apply 5S, takt time, and flow attributes to optimize material, space, and information flow and prepare visual maps (VMapQ) and	L3	Apply

Soft Computing and Optimization Techniques (RCP23MCPE815)

Course Contents

Unit-I — 06 Hrs.

Foundations of Soft Computing and Intelligent Systems

- Concept of Soft Computing: Definition, characteristics, hybridization, and advantages over hard computing
- Uncertainty modeling: Approximate reasoning vs probabilistic reasoning
- Intelligent systems architecture: Learning, adaptation, and generalization
- Need and applications of soft computing in mechanical engineering
- Optimization Fundamentals: Global and local optima, problem formulation
- Introduction to optimization landscapes: multi-modal, convex, and non-convex functions, eigenvalue decomposition, singular value decomposition, high-dimensional
- Classification of optimization problems in machine learning
- Review and discussion of optimization methods: Linear Programming: Graphical method, Simplex method, Duality; Unconstrained Optimization: Gradient-based methods, Cauchy's steepest descent, Newton's method, Conjugate gradient method; Constrained Optimization: Direct methods, Penalty function methods, Steepest descent method (Only review is expected as these methods are discussed in semester III and IV. The questions should not be asked in the theory exam.)

Unit-II — 06 Hrs.

Fuzzy Logic and Hybrid Systems

- Fuzzy Set Theory: Fuzzy sets, operations, membership functions
- Fuzzy relations, propositions, implications, inference systems
- Defuzzification techniques
- Fuzzy Logic Controller (FLC): Design, rule base, inference mechanism

Unit-III — 11 Hrs.

Evolutionary Algorithms (EA)

- Introduction to EA, evolutionary computation concepts
- Genetic Algorithm (GA); Genetic Programming (GP); Evolutionary Programming (EP); Evolution Strategies (ES)
- Differential Evolution (DE); Cultural Algorithm (CA); Memetic Algorithms (MA); Co-evolutionary Algorithms
- Artificial Immune System (AIS); Biogeography-Based Optimization (BBO)

Unit-IV **11 Hrs.**

Swarm Intelligence Techniques

- Particle Swarm Optimization (PSO); Ant Colony Optimization (ACO); Artificial Bee Colony (ABC) Algorithm; Firefly Algorithm (FA); Cuckoo Search Algorithm (CSA)
- Bat Algorithm; Grey Wolf Optimizer (GWO); Whale Optimization Algorithm (WOA); Dragonfly Algorithm (DA)
- Grasshopper Optimization Algorithm (GOA); Salp Swarm Algorithm (SSA); Moth Flame Optimization (MFO); Ant Lion Optimizer (ALO)
- Cat Swarm Optimization (CSO); Glowworm Swarm Optimization (GSO); Introduction to hybrid / emerging techniques: Hybrid GA–PSO; neuro-evolution techniques; fuzzy evolutionary algorithms; Quantum-inspired evolutionary algorithms; multi-objective evolutionary algorithms (MOEA – NSGA-II, SPEA2)

Unit-V **08 Hrs.**

Multi-Criteria Decision Making (MCDM)

- Introduction to decision-making in engineering systems
- Need for MCDM in complex mechanical engineering problems
- Types of decision-making environments: deterministic, uncertain, fuzzy
- Basic concepts of MCDM: Alternatives, criteria, attributes; Decision matrix formulation; Criteria weighting and normalization techniques
- Classification of MCDM methods
- Analytical Hierarchy Process (AHP):
- Technique for Order Preference by Similarity to Ideal Solution (TOPSIS):
- VIKOR Method:
- Entropy Method for criteria weight determination
- Fuzzy MCDM approaches: Fuzzy AHP, Fuzzy TOPSIS
- Handling uncertainty in decision-making

Books Recommended

Textbooks

1 Mangey Ram, and Suraj B. Singh, Soft Computing: Techniques om Engineering Sciences, De Gruyter, 2020.

2 S. Chakraverty, Deepti M. Sahoo, and Nisha R. Mahato, Concept of Soft Computing: Fuzzy and ANN Programming, Springer Nature Singapore, 2019.

3 Ashish M. Gujarathi, B. V. Babu, Evolutionary Computation: Techniques and Applications, CRC Press 2016.

4 Tettamanzi Andrea, Tomassini and Marco, Soft Computing Integrating Evolutionary, Neural, and Fuzzy Systems, Springer, 2001.

5 Singiresu S Rao, Engineering Optimization Theory and Practice, John Wiley & Sons Inc. 2019

6 Parag Kulkarni and Prachi Joshi, "Artificial Intelligence – Building Intelligent Systems", PHI learning Pvt. Ltd., 2015

Reference Books

1 Deisenroth, Faisal, Ong, Mathematics for Machine Learning, Cambridge University Press, 2020.

2 X. Yao,Evolutionary Computation: Theory and Applications, World Scientific Publ. Co., Singapore, 1999.

3 Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, “Digital Image Processing Using MATLAB”, Third Edition Tata Mc Graw Hill Pvt. Ltd., 2011.

4 Solanki, Kumar, Nayyar, Emerging Trends and Applications of Machine Learning, IGI Global, 2018.

5 Mohri, Rostamizdeh, Talwalkar, Foundations of Machine Learning, MIT Press, 2018.

6 Kumar, Zindani, Davim, Artificial Intelligence in Mechanical and Industrial Engineering, CRC Press, 2021.

Web References

1 Introduction to Soft Computing
https://onlinecourses.nptel.ac.in/noc26_cs44/preview

2 Soft Computing Techniques
https://onlinecourses.swayam2.ac.in/e-learning/preview/ntr26_ed73

3 Soft Computing Techniques
https://onlinecourses.nptel.ac.in/noc26_ma35/preview

4 Evolutionary Computation For Single And Multi-Objective Optimization
https://onlinecourses.nptel.ac.in/noc26_me17/preview1

Program: Mechanical Engineering	Final Y. B.Tech.	Semester: VII/VIII
Startup Registration and Development (RCP23MCPE816)		

Prerequisites:

1. Fundamentals of Business Development
2. Entrepreneurial Business Models

Course Objectives:

1. To enable learners to understand the complete startup registration process, legal structures, and initial compliance requirements in India.
2. To equip learners with knowledge of government policies, incentives, and funding opportunities available for startups.
3. To develop practical skills for preparing essential business documents and protecting intellectual property.
4. To enable learners to evaluate fundraising strategies and financial planning for early-stage startups.
5. To ensure understanding of taxation, auditing, and regulatory compliance for sustainable startup growth.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Execute appropriate legal structures and complete the startup registration process with required compliances.	L3	Apply
CO2	Apply government schemes, incentives, and funding policies effectively for startup development.	L3	Apply
CO3	Implement key registration documents and implement intellectual property protection strategies.	L3	Apply
CO4	Formulate financial models and fundraising plans suitable for engineering-based startups.	L6	Create
CO5	Employ taxation, auditing, and regulatory requirements while planning for business growth.	L3	Apply

Startup Registration and Development (RCP23MCPE816)

Course Contents

Unit-I **10 Hrs.**

Introduction to Startup Registration.

Definition, types, and importance of startups in the Indian economy. Comparison of different legal structures such as Proprietorship, LLP, Private Limited, and Public Limited companies. Step-by-step process of business registration, including necessary approvals and filings. Case studies on successful and challenging startup registrations with a focus on mechanical and engineering ventures.

Unit-II **08 Hrs.**

Government Policies and Incentives for Startups.

Overview of Startup India initiative, MSME schemes, and other relevant government policies. Tax benefits, grants, subsidies, and financial incentives available to startups. Public and private funding support mechanisms. Case studies of startups that successfully leveraged government incentives for early growth.

Unit-III **08 Hrs.**

Business Compliance and Documentation.

Preparation of important documents, including Memorandum of Association, Articles of Association, GST registration, and UDYAM certification. Obtaining necessary business licenses, permits, and compliance reports. Understanding business ethics, legal challenges, and documentation best practices for engineering startups.

Unit-IV **08 Hrs.**

Intellectual Property Rights for Startups.

Importance of Patents, Trademarks, Copyrights, and Trade Secrets for protecting innovations in mechanical and engineering fields. Filing procedures, legal aspects, and maintenance of IPR. IP commercialization, licensing strategies, and case studies on successful IP protection by startups.

Unit-V **08 Hrs.**

Fundraising, Taxation, Compliance, and Growth Strategies.

Seed funding, angel investors, venture capital, and crowdfunding options. Investor relations, pitching techniques, term sheets, and equity dilution concepts. GST, corporate tax, financial reporting, auditing, and legal risk management. Business growth pathways, including mergers, acquisitions, and IPOs, along with finalization of the startup business plan and course review.

Books Recommended

Reference Books

1 Purohit, Prachi. Startup India: The Complete Guide to Launching and Managing a Business. Notion Press, Chennai, 2021.

2 Joshi, M.V. Entrepreneurship Development and Startup India. Himalaya Publishing House, Mumbai, 2020.

3 Pathak, Akhileshwar. Legal Aspects of Business. McGraw Hill, New Delhi, 2018.

4 Hegde, Dinesh S. Indian Startups and their Funding Journey. Springer, New Delhi, 2021.

5 Sharma, Rajat. Business Laws for Entrepreneurs. Pearson, New Delhi, 2019.

6 Blank, Steve, and Bob Dorf. The Startup Owner's Manual. K&S Ranch Publishing, Pescadero, 2012.

7 Feld, Brad, and Jason Mendelson. Venture Deals: Be Smarter Than Your Lawyer and Venture Capitalist. Wiley, New Jersey, 2019.

8 Desai, Vasant. Entrepreneurship Development in India. Himalaya Publishing House, Mumbai, 2019.

Program: Mechanical Engineering	Final Y. B.Tech.	Semester: VII/VIII
Hydrogen Powered Vehicles (RCP23MCPE817)		

Prerequisites:

1. Fundamentals of mechanical, electronics, and electrical engineering.
2. Fundamentals of chemistry, physics, and engineering mechanics.

Course Objectives:

1. To understand the fundamentals of hydrogen as a clean energy carrier, including its properties, production methods, and role in the global energy landscape.
2. To explain the working principles, types, and material aspects of hydrogen fuel cells used in transportation systems.
3. To analyze hydrogen storage techniques, distribution infrastructure, and safety standards for practical implementation.
4. To develop an understanding of the design, architecture, and integration of hydrogen-powered vehicle systems.
5. To evaluate environmental, economic, and technological aspects of hydrogen mobility for sustainable development.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Analyze hydrogen production methods, properties, and types to assess their environmental impact in energy applications.	L4	Analyze
CO2	Analyze different fuel cell technologies, their working principles, materials, and performance characteristics.	L4	Analyze
CO3	Evaluate hydrogen storage methods, infrastructure requirements, and safety practices in hydrogen systems.	L5	Evaluate
CO4	Analyze the architecture, subsystem integration, and performance of hydrogen-powered vehicles.	L4	Analyze
CO5	Analyze the environmental impacts, economic feasibility, and future trends of hydrogen technology in sustainable transportation systems.	L4	Analyze

Hydrogen Powered Vehicles (RCP23MCPE817)

Course Contents

Unit-I **08 Hrs.**

Hydrogen Fundamentals and Production

- Hydrogen as an energy carrier: Properties, advantages, and limitations
- Global hydrogen economy: Opportunities, challenges, and applications in transportation
- Physical and chemical characteristics relevant to transportation.
- Hydrogen production methods: Steam reforming, electrolysis, biomass gasification, thermochemical methods
- Types of hydrogen: Grey, blue, green – environmental impact comparison
- Water splitting using renewable energy sources

Unit-II **08 Hrs.**

Hydrogen Fuel Cells – Principles and Materials

- Working principles of fuel cells: PEMFC, SOFC, DMFC
- Performance characteristics, advantages, limitations, and comparative analysis
- Thermodynamic principles and efficiency of fuel cells
- Materials in fuel cells: Catalysts, membranes, bipolar plates, gas diffusion layers, electrodes
- Material selection criteria and degradation mechanisms
- Challenges: Durability, cost, and efficiency improvement strategies

Unit-III **08 Hrs.**

Hydrogen Storage, Infrastructure, and Safety

- Hydrogen storage methods: Compressed, liquid, metal hydrides, chemical and solid-state storage
- Hydrogen transportation and refueling infrastructure
- Design and operation of hydrogen refueling stations
- Safety considerations: Handling, storage, and transportation risks
- Codes, standards, and regulations for hydrogen systems
- Cost and feasibility analysis of hydrogen logistics
- Emerging technologies in hydrogen storage and distribution

Unit-IV **10 Hrs.**

Design and Architecture of Hydrogen-Powered Vehicles

- Vehicle architecture: Fuel cell stack, hydrogen tank, electric drivetrain, auxiliary systems
- Fuel cell integration into vehicle platforms and hybrid systems
- Power management systems and hybrid configurations
- Thermal management of fuel cells
- Integration with digital technologies: IoT and AI for monitoring and optimization
- Comparison: Hydrogen-powered vehicles vs BEVs and ICE vehicles
- Regulations and standards for hydrogen-powered vehicles
- Case studies: Toyota Mirai, Hyundai Nexo, Honda Clarity Fuel Cell

Unit-V **08 Hrs.**

Environmental Impact, Economics, and Future Trends

- Life Cycle Assessment (LCA) of hydrogen-powered vehicles
- Environmental and economic benefits of hydrogen technology
- Policies and global initiatives (EU Hydrogen Strategy, Japan Hydrogen Roadmap)
- Economic viability and market potential of hydrogen vehicles
- Barriers to large-scale adoption and mitigation strategies
- Hydrogen in renewable energy integration and energy storage
- Applications in heavy-duty transport (buses, trucks, trains, ships, aircraft)
- Emerging trends: Autonomous hydrogen vehicles and advanced fuel cell technologies
- Case reference: Hindenburg Disaster and modern safety advancements
- Contribution to Sustainable Development Goals: SDG 7 (Clean Energy), SDG 13 (Climate Action)

Books Recommended

Textbooks

1 Pasquale Corbo, Fortunato Migliardini, Ottorino Veneri, Hydrogen Fuel Cells for Road Vehicles, Springer London, 2011.

2 Marco Alverà, The Hydrogen Revolution: A Blueprint for the Future of Clean Energy, Hodder & Stoughton, 2021.

3 Paulo Emilio Miranda, Science and Engineering of Hydrogen-Based Energy Technologies: Hydrogen Production and Practical Applications in Energy Generation, Elsevier Science, 2018.

4 Catherine Azzaro-Pantel, Hydrogen Supply Chain: Design, Deployment and Operation, Elsevier Science, 2018.

5 Shigenori Mitsushima, Viktor Hacker, Fuel Cells and Hydrogen: From Fundamentals to Applied Research, Elsevier, 2018.

6 Adolfo Iulianelli, Angelo Basile, Advances in Hydrogen Production, Storage and Distribution, Woodhead Publishing, 2014.

Reference Books

1 Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Practice, CRC Press, 2009.

2 Mehmet Sankir, Nurdan Demirci Sankir, Hydrogen Electrical Vehicles, Wiley, 2023.

3 Akari Hayashi, Hai-Wen Li, Junichiro Yamabe, Kazunari Sasaki, Stephen M. Lyth, Teppei Ogura, Hydrogen Energy Engineering: A Japanese Perspective, Springer Japan.

4 Selim Koca, Transition to Hydrogen Fuel Cell Vehicles, Nova Science Publishers, 2010.

5 Ronald K. Jurgen, Fuel Cell Hybrid EVs, SAE International, 2010.

6 Amgad Elgowainy, Electric, Hybrid, and Fuel Cell Vehicles, Springer New York, 2021.

7 Joseph M. Norbeck, Thomas Durbin, James Heffel, Michelle Montano, Hydrogen Fuel for Surface Transportation, SAE International, 1996.

8 James John MacKenzie, The Keys to the Car: Electric and Hydrogen Vehicles for the 21st Century, World Resources Institute, 1994.

Web References

1 Hydrogen Energy: Production, Storage, Transportation and Safety
https://nptel.ac.in/courses/103101215

2 Cryogenic Hydrogen Technology
https://nptel.ac.in/courses/112105422

3 Fuel Cell Technology
https://nptel.ac.in/courses/103102015

Program: Mechanical Engineering	**Final Y. B.Tech.**	**Semester: VII/VIII**
Internship (OJT) cum Project (RCP23IPELX11		

Prerequisites:

1. Fundamental knowledge of engineering concepts and programming
2. Basic understanding of professional ethics and communication skills
3. Exposure to laboratory courses and mini-projects
4. Teamwork and problem-solving skills

Course Objectives:

1. To provide practical exposure to industrial and professional environments.
2. To bridge the gap between academic learning and industry practices.
3. To develop technical, communication, teamwork, and managerial skills.
4. To enable application of engineering knowledge for solving real-world problems.
5. To familiarize students with modern tools, technologies, and professional ethics.
6. To prepare students for industry-oriented careers through project implementation and professional experience.

Course Outcomes:

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

CO	**Course Outcomes**	**Bloom's Level**	**Bloom's Description**
CO1	Apply engineering knowledge and technical skills in industrial environments.	L3	Apply
CO2	Analyze and solve practical engineering problems using appropriate tools and techniques.	L4	Analyze
CO3	Demonstrate professional ethics, teamwork, communication, and organizational skills.	L3	Apply
CO4	Utilize modern engineering tools and technologies for assigned tasks and projects.	L3	Apply
CO5	Prepare technical reports, presentations, and project documentation effectively.	L6	Create
CO6	Adapt to professional work culture and demonstrate readiness for professional careers.	L3	Apply

Internship (OJT) cum Project (RCP23IPELX11

Overview of the OJT Process

The On-Job Training (OJT) program begins with an introduction to workplace ethics, safety practices, organizational culture, and professional conduct to prepare students for industrial environments. Students are then exposed to industrial processes, workflow practices, tools, and modern technologies relevant to their domain of study.
During the technical training phase, students work on assigned industrial tasks and projects under the guidance of faculty mentors and industry supervisors. The program emphasizes the application of engineering concepts, teamwork, communication skills, and problem-solving abilities in real-world professional settings.
The later stages of the OJT focus on project implementation, report writing, technical documentation, and presentation preparation. Students are required to maintain logbooks and progress records throughout the training period. At the end of the semester, students present their project work through demonstrations and viva-voce examinations, followed by comprehensive evaluation and feedback.

Internship (OJT) Schedule, Duration and Credits

The Internship / On-Job Training (OJT) cum Project is an integral part of the Final Year B.Tech. program and carries a total of **18 academic credits** toward completion of the degree requirements. Each credit corresponds to **40 hours** of work, resulting in approximately **550-600 hours** of industrial training and project work over one semester.
The full-time OJT program is conducted during the designated semester as per the academic. schedule. The duration of the OJT is one complete semester in the final year. Faculty mentors are assigned for mentoring, monitoring, and evaluating students throughout the OJT period.
Approximately 50% of the students undergo OJT during Semester VII while the remaining students continue academic activities in the institute. In Semester VIII, the arrangement is interchanged to ensure equal academic and industrial exposure for all students.
To avoid academic scheduling conflicts and ensure fair evaluation, oral, practical, and End Semester. Examinations for both Semester VII and Semester VIII will be conducted at the end of Semester VIII. Students are issued a combined marksheet covering both semesters.

Types of External OJT Opportunities

Sr. No.	Type of OJT	Examples / Description
1	Industry OJT	Industrial internships with or without stipend.
2	Government / PSU OJT	BARC, SAMEER, Railways, ISRO, etc.
3	Research OJT	IITs, NITs, IISc, IIMs, and other research institutes.
4	Institute-Based OJT	OJT at institutes approved by DJSCE and departments.
5	Other Approved OJT	Any approved industrial/research work relevant to the domain.

OJT / Internship Sources

To facilitate OJT and internship opportunities, AICTE has signed Memorandums of Understanding (MoUs) with various industries, government organizations, and training institutions. These collaborations provide students with industrial exposure, skill development opportunities, research internships, and professional training through multiple recognized platforms and organizations.
Students may also approach organizations such as the Board of Apprenticeship Training (BOAT) and Board of Practical Training (BOPT) for additional training opportunities.

Mechanical Department R.C.P.I.T. OFFICE SEAL SHIRPUR

Major OJT / Internship Sources

Sr. No.	Organization / Platform	Nature of Opportunity
1	Internshala	Internship and industry training opportunities
2	NETiit (Taiwan)	International internship opportunities
3	HireMee	Skill-based internships and employability support
4	IGNCA	Research and cultural project opportunities
5	CCEI, Republic of Korea	International innovation and creative economy internships
6	IIWM, Bangalore	Waste management and sustainability projects
7	Engineering Council of India (ECI)	Engineering and professional development activities
8	Fourth Ambit	Industry training and technical internships
9	LinkedIn	Professional networking and internship opportunities
10	Telecom Sector Skill Council (TSSC)	Telecom and communication technology training
11	SCHOLARSMERIT	Internship and skill enhancement programs
12	Studenting Era	Student internship and academic support activities
13	MSME	Industry exposure and entrepreneurship opportunities
14	BOAT	Apprenticeship and industrial training programs
15	BOPT	Practical and apprenticeship-based training opportunities

Evaluation Metrics

Sr. No.	Evaluation Component	Marks
1	Internal Review 1	100
2	Final Internal Review	100
3	End Semester Evaluation (OJT Viva / Presentation)	100
4	Project Report & Demonstration	100
	Total	**400**

Evaluation Parameters

The student shall be evaluated based on the following parameters:

- Understanding of assigned work.
- Progress and task completion.
- Technical skill development.
- Learning ability and initiative.
- Professional behaviour and discipline.
- Communication and presentation skills.

- Problem solving and contribution.
- Quality of work and innovation.
- Logbook maintenance and report documentation.
- Application of engineering knowledge.

Necessary Documents

Students are required to submit and maintain the following documents during the OJT period:

1. No Objection Certificate (NOC)
2. Undertaking for opting OJT
3. OJT Joining Form
4. Parent/Guardian Undertaking Form
5. Contact Details and OJT Objectives Form
6. Student Logbook / Daily Activity Record
7. Internal Review Evaluation Sheets
8. External Supervisor Evaluation Form
9. Internal Supervisor Feedback Form
10. Student Feedback Form
11. SDG Mapping Form
12. Final OJT Report
13. Project Report and Presentation
14. OJT Completion Certificate

Scheme of Examination

Component	**Marks**
Continuous Internal Assessment	200
End Semester OJT Evaluation	100
Project Report & Presentation	100
Total	**400 Marks**

Program: Mechanical Engineering	**Final Y. B.Tech.**	**Semester: VII/VIII**
Machine Learning for Mechanical Engineers (RCP23MCSC801)		

Prerequisites:

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Course Objectives:

1. To understand the fundamentals of machine learning and intelligent systems.
2. To apply supervised and unsupervised learning techniques to engineering datasets.
3. To analyze engineering problems using machine learning workflows.
4. To evaluate machine learning model performance for industrial applications.
5. To develop awareness of AI-enabled mechanical engineering systems.

Course Outcomes:

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

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Explain the concepts and workflow of machine learning systems.	L2	Understand
CO2	Apply regression and classification algorithms to engineering datasets.	L3	Apply
CO3	Analyze industrial datasets using clustering and predictive models.	L4	Analyze
CO4	Evaluate machine learning model performance using suitable metrics.	L5	Evaluate
CO5	Interpret machine learning applications in mechanical engineering industries.	L2	Understand

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Machine Learning for Mechanical Engineers (RCP23MCSC801)

Course Contents

Unit-I **01 Hrs.**

Introduction to Artificial Intelligence and Machine Learning

- Introduction to Artificial Intelligence and Machine Learning;
- Role of ML in engineering industries;
- Difference between AI, ML, and Deep Learning;
- Machine learning workflow;
- Applications of ML in mechanical engineering;
- Challenges and limitations of ML systems.

Unit-II **02 Hrs.**

Machine Learning Fundamentals and Data Preparation

- Types of machine learning:
- Supervised learning, Unsupervised learning, Reinforcement learning (overview), Deep learning (overview);
- Training data and testing data;
- Features and labels;
- Data preparation for ML models.

Unit-III **02 Hrs.**

Regression-Based Supervised Learning Techniques

- Introduction to supervised learning;
- Linear regression;
- Polynomial regression;
- Model training and prediction;
- Applications of regression models in engineering systems.

Unit-IV **02 Hrs.**

Classification Techniques for Engineering Applications

- Logistic regression;
- Decision Trees;
- K-Nearest Neighbor (KNN);
- Classification workflow;
- Introduction to feature engineering;
- Industrial classification problems.

Unit-V **02 Hrs.**

Unsupervised Learning and Clustering Techniques

- Introduction to unsupervised learning;
- Clustering concepts;
- K-Means clustering;
- Hierarchical clustering;
- Industrial data grouping and segmentation;
- Pattern recognition concepts.

Unit-VI **01 Hrs.**

Dimensionality Reduction and Pattern Discovery

- Dimensionality reduction basics;
- Similarity and distance measures;
- Feature extraction concepts;
- Pattern discovery in engineering datasets;
- Data visualization for clustering results.

Unit-VII **02 Hrs.**

Model Evaluation and Predictive Analytics

- Model evaluation concepts;
- Accuracy, Precision, Recall, and F1-score;
- Confusion Matrix;
- Training-validation-testing concepts;
- Cross-validation basics;
- Error analysis;
- Introduction to predictive analytics;
- Industrial analytics workflow;
- Interpretation of machine learning results.

Unit-VIII **02 Hrs.**

Machine Learning Applications in Mechanical Engineering

- Predictive maintenance systems;
- Smart manufacturing analytics;
- AI-enabled quality inspection;
- Industrial automation analytics;
- ML applications in automotive engineering;
- Robotics analytics; Energy system optimization;

- Industrial IoT and ML integration;
- Case studies on engineering ML applications;
- Mini-project development using engineering datasets.

Suggested Coursera Mapping

Module	Suggested Coursera Content Provider
Introduction to Machine Learning	Andrew Ng, Stanford, DeepLearning.AI
Supervised Learning	IBM, University of Michigan
Clustering and Unsupervised Learning	Google, IBM
Model Evaluation and Analytics	Microsoft, AWS
Industrial ML Applications	NVIDIA, DeepLearning.AI