Shri Vile Parle Kelavani Mandal's

Dwarkadas J. Sanghvi College of Engineering

(Autonomous College affiliated to the University of Mumbai)

Scheme and Detailed Syllabus (DJS23)

Final Year B. Tech

In

Mechanical Engineering

(Semester VII and VIII)

Revision 0 (Effective from A.Y. 2026-27)

Scheme for Final Year of B.Tech. Program in Mechanical Engineering: Semester VII (Autonomous-DJS23 NEP) (Academic Year 2026-2027)

Sr. No.	Course Code	Course Title	Teaching Scheme (hrs.)				Semester End Examination (SEE) - A						Continuous Assessment (CA) - B						A+B	Credits Earned	
			Th. (Hrs)	P (Hrs)	T (Hrs)	Credits	Duration (Hrs)	Th	O	P	O&P	SEE Total (A)	TT 1	TT 2	TT 3	TT Total	T/W	CA Total (B)			
1	DJS23MCPC701	Design of Mechanical Systems	3	-	-	3	2	60	-	-	-	60	15	15	10	40	-	**40**	100	3	**4**
	DJS23MLPC701	Design of Mechanical Systems Lab	-	2	-	1	2	-	25	-	-	25	-	-	-	-	25	**25**	50	1	
2 @	DJS23MCPE711	Prototyping and Design Validation	3	-	-	3	2	60	-	-	-	60	15	15	10	40	-	**40**	100	3	**4**
	DJS23MLPE711	Prototyping and Design Validation Lab	-	2	-	1	2	-	25	-	-	25	-	-	-	-	25	**25**	50	1	
	DJS23MCPE712	Creative Engineering Design	3	-	-	3	2	60	-	-	-	60	15	15	10	40	-	**40**	100	3	
	DJS23MLPE712	Creative Engineering Design Lab	-	2	-	1	2	-	25	-	-	25	-	-	-	-	25	**25**	50	1	
	DJS23MCPE713	Cryogenics	3	-	-	3	2	60	-	-	-	60	15	15	10	40	-	**40**	100	3	
	DJS23MLPE713	Cryogenics Lab	-	2	-	1	2	-	25	-	-	25	-	-	-	-	25	**25**	50	1	
	DJS23MCPE714	Micro-Electromechanical Systems	3	-	-	3	2	60	-	-	-	60	15	15	10	40	-	**40**	100	3	
	DJS23MLPE714	Micro-Electromechanical Systems Lab	-	2	-	1	2	-	25	-	-	25	-	-	-	-	25	**25**	50	1	
	DJS23MCPE715	Vehicle Testing and Safety	3	-	-	3	2	60	-	-	-	60	15	15	10	40	-	**40**	100	3	
	DJS23MLPE715	Vehicle Testing and Safety Lab	-	2	-	1	2	-	25	-	-	25	-	-	-	-	25	**25**	50	1	
	DJS23MCPE716	Bionics Engineering	3	-	-	3	2	60	-	-	-	60	15	15	10	40	-	**40**	100	3	
	DJS23MLPE716	Bionics Engineering Lab	-	2	-	1	2	-	25	-	-	25	-	-	-	-	25	**25**	50	1	
	DJS23MCPE717	Big Data Analytics	3	-	-	3	2	60	-	-	-	60	15	15	10	40	-	**40**	100	3	
	DJS23MLPE717	Big Data Analytics Lab	-	2	-	1	2	-	25	-	-	25	-	-	-	-	25	**25**	50	1	
	DJS23MCPE718	Startup Sustainability and Scalability	3	-	-	3	2	60	-	-	-	60	15	15	10	40	-	**40**	100	3	
	DJS23MLPE718	Startup Sustainability and Scalability Lab	-	2	-	1	2	-	25	-	-	25	-	-	-	-	25	**25**	50	1	
3 #	DJS23MCPE721	Process Equipment Design	3	-	-	3	2	60	-	-	-	60	15	15	10	40	-	**40**	100	3	**4**
	DJS23MLPE721	Process Equipment Design Lab	-	2	-	1	2	-	25	-	-	25	-	-	-	-	25	**25**	50	1	
	DJS23MCPE722	Computational Fluid Dynamics	3	-	-	3	2	60	-	-	-	60	15	15	10	40	-	**40**	100	3	
	DJS23MLPE722	Computational Fluid Dynamics Lab	-	2	-	1	2	-	25	-	-	25	-	-	-	-	25	**25**	50	1	
	DJS23MCPE723	Sustainable Manufacturing	3	-	-	3	2	60	-	-	-	60	15	15	10	40	-	**40**	100	3	
	DJS23MLPE723	Sustainable Manufacturing Lab	-	2	-	1	2	-	25	-	-	25	-	-	-	-	25	**25**	50	1	
	DJS23MCPE724	Motorsports Engineering	3	-	-	3	2	60	-	-	-	60	15	15	10	40	-	**40**	100	3	
	DJS23MLPE724	Motorsports Engineering Lab	-	2	-	1	2	-	25	-	-	25	-	-	-	-	25	**25**	50	1	
	DJS23MCPE725	Flexible Manufacturing Systems	3	-	-	3	2	60	-	-	-	60	15	15	10	40	-	**40**	100	3	
	DJS23MLPE725	Flexible Manufacturing Systems Lab	-	2	-	1	2	-	25	-	-	25	-	-	-	-	25	**25**	50	1	
	DJS23MCPE726	Business Analytics	3	-	-	3	2	60	-	-	-	60	15	15	10	40	-	**40**	100	3	
	DJS23MLPE726	Business Analytics Lab	-	2	-	1	2	-	25	-	-	25	-	-	-	-	25	**25**	50	1	
	DJS23MCPE727	Startup Compliances and Exit Strategies	3	-	-	3	2	60	-	-	-	60	15	15	10	40	-	**40**	100	3	
	DJS23MLPE727	Startup Compliances and Exit Strategies Lab	-	2	-	1	2	-	25	-	-	25	-	-	-	-	25	**25**	50	1	
4	DJS23MCMD701	Industrial Engineering and Management	3	-	-	3	2	60	-	-	-	60	15	15	10	40	-	**40**	100	3	**3**

Prepared by　　　Checked by　　　Head of the Department　　　Principal

Sr. No.	Course Code	Course Title	Teaching Scheme (hrs.)				Semester End Examination (SEE) - A						Continuous Assessment (CA) - B						A+B	Credits Earned	
			Th. (Hrs)	P (Hrs)	T (Hrs)	Credits	Duration (Hrs)	Th	O	P	O&P	SEE Total (A)	TT 1	TT 2	TT 3	TT Total	T/W	CA Total (B)			
5	DJS23MSC701	Data Science for Mechanical Engineers	1	-	-	1	-	-	-	-	-	-	15	15	10	40	-	**40**	40	1	**1**
6	DJS23ITELX12	Research Ecosystem	-	-	2	2	-	-	-	-	-	-	-	-	-	-	50	**50**	50	2	**2**
7	DJS23IPELX13	Major Project	-	8	-	4	2	-	-	-	50	50	-	-	-	-	50	**50**	100	4	**4**
8	DJS23ICHSX11	Disaster Management and Preparedness	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Total	**15**	**14**	**2**	**22**	**16**	**240**	**75**	-	**50**	**365**	**75**	**75**	**50**	**200**	**175**	**375**	**740**	**22**	

@ Any 1 Program Elective-III from the given list. # Any 1 Program Elective- IV from the given list. 8: Coursera curated course.
Th: Theory; P: Practical; T: Tutorial; O: Oral; P: Practical; O&P: Oral and Practical; TT1: Term Test 1; TT2: Term Test 2; TT3: Term Test 3; TT: Term Test; T/W: Term Work

Prepared by Checked by Head of the Department Principal

Continuous Assessment (A):

Course	Assessment Tools	Marks	Time (min.)
Theory	a. Term test 1 (based on 40 % syllabus)	15	45
	b. Term test 2 (next 40 % syllabus)	15	45
	c. Assignment / course project / group discussion / presentation / quiz/ any other.	10	--
	Total Marks (a + b + c)	40	--
Audit course	Performance in the assignments / quiz / power point presentation / poster presentation / group project / any other tool.	--	As applicable
Laboratory	Performance in the laboratory and documentation.	25	
Tutorial	Performance in each tutorial & / assignment.	25	
Laboratory & Tutorial	Performance in the laboratory and tutorial.	50	

The final certification and acceptance of term work will be subject to satisfactory performance upon fulfilling the minimum passing criteria in the term work / completion of the audit course.

Semester End Assessment (B):

Course	Assessment Tools	Marks	Time (hrs.)
Theory / * Computer based	Written paper based on the entire syllabus. * Computer-based assessment on the college premises.	60	2
Oral	Questions based on the entire syllabus.	25	As applicable
Practical	Performance of the practical assigned during the examination and the output / results obtained.	25	2
Oral & Practical	Project-based courses - Performance of the practical assigned during the examination and the output/results obtained. Based on the practical performed during the examination and on the entire syllabus.	as per the scheme	2

Program: Mechanical Engineering	**Final Year B.Tech.**	**Semester: VII**
Course: Design of Mechanical Systems (DJS23MCPC701)		
Course: Design of Mechanical Systems Lab (DJS23MLPC701)		

Pre-requisites:
1. Knowledge of Material Technology, Mechanics of Materials, and Design of Machine Elements.

Objectives:
1. To acquaint with functional and strength design principles of important machine elements.
2. To study the detailed design procedure of the different types of machine elements.
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.

Outcomes: On completion of the course, the learner will be able to:
1. Design gears based on the given conditions and develop multispeed gearboxes for a specified machine tool application.
2. Select bearings for a given application.
3. Design hoisting mechanism of an Electric overhead traveling crane.
4. Design belt conveyor systems.
5. Design pumps for a given application.

Design of Mechanical Systems (DJS23MCPC701)		
Unit	**Description**	**Duration**
1	**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).	**15**
2	**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.	**10**
3	**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).	**8**
4	**Design of Belt Conveyors:**	**5**

	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.	
5	**Design of gear pump:** Selection of motor, Design of gears, Selection of bearings, Design of bolts, Design of suction and delivery pipes.	4
	Total	**42**

Design of Mechanical Systems Lab (DJS23MLPC701)	
Sr. No.	**Experiment Title**
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 the 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 a minimum of 5 to 6 components is expected.

Books Recommended:

Textbooks:

- Richard G. Budynas and J. Keith Nisbett, Shigley's Mechanical Engineering Design, McGraw-Hill Education, New York, 2024.
- V. B. Bhandari, Design of Machine Elements, McGraw-Hill Education, New Delhi, 2021.
- S. P. Patil, Mechanical System Design, Jaico Publishing House, Mumbai, 2004.
- B. Sharma and H. Purohit, Design of Machine Elements, Prentice Hall India, New Delhi, 2008.
- Robert L. Norton, Machine Design - An Integrated Approach, Pearson Education, Upper Saddle River, NJ, 2006.
- J.E. Shigley, Mechanical Engineering Design, McGraw Hill, New York, 2009.

Reference Books:

- S. K. Basu and D. K. Pal, Design of Machine Tools, CBS Publishers & Distributors, New Delhi, 2018.
- N. K. Mehta, Machine Tool Design, McGraw-Hill Education, New Delhi, 2012.
- PSG College of Technology, Design Data: Data Book of Engineers, Kalaikathir Achchagam, Coimbatore, 2023.
- S. S. Khandare and A. V. Kale, Design of Engine Parts, Charotar Publishing House, Anand, 2008.
- Pandya & Shah, Machine Design, Charotar Publishing, Anand, 2020.
- Reshetov, Machine Design, Mir Publication, Moscow, 2019.
- Black & Adams, Machine Design, McGraw Hill, New York, 2021.
- Mahadevan, Design Data Book,CBS Publishers & Distributors Pvt Ltd,2013

Program: Mechanical Engineering	**Final Year B.Tech.**	**Semester: VII**
Course: Prototyping and Design Validation (DJS23MCPE711)		
Course: Prototyping and Design Validation Laboratory (DJS23MLPE711)		

Pre-requisite:

1. Fundamentals of Mechanical Engineering

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.

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

1. Explain the role of prototyping in product development and design validation.
2. Compare various methods of prototyping and select a suitable method for a given application.
3. Demonstrate proficiency in utilizing various prototyping technologies and techniques.
4. Plan and execute design validation tests, including usability, functional, and compliance testing.
5. Understand regulatory and compliance requirements and integrate them into the design validation process.

Prototyping and Design Validation (DJS23MCPE711)		
Unit	**Description**	**Duration**
1	**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	8
2	**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	8
3	**Prototyping Technologies and Tools** • Rapid prototyping technologies: • 3D printing, CNC machining • Injection molding, vacuum casting	10

	• 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	
4	**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	8
5	**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	8
	Total	**42**

Prototyping and Design Validation Laboratory (DJS23MLPE711)	
Exp.	**Suggested Experiments/ Exercises/ Assignments**
1	Study the role of prototyping in the product design and development process.
2	Low-fidelity prototyping: sketching, wireframing, paper, 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:

- Prototyping and Modelmaking for Product Design by Bjarki Hallgrimsson, 2nd Edition, Quercus Publishing, 2023.
- Rapid Prototyping: Principles and Applications in Manufacturing by Chua, C.K., Leong, K.F., John Wiley and Sons Inc., 2003.
- Rapid Prototyping: Principles and Applications by Noorani, R., John Wiley & Sons, Inc., New Jersey, 2006.

Reference Books:

- Prototyping: A Practitioner's Guide by Todd Zaki Warfel, Rosenfeld Media 2009.
- Prototype: Design and Craft in the 21st Century, by Louise Valentine, Bloomsbury Publishing 2013.
- Product Design and Development" by Karl T. Ulrich and Steven D. Eppinger, McGraw-Hill/Irwin, 2012.

Web References:

- Electronics equipment integration and Prototype building: https://nptel.ac.in/courses/108108157
- Physical Modelling for Electronics Enclosures using Rapid prototyping: https://nptel.ac.in/courses/108108115

Program: Mechanical Engineering	Final Year B.Tech.	Semester: VII
Course: Creative Engineering Design (DJS23MCPE712)		
Course: Creative Engineering Design Laboratory (DJS23MLPE712)		

Pre-requisite:

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

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.

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

1. Apply appropriate methods to identify, analyze, and prioritize customer requirements for engineering design problems.
2. Apply problem definition techniques to convert customer needs into structured engineering specifications.
3. Apply creative ideation and evaluation techniques to generate and select feasible design concepts.
4. Apply detailed design principles, including material selection, CAD modeling, and DFMA, to develop engineering solutions.
5. Apply prototyping, testing, and validation methods to evaluate and refine engineering design solutions.

Creative Engineering Design (DJS23MCPE712)		
Unit	**Description**	**Duration**
1	**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	**8**
2	**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	**8**

	• Setting final specifications and design targets • Case studies on requirement-to-specification transformation	
3	**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	**8**
4	**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	**9**
5	**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	**9**
	Total	**42**

Creative Engineering Design Laboratory (DJS23MLPE712)	
Exp.	**Suggested Experiments/ Exercises/ Assignments/ Activities/ Discussions/ Case studies**
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:

- Karl T. Ulrich and Steven D. Eppinger, Product Design and Development, McGraw Hill Education, 6th Edition, 2016.
- C. Charyton, Creative Engineering Design Assessment: Background, Directions, Manual, Scoring Guide, and Uses, Springer London, 2013.

Reference Books:

- A. Chakrabarti, Engineering Design Synthesis: Understanding, Approaches and Tools, Springer, 2002.
- K. Otto, and K. Wood, Product Design, Prentice Hall, 2000.
- T. Taura, Creative Design Engineering: Introduction to an Interdisciplinary Approach, Elsevier Science, 2016.

Web References:

- Creative Engineering Design (https://nptel.ac.in/courses/107108010)
- Understanding Creativity and Creative Writing (https://nptel.ac.in/courses/109101017)

Program: Mechanical Engineering	**Final Year B.Tech.**	**Semester: VII**
Course: Cryogenics (DJS23MCPE713)		
Course: Cryogenics Laboratory (DJS23MLPE713)		

Pre-requisites:

1. Fundamentals of Thermodynamics; Fundamentals of Heat Transfer; Refrigeration

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.

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

1. 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.
2. 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.
3. Analyse different cryogenic refrigeration systems and their working principles and compare the requirements, types, and applications of cryocoolers, especially in space technology.
4. 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.
5. Understand the design and development of cryogenic storage and transfer systems and safety practices to mitigate health hazards associated with cryogenic systems.

Cryogenics (DJS23MCPE713)		
Unit	**Description**	**Duration**
1	**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.	**8**
2	**Cryogenic Fluids:** Properties 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.	**8**
3	**Cryogenic Refrigeration Systems:** Ideal Refrigeration System, Joule-Thomson (JT) Refrigeration, Phillips Refrigerator, Vuilleumier (VM) Refrigerator, Solvay Refrigerator, Gifford-McMahon (G-M) Refrigerator, Magnetic Cooling.	**9**

	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**.**	
4	**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.	**9**
5	**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.	**8**
	Total	**42**

Cryogenics Laboratory (DJS23MLPE713)	
Sr. No.	**Experiment Title**
	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:

- S. S. Thipse, Cryogenics A Textbook, Alpha Science, 2012.
- Beth Evans, Tom Bradshaw and John Vandore, Cryogenics, IOP Publishing Ltd, 2022.
- Mukhopadhyay Mamata, Fundamentals of Cryogenic Engineering, PHI, Learning, 2018.

Reference Books:

- Thomas M. Flynn, Cryogenic Engineering Second Edition, Marcel Dekker, New York, 2005.
- Randall F. Barron, Cryogenic Systems, Oxford University Press, 1985.
- J.G. Weisend II, Handbook of Cryogenic Engineering, Taylor & Francis, 1998.

Web References:

- Cryogenic Engineering (https://archive.nptel.ac.in/courses/112/101/112101004/)
- Cryogenic Hydrogen Technology (https://nptel.ac.in/courses/112105422)

Program: Mechanical Engineering	Final Year B.Tech.	Semester: VII
Course: Micro Electro Mechanical Systems (DJS23MCPE714)		
Course: Micro Electro Mechanical Systems Laboratory (DJS23MLPE714)		

Objective:

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.

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

1. Knowledge and ability to explain the evolution of MEMS technology and its applications across various industries.
2. Demonstrate understanding of scaling laws and their impact on miniaturization and performance in MEMS systems.
3. Gain practical knowledge of fabrication processes like deposition, etching, micromachining, and the LIGA process, critical to MEMS device creation.
4. Ability to design and analyse MEMS-based sensors, including mechanical, magnetic, thermal, and radiation sensors.
5. Acquire the skills to choose and apply proper bonding and packaging techniques for MEMS devices to ensure system functionality and reliability.

Micro Electro Mechanical Systems (DJS23MCPE714)		
Unit	**Description**	**Duration**
1	**Introduction to Micro Electro Mechanical System (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	**6**
2	**Scaling Law** 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, Piezo resistive, Thermoelectric, Shape memory alloy	**9**
3	**Deposition and Patterning in MEMS** Epitaxy - Classification, molecular beam epitaxy.	**10**

	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.	
4	**MEMS devices** **Mechanical Sensor:** MEMS pressure sensors, MEMS accelerometers, MEMS gyroscopes, MEMS energy harvesters, Flow Micro sensors **Magnetic Sensors:** Magneto galvanic Micro sensors, Magneto resistive Devices **Thermal Sensors and Radiation Sensors:** Resistive temperature micro sensors, micro thermocouples, thermo diodes and thermo transistors, photoconductive devices, photovoltaic devices, micro antenna	**8**
5	**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.	**6**
	Total	**42**

Micro Electro Mechanical Systems Laboratory (DJS23MLPE714)	
Sr. No.	**Experiment Title**
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 of 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:

Text Books

- Tai-Ran Hsu, MEMS and Microsystems Design and Manufacture, TMH, 2002
- Sorab K. Gandhi, "VLSI Fabrication Principles", Wiley, Student Edition
- Mark Madou, Fundamentals of Micro fabrication, CRC Press, New York, 1997

References Books

- N. Maluf, K Williams, "An Introduction to Micro-Electromechanical Systems Engineering", Artech House Inc., Second Edition.
- G. S. May and S. M. Sze, "Fundamentals of Semiconductor Fabrication", Wiley, First Edition.Julian W GardnerV.K.Vardan, O.O.Awadelkarim, Microsensors, MEMS, and Smart Devices, John Wiley & Sons, 2001
- Thomas B. Jones, Electromechanics and MEMS, Cambridge University Press, 2001
- Stephen D. Senturia, Microsystem design, Springer (India), 2006

Program: Mechanical Engineering	**Final Year B.Tech.**	**Semester: VII**
Course: Vehicle Testing and Safety (DJS23MCPE715)		
Course: Vehicle Testing and Safety Laboratory (DJS23MLPE715)		

Pre-requisite: --

1. Basics of automotive systems
2. Basics of engineering mechanics and materials
3. CAD/FEA tools
4. Basic electronics

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.

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

1. To describe vehicle safety standards and testing protocols
2. To analyze vehicle systems' performance under real-world conditions
3. To relate vehicle maintenance practices and ergonomics to safety
4. To analyze road safety factors and traffic control measures

Vehicle Testing and Safety (DJS23MCPE715)		
Unit	**Description**	**Duration**
1	**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.	**09**
2	**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.	**09**
3	**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.	**09**

	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.	
4	**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	**08**
5	**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.	**07**
	Total	**42**

Vehicle Testing and Safety Laboratory (DJS23MLPE815)	
Sr. No.	**Suggested experiments**
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
Simulation based	
5	Simulation of braking distance vs. speed on MATLAB Simulink Software
6	Crash impact analysis of different deformation zone designs on ANSYS / Solidworks
7	Data analysis and visualization of vehicle parameters using an OBD scan tool
Performance based	
8	Ergonomic evaluation of a passenger vehicle cabin
9	Investigation of vibration in a light motor vehicle in dynamic conditions.
10	Experimental brake test data acquisition and analysis
11	Experimental determination of volumetric efficiency of any engine
12	Experimental investigations on an automotive HVAC system
13	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.

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 standard

Program: Mechanical Engineering	Final Year B.Tech.	Semester: VII
Course: Bionics Engineering (DJS23MCPE716)		
Course: Bionics Engineering Laboratory (DJS23MLPE716)		

Pre-requisites:

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

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.

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

1. Explain the principles of bio-inspired design and biomimetics and analyze their relevance in solving engineering problems.
2. Evaluate different bio-inspired materials and smart materials based on their properties and applications in sustainable engineering.
3. Analyze the working principles and classifications of bio-inspired sensors and their applications in real-world systems.
4. Apply bio-inspired manufacturing and fabrication techniques to develop innovative and sustainable engineering solutions.
5. Design and assess bio-inspired robotic systems and motion mechanisms for applications in aerospace, biomedical, and energy sectors.

Bionics Engineering (DJS23MCPE716)		
Unit	**Description**	**Duration**
1	**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.	**9**
2	**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,	**9**

	Biodegradable plastics and Circular materials. Advanced & Emerging Technologies like AI in Material Design, Protein-based Materials, Biohybrid Systems, Necrobotics and Edible Electronics.	
3	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.	**8**
4	**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	**8**
5	**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.	**8**
	Total	**42**

Bionics Engineering Laboratory (DJS23MLPE716)	
Sr. No.	**Experimental**
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 for 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 our 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 our 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 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:

- Yoseph Bar-Cohen, Biomimetics: Nature-Based Innovation, CRC Press, 2011.
- Wole Soboyejo and Leo Daniel, Bioinspired Structures and Design: Butterfly Wings, Lotus
- Leaves, and Other Natural Wonders, Cambridge University Press, 2018.
- Janine M. Benyus, Biomimicry: Innovation Inspired by Nature, Harper Perennial, 2002.
- Junzhi Yu, Bioinspired Robotics: Mechanisms and Control, Elsevier, 2022.
- Nathan F. Lepora, Anna Mura, and Tony J. Prescott (Eds.), Biomimetic and Biohybrid Systems, Springer, 2013.

Reference Books:

- Alicia Kim, Bioinspired Engineering, Wiley, 2021

Web Reference

- https://onlinecourses.nptel.ac.in/noc22_ge24/preview
- https://www.youtube.com/watch?v=ksk4ScMz1io
- https://www.youtube.com/watch?v=2gn8i3lepIM
- https://www.youtube.com/channel/UCIXuV51iFsvyiZta2zp7TzQ

Program: Mechanical Engineering	**Final Year B.Tech.**	**Semester: VII**
Course: Big Data Analytics (DJS23MCPE717)		
Course: Big Data Analytics Lab (DJS23MLPE717)		

Pre-requisites:

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

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

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

1. Explain big data concepts, architecture, and distributed computing frameworks used in engineering systems
2. Apply distributed storage and NoSQL database techniques for managing large-scale engineering data
3. Implement big data processing frameworks (e.g., Hadoop/Spark) for batch and real-time data analysis
4. Analyze industrial and mechanical system data using big data techniques for applications such as predictive maintenance and system monitoring
5. Develop data visualization solutions and interpret big data insights for engineering decision-making and optimization

Big Data Analytics (DJS23MCPE717)		
Unit	**Description**	**Duration**
1	**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)	**8**
2	**Big Data Storage and Management Systems** • Distributed file systems: HDFS working and data replication	**8**

	• 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	
3	**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)	**10**
4	**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	**8**
5	**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	**8**
	Total	**42**

Big Data Analytics Lab (DJS23MLPE717)	
Sr. No.	**Experiment Title**
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 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:

- M.Thangaraj, S. Suguna, G. Sudha, Big Data Analytics: Concepts, Techniques, Tools and Technologies, PHI Learning Pvt. Ltd., 2022.
- B. L. S. Prakasa Rao, S. B. Rao, and Saumyadipta Pyne, Big Data Analytics: Methods and Applications, Springer India, 2016.
- EMC Education Services, Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data, Wiley, 2014.
- David Loshin, Big Data Analytics: From Strategic Planning to Enterprise Integration with Tools, Techniques, NoSQL, and Graph, Morgan Kaufmann, 2013.

Reference Books:

- Edward L. Robinson, Data Analysis for Scientists and Engineers, Princeton University Press, 2016.
- Parikshit N. Mahalle, Pravin P. Hujare, and Gitanjali Rahul Shinde, Predictive Analytics for Mechanical Engineering: A Beginners Guide, Springer Nature Singapore, 2023.
- Venkat Ankam, Big Data Analytics, Packt Publishing, 2016.
- Dina Darwish, Big Data Analytics Techniques for Market Intelligence, IGI Global, 2023.
- Francesco Corea, Big Data Analytics: A Management Perspective, Springer International Publishing, 2016.
- Mohammed Guller, Big Data Analytics with Spark: A Practitioner's Guide to Using Spark for Large Scale Data Analysis, Apress, 2015.

Web References:

- Algorithms for Big Data (https://nptel.ac.in/courses/106106142).
- Big Data Computing (https://nptel.ac.in/courses/106104189).

Program: Mechanical Engineering	Final Year B.Tech.	Semester: VII
Course: Startup Sustainability and Scalability (DJS23MCPE718)		
Course: Startup Sustainability and Scalability Lab (DJS23MLPE718)		

Pre-requisites:

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

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 analyse risks, build resilience and prepare financially healthy scaling plans for technology and mechanical engineering-based startups.

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

1. Differentiate between sustainability and scalability and effectively integrate both into the startup strategy.
2. Design and implement sustainable business practices tailored to engineering and hardware-driven ventures.
3. Develop scalable operations, supply chains, team structures, and funding strategies.
4. Evaluate key performance metrics and apply risk management tools for sustainable scaling.
5. Create a comprehensive sustainability and scalability roadmap for a mechanical engineering startup.

Startup Sustainability and Scalability (DJS23MCPE718)		
Unit	**Description**	**Duration**
1	**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.	**8**
2	**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.	**8**
3	**Scaling Strategies and Operations.** Types of scaling including horizontal, vertical and geographic expansion. Building scalable processes, technology infrastructure and automation systems. Team scaling	**8**

	approaches and maintaining organizational culture. Technology leverage and automation specifically useful for mechanical and engineering startups.	
4	**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.	8
5	**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.	10
	Total	**42**

Startup Sustainability and Scalability Laboratory (DJS23MLPE718)	
Sr. No.	**Exercise Title**
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 & 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 & culture plan for scaling from 10 to 100+ team members.
8	**Final Project: Comprehensive Sustainability & Scalability Plan** — Prepare and present a detailed roadmap for a chosen startup idea, including implementation timeline and metrics.

Books Recommended:

Textbooks:

- Alexander Osterwalder & Yves Pigneur – Business Model Generation / Value Proposition Design
- Eric Ries – The Lean Startup / The Startup Way
- Reid Hoffman & Chris Yeh – Blitzscaling
- Peter Thiel – Zero to One
- John Elkington – Green Swans: The Coming Boom in Regenerative Capitalism
- Stuart L. Hart – Capitalism at the Crossroads

- Reports: World Economic Forum reports on sustainable growth, NITI Aayog documents on sustainable development

Web References:

Journal

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 Year B.Tech.	Semester: VII
Course: Process Equipment Design (DJS23MCPE721)		
Course: Process Equipment Design Laboratory (DJS23MLPE721)		

Pre-requisites:
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

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.

Outcomes: On completion of the course, the learner will be able to:
1. Apply design principles, optimization techniques, and relevant design codes (IS, ASME, TEMA, API, BS) in process equipment design.
2. Design reaction vessels and select suitable agitators, jackets, and sealing systems based on process requirements.
3. Design storage tanks, including shells, plates, roofs, and structural supports.
4. Design shell-and-tube heat exchangers and their key components in line with TEMA standards.
5. Design distillation columns, tray supports, and packing supports, considering applicable standards.

Process Equipment Design (DJS23MCPE721)		
Unit	**Description**	**Duration**
1	**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.	**06**
2	**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.	**10**
3	**Mechanical design of Storage Tank:**	**08**

	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.	
4	**Mechanical design of Shell & Tube Heat Exchanger:** Mechanical design of shell, tube, tube sheet, head, channel shell, etc. of shell & tube heat exchanger.	**08**
5	**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.	**10**
	Total	**42**

Process Equipment Design Laboratory (DJS23MLPE721)	
Sr. No.	**Experiment Title**
	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
	Prepare a layout for the following using any CAD software (Minimum two):
1	Layout of Reaction Vessel with Jacket & Agitator
2	Layout of Storage Tank with Roof & Supports
3	Layout of Shell & Tube Heat Exchanger
4	Layout 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:

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

Reference Books:

- Bureau of Indian Standards, Code for Unfired Pressure Vessels (IS: 2825), BIS, New Delhi, 1969.
- D. R. Moss and M. M. Basic, Pressure Vessel Design Manual, Elsevier Butterworth-Heinemann,

Oxford, 2013.
- E. F. Megyesy, Pressure Vessel Handbook, Pressure Vessel Publishing, Tulsa, 2008.
- L. E. Brownell and E. H. Young, Process Equipment Design, John Wiley & Sons, New York, 2

Web References:

- Process Equipment Design (https://nptel.ac.in/courses/103107207)
- Principles and Practices of Process Equipment and Plant Design (https://onlinecourses.nptel.ac.in/noc21_ch52/preview)
- Equipment Design: Mechanical Aspects (https://onlinecourses.nptel.ac.in/noc20_ch17/preview)

Program: Mechanical Engineering	Final Year B.Tech.	Semester: VII
Course: Computational Fluid Dynamics (DJS23MCPE722)		
Course: Computational Fluid Dynamics Lab (DJS23MLPE722)		

Pre-requisites:

1. Engineering Mathematics (Calculus, Linear Algebra, Differential Equations)
2. Fundamentals of Fluid Mechanics
3. Fundamentals of Heat Transfer

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 discretization 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.

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

1. Explain the fundamentals of Computational Fluid Dynamics, including solution methodology, grid generation, and discretization techniques
2. Analyze the governing equations of fluid flow and heat transfer, classify partial differential equations based on their mathematical nature and boundary conditions, and interpret the basic concepts of turbulence modeling
3. Apply the finite volume method to solve one-dimensional and multi-dimensional diffusion problems, including steady and unsteady heat conduction
4. Evaluate various discretization schemes for convection–diffusion problems based on their numerical properties such as stability, boundedness, and transportiveness
5. Implement Pressure–Velocity coupling algorithms, including SIMPLE and its variants, for solving steady incompressible flow problems.

Computational Fluid Dynamics (DJS23MCPE722)		
Unit	**Description**	**Duration**
1	**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)	05

2	**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, 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	12
3	**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	09
4	**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)	08
5	**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	08

		Total	42

Computational Fluid Dynamics Lab (DJS23MLPE722)	
Sr. No.	**Experiment Title**
	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
	Numerical Analysis (Implementation using Python/MATLAB/C++/C)
8	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
9	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
10	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
11	Develop a numerical solver for analyzing one-dimensional unsteady-state heat conduction using an explicit finite volume scheme
12	Develop a numerical solver for analyzing one-dimensional unsteady-state heat conduction using an implicit finite volume scheme
13	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:

- S. Versteeg, W. Malalasekera, *An Introduction to Computational Fluid Dynamics: The Finite Volume Method*, Pearson Education, London, 2020.
- S. V. Patankar, *Numerical Heat Transfer and Fluid Flow*, CRC Press, Boca Raton, 2021.
- C. Hirsch, *Numerical Computation of Internal and External Flows: The Fundamentals of Computational Fluid Dynamics, Volumes 1 & 2*, Butterworth Heinemann, Oxford, 2020.
- T. J. Chung, *Computational Fluid Dynamics, 3rd Edition*, Cambridge University Press, Cambridge, 2019.
- R. Mittal, G. Iaccarino, *Fundamentals of Numerical Turbulence Modeling for CFD*, Springer, Cham, 2021.

Reference Books:

- John D. Anderson, Jr., *Computational Fluid Dynamics: The Basics with Applications*, McGraw-Hill Education, New York, 2023.
- C. J. K. Knight, *Multiphase Computational Fluid Dynamics: Methods and Applications*, Academic Press, Boston, 2020.
- R. H. Pletcher, J. C. Tannehill, D. Anderson, *Computational Fluid Mechanics and Heat Transfer, 4th Edition*, CRC Press, Boca Raton, 2019.
- O. C. Zienkiewicz, R. L. Taylor, *The Finite Volume Method for Fluid Dynamics with Multigrid and Multilevel Techniques*, Elsevier, Amsterdam, 2020.
- P. Niyogi, P. Chatterjee, *Computational Fluid Dynamics with Recent Applications: A Systematic Approach*, CRC Press, Boca Raton, 2021.
- K. Muralidhar, T. Sundararajan, *Computational Fluid Flow and Heat Transfer, 3rd Edition*, Narosa Publishing House, New Delhi, 2020.
- D. A. Caughey, D. A. Shepherd, *Computational Methods for Fluid Dynamics: Practical Workflow and Case Studies*, Elsevier, Amsterdam, 2022.
- M. Griebel, T. Dornseifer, T. Neunhoeffer, *Numerical Simulation in Fluid Dynamics: A Practical Introduction*, SIAM, Philadelphia, 2020.
- S. B. Pope, *Turbulent Flows: Advanced Topics and Modelling Extensions*, Cambridge University Press, Cambridge, 2020.

Web References:

- Computational Fluid Dynamics (https://nptel.ac.in/courses/112105045)
- Computational Fluid Dynamics and Heat Transfer (https://nptel.ac.in/courses/112104302)
- Computational Fluid Dynamics using Finite Volume Method (https://nptel.ac.in/courses/112106294)
- Computational Fluid Dynamics for Incompressible Flows (https://nptel.ac.in/courses/112103289)
- Foundations of Computational Fluid Dynamics (https://nptel.ac.in/courses/112106186)

Program: Mechanical Engineering	Final Year B.Tech.	Semester: VII
Course: Sustainable Manufacturing (DJS23MCPE723)		
Course: Sustainable Manufacturing Laboratory (DJS23MLPE723)		

Pre-requisites:

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

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.

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

1. Understand and articulate the principles and importance of sustainable manufacturing.
2. Perform environmental impact assessments using LCA methodologies, carbon footprint analysis, and regulatory frameworks.
3. Implement sustainable design methodologies integrating material selection, product lifecycle optimization, and end-of-life strategies.
4. Enhance manufacturing efficiency through energy optimization, waste minimization, and advanced sustainable technologies.
5. Develop resilient and circular supply chain models incorporating green logistics, ethical sourcing, and digital transparency.
6. Evaluate sustainability metrics, frameworks, and regulations while exploring emerging technologies and future trends in sustainable manufacturing.

Sustainable Manufacturing (DJS23MCPE723)		
Unit	**Description**	**Duration**
1	**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.	**6**
2	**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.	**6**
3	**Sustainable Product Design and Service:** 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. Sustainable product-service system, strategies and tools. Application of additive manufacturing in sustainable design, extended	**8**

	producer responsibility (EPR) and regulatory aspects, and case studies on sustainable product innovations.	
4	**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.	**8**
5	**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.	**8**
6	**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.	**6**
	Total	**42**

Sustainable Manufacturing Laboratory (DJS23MLPE723)	
Sr. No.	**Experiment Title**
	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).
	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:

- Umeda, Y., Fukushige, S., & Kondoh, S., Sustainable Manufacturing: An Introduction, Springer, 2022.
- Jawahir, I. S., & Dillon, O. W. (Eds.), Sustainable Manufacturing: The Path to a Circular Economy, Springer, 2019.
- 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.
- Sutherland, J. W., Jawahir, I. S., & Brocchi, E. (Eds.), Progress in Sustainable Manufacturing, Springer, 2018.

- Low, J. S. C., & Ong, S. K. (Eds.), Sustainable Manufacturing and Remanufacturing Management: Enhancing Knowledge through Lifecycle Thinking, Springer, 2014.
- Dornfeld, D. A. (Ed.), Green Manufacturing: Fundamentals and Applications, Springer Science & Business Media, 2012.
- Ashby, M. F., Materials and the Environment: Eco-informed Material Choice, Elsevier, 2012.

Reference Books:

- Hauschild, M. Z., Rosenbaum, R. K., & Olsen, S. I. (Eds.), Life Cycle Assessment: Theory and Practice, Springer, 2018.
- Seidel, M. (Ed.), Green Supply Chain Management: Product Life Cycle Approach, Springer, 2017.
- Allwood, J. M., & Cullen, J. M., Sustainable Materials: With Both Eyes Open, UIT Cambridge, 2012.
- Atkinson, G., Dietz, S., & Neumayer, E., Handbook of Sustainable Manufacturing, Edward Elgar Publishing Limited, 2007.
- Fiksel, J., Design for Environment: A Guide to Sustainable Product Development, McGraw Hill, 2009

Web References:

- Sustainability through Green Manufacturing Systems: An Applied Approach, IIT Kanpur: https://nptel.ac.in/courses/112104225
- System Design for Sustainability, IIT Guwahati: https://nptel.ac.in/courses/107103081

Program: Mechanical Engineering	Final Year B.Tech.	Semester: VII
Course: Motorsports Engineering (DJS23MCPE724)		
Course: Motorsports Engineering Laboratory (DJS23MLPE724)		

Pre-requisites:

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.

Objectives:

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

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

1. Explain competition vehicle categories and apply knowledge of advanced materials and manufacturing techniques in motorsport applications.
2. Apply design and simulation techniques to analyze and evaluate motorsport vehicle structures.
3. Analyze vehicle stability using tire dynamics, suspension geometry, and control systems.
4. Analyze, design, and evaluate high-performance motorsport powertrains to optimize vehicle performance.
5. Analyze the performance of motorsport aerodynamics components.
6. Comprehend the need for data acquisition and analysis in motorsports.

Motorsports Engineering (DJS23MCPE724)		
Unit	**Description**	**Duration**
1	**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, aluminum, 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.	**9**
2	**Design, Analysis, and Optimization of Competition Vehicles** Introduction to structural design principles for competition vehicles; finite element modeling and simulation for structural analysis; shape and topology optimization methods; identification and analysis of common structural failure modes; non-destructive testing (NDT) techniques.	**8**
3	**Vehicle Stability:** Concept of vehicle stability and controllability; tire mechanics and force generation, slip angle, cornering stiffness, and tire models; suspension geometry and chassis	**9**

	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.	
4	**Powertrains in Motorsport:** Role and evolution of powertrain; features of high-performance SI and CI engines; performance optimization; tuning of intake, exhaust, and fuel systems; turbocharging; combustion; 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 are employed in motorsports. Sustainable and future technologies.	**8**
5	**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, and driver performance; and the importance of real-time data and telemetry in race strategy optimization and live tuning.	**8**
	Total	**42**

Motorsports Engineering Laboratory (DJS23MLPE724)	
Sr. No.	**Experiment/Case study**
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/Crank shaft/Piston) using Finite Element Analysis (FEA) software.
5	Crash analysis of the impact attenuator by 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 on excel / Python code
9	Comparative analysis of the gradeability of any 2 vehicles on excel/python
10	Simulations on airfoil optimization and drag force estimation on ANSYS / Simscale
11	Comparative simulations of different aerodynamic devices on ANSYS / 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:

- Andrew Livesey, Advanced Motorsport Engineering, Routledge, London, 2012.
- Simon McBeath, Competition Car Composites: A Practical Handbook, Veloce Publishing, Dorchester, 2016.
- John C. Dixon, Suspension Geometry and Computation, John Wiley & Sons, Hoboken (NJ), 2009.
- William F. Milliken and Douglas L. Milliken, Race Car Vehicle Dynamics, SAE International, Warrendale (PA), 1995.
- Herb Adams, Chassis Engineering: Chassis Design, Building & Tuning for High Performance Cars, HP Books/Penguin Publishing Group, London, 1993.
- Michael F. Ashby, Materials Selection in Mechanical Design, Butterworth-Heinemann, Burlington, MA, 2005.

Program: Mechanical Engineering	**Final Year B.Tech.**	**Semester: VII**
Course: Flexible Manufacturing System (DJS23MCPE725)		
Course: Flexible Manufacturing System Laboratory (DJS23MLPE725)		

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.

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

1. Students will have a solid foundation in the evolution, principles, and economic justification of FMS, along with the role of CIM (Computer Integrated Manufacturing) in enhancing flexibility. Also, will be able to distinguish between job shop, batch production, and mass production systems
2. Students will be able to design efficient workstations, integrate automated systems like AGVS and ASRS, and manage storage and work-in-progress inventories in FMS.
3. Students will be able to form part families, apply part classification systems, design machine cells, and use clustering algorithms to enhance manufacturing efficiency.
4. Students will be capable of applying algorithms to assess FMS flexibility and determine the necessary resources to support manufacturing cells.
5. Students will learn how to use Petri nets to model and analyze complex manufacturing systems, improving production planning, system coordination, and resource utilization.

Motorsports Engineering (DJS23MCPE725)		
Unit	**Description**	**Duration**
1	**1.1 Introduction –** FMS evolution, need for flexibility, economic justification of FMS, role of CIM in FMS, case studies. **1.2 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.	**9**
2	**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.	**9**
3	**Cellular manufacturing -** Formation of part families, Part classification, Coding system optiz, Machine cells design, clustering methods, modern algorithms, benefits of GT, cell characteristic - system definition and sizing, human resources and its objective, staffing, supervisor role.	**10**
4	**Evaluation of FMS –** Algorithms for cell evaluations, measure of flexibility.	**4**
5	**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.	**10**
	Total	**42**

Course: Flexible Manufacturing system Laboratory (DJS23MLPE725)	
Sr. No.	**Experiment Title**
1	Determine the components and configuration of the FMS to simulate machines, robots, conveyors, automated Guided Vehicles (AGVs), and storage.
2	Define the inputs to be provided to the FMS system: product types, production rates, machine setup times, and processing times.
3	Simulation 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.

Books Recommended:

References 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. Dr. 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 Year B.Tech.	Semester: VII
Course: Business Analytics (DJS23MCPE726)		
Course: Business Analytics Lab (DJS23MLPE726)		

Pre-requisites:

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

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

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

1. Analyze business analytics frameworks and evaluate their role in decision-making within mechanical engineering industries
2. Apply advanced predictive and prescriptive analytics techniques to solve engineering business problems involving uncertainty and risk
3. Evaluate and implement advanced AI techniques such as GANs, Transfer Learning, Neuroevolution, and Agentic AI for business analytics applications
4. Analyze and interpret results from Explainable AI (XAI) methods to support transparent and ethical decision-making in engineering business systems
5. Assess emerging technologies such as Quantum AI and multimodal AI for enhancing business analytics strategies in modern mechanical industries

Business Analytics (DJS23MCPE726)		
Unit	**Description**	**Duration**
1	**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	**8**
2	**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)	**8**

3	**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	**10**
4	**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	**8**
5	**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	**8**
	Total	**42**

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

Business Analytics Lab (DJS23MLPE726)	
Sr. No.	**Experiment Title**
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:

- Foster Provost & 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.
- S. Christian Albright & Wayne L. Winston, Business Analytics: Data Analysis & Decision Making, Cengage Learning, Boston, USA, 6th Edition, 2016.
- Ramesh Sharda, Dursun Delen & Efraim Turban, Business Intelligence, Analytics, and Data Science: A Managerial Perspective, Pearson, London, UK, 5th Edition, 2024.
- Galit Shmueli, Peter C. Bruce, Nitin R. Patel & Mia Stephens, Machine Learning for Business Analytics, Wiley, Hoboken, USA, 2nd Edition, 2023.
- James Evans, Business Analytics: Methods, Models, and Decisions, Pearson, London, UK, 2nd Edition, 2015.

Reference Books:

- Wes McKinney, Python for Data Analysis: Data Wrangling with Pandas, NumPy, and Jupyter, O'Reilly Media, Sebastopol, USA, 2nd Edition, 2017.
- Trevor Hastie, Robert Tibshirani & Jerome Friedman, The Elements of Statistical Learning: Data Mining, Inference, and Prediction, Springer, New York, USA, 2nd Edition, 2009.
- Dean Abbott, Applied Predictive Analytics: Principles and Techniques for the Professional Data Analyst, Wiley, Hoboken, USA, 1st Edition, 2014.
- Hadley Wickham & Garrett Grolemund, R for Data Science: Import, Tidy, Transform, Visualize, and Model Data, O'Reilly Media, Sebastopol, USA, 1st Edition, 2017.
- Ian H. Witten, Eibe Frank & Mark A. Hall, Data Mining: Practical Machine Learning Tools and Techniques, Morgan Kaufmann, Burlington, USA, 4th Edition, 2016.

Web References:

- Business Analytics For Management Decision (https://nptel.ac.in/courses/110105089)
- Business Intelligence & Analytics (https://nptel.ac.in/courses/106106361)
- Business Analytics & Text Mining Modeling Using Python (https://nptel.ac.in/courses/110107129).
- Business Analytics & Data Mining Modeling Using R Part II (https://nptel.ac.in/courses/110107095)
- Introduction to Business Analysis for Engineers (https://nptel.ac.in/courses/110106050)

- Business Statistics (https://nptel.ac.in/courses/110107114)
- Business analytics and data mining Modeling using R (https://nptel.ac.in/courses/110107092)

Program: Mechanical Engineering	Final Year B.Tech.	Semester: VII
Course: Startup Compliances and Exit Strategies (DJS23MCPE727)		
Course: Startup Compliances and Exit Strategies Lab (DJS23MLPE727)		

Pre-requisites:
1. Fundamentals of Business Development
2. Entrepreneurial Business Models
3. Startup Registration and Development

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.

Outcomes: On completion of the course, the learner will be able to:
1. Identify and fulfil major statutory, legal and regulatory compliances for startups in India.
2. Effectively manage IPR, taxation, labor and technology-related compliances for engineering startups.
3. Evaluate and select appropriate exit strategies based on business stage, valuation and goals.
4. Prepare documentation and processes required for compliance management and due diligence before exit.
5. Develop a complete compliance and exit roadmap for a mechanical engineering startup.

Startup Compliances and Exit Strategies (DJS23MCPE727)		
Unit	**Description**	**Duration**
1	**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.	**10**
2	**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.	**08**
3	**Taxation, Financial, and Labor Compliance.**	**08**

	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.	
4	**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.	**08**
5	**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.	**08**
	Total	**42**

Startup Compliances and Exit Strategies Lab (DJS23MLPE727)	
Sr. No.	**Exercise Title**
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 by Vinay Vaish (Vaish Associates)
2. Bloomsbury's Handbook for Start-Ups – A Tax and Regulatory Guide by CA Radhika Jain
3. Beyond the Incorporation: A Startup Guide to Navigating Taxation, Registrations, and Compliances in India by CA Megha Jain
4. MSME & Start Ups Law & Practice, 2024 by CS Amit Baxi, FCA Nisha Bhandari and FCA Satyadev Purohit
5. Taxmann's Company Law & Practice by G.K. Kapoor and Sanjay Dhamija

6. Intellectual Property Rights by 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:

Journal

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 Year B.Tech.**	**Semester: VII**
Course: Industrial Engineering and Management (DJS23MCMD741)		

Pre-requisites:

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

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.

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

1. Explain Industrial Engineering concepts, productivity measures, and value engineering principles.
2. Apply work study techniques using modern tools such as AI-based motion and time analysis.
3. Analyze work systems considering ergonomics, human factors, and organizational behaviour.
4. Design efficient facility layouts and production systems using digital and optimization techniques.
5. Evaluate agile, lean, and smart manufacturing systems for productivity improvement.

Industrial Engineering and Management (DJS23MCMD741)		
Unit	**Description**	**Duration**
1	**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).	**8**
2	**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	**8**
3	**Ergonomics** • Definition of Ergonomics	**8**

	• Objectives of Ergonomics • Importance of Ergonomics • History and Development • Latest trends of Ergonomics in Different Industries • Types of Ergonomics • Benefits of Ergonomics	
4	**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	**8**
5	**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)	**10**
	Total	**42**

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:

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

Program: All programs	Final Year B. Tech.	Semester: VII
Course: Research Ecosystem (DJS23ITELX12)		

Pre-requisites:

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.

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).

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

1. Analyze complex engineering and societal problems to evaluate literature and patents and formulate clear research gaps.
2. Design and apply advanced research methods and tools to acquire data and evaluate solution performance.
3. Transform research insights into prototypes or startup concepts using innovation frameworks and Technology Readiness Levels.
4. Evaluate ethical, socio-technical, and sustainability issues and create responsible engineering solutions.
5. Synthesize multidisciplinary knowledge to create research proposals and scalable, future-ready solutions.

Research Ecosystem (DJS23ITELX12)		
Unit	**Description**	**Duration**

1	**Research Gap Identification & 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
		5

	Activities: • Convert Industry/ Societal problem into research problem. • Analyze research articles and extract research gaps.	

2	**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).
		6

3	**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.	**5**

4	**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.
		6

5	**Integrated Research, Proposals and Future Engineering Challenges** • Systems thinking and holistic analysis • Multidisciplinary problem solving: ▪ Healthcare tech., climate tech., smart mobility	**6**

	• 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	
	Total	**28**

Term Work Guidelines:

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

b) **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.

b) **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:

- Kothari, C. R., Research Methodology: Methods and Techniques, New Age International Publishers, New Delhi, 2023.
- Booth, W. C., Colomb, G. G., Williams, J. M., Bizup, J., & FitzGerald, W. T., The Craft of Research, University of Chicago Press, Chicago, 2024.
- Montgomery, D. C., Design and Analysis of Experiments, Wiley, New York, 2020.
- Singh, Pooja, Katiyar, Aman, Rawat, Shalini, Dhuri, Archana, Research Methodology and IPR, RK Publications, India, 2025.
- Blok, Vincent (Ed.), Putting Responsible Research and Innovation into Practice: A Multi-Stakeholder Approach, Springer Cham, Switzerland, 2022.

Web References:

- Research Methodology: Quantitative Methods and Computer Application (https://onlinecourses.swayam2.ac.in/e-learning/preview/ini26_ma02)

- Research Methodology and IPR
(https://onlinecourses.swayam2.ac.in/e-learning/preview/ntr26_ed28)
- Research and Publication Ethics
(https://onlinecourses.swayam2.ac.in/e-learning/preview/nou26_ge46)
- Research Ethics and Plagiarism
(https://onlinecourses.swayam2.ac.in/e-learning/preview/nou26_ge26)
- Quantitative and Mixed Methods Research for Management
(https://onlinecourses.swayam2.ac.in/e-learning/preview/imb26_mg21)
- Doing Qualitative Research
(https://onlinecourses.swayam2.ac.in/e-learning/preview/nou26_ge61)

Program: Mechanical Engineering	Final Year B.Tech.	Semester: VII
Course: Major Project (DJS23IPELX13)		

Objectives

The primary purpose of the Major Project is to enable students to apply the knowledge and skills acquired across the program to conceive, design, implement, and evaluate a comprehensive solution to a real-world problem. The project strengthens technical competence, communication, and teamwork by integrating design, development, technical writing, presentation, and collaborative work. It emphasizes professional engineering practice and addresses a range of non-technical considerations such as economic factors, safety, reliability, ethics, sustainability, and environmental and societal impact.

Course Outcomes (CO)

On successful completion of the Major Project, the student will be able to:

CO1: Apply technical knowledge gained from previous courses to identify real-life, industry, or societal problems and design appropriate solutions.

CO2: Demonstrate the technical skills required to design, develop, build, and test engineering systems, products, software, or hardware using modern engineering and IT tools.

CO3: Apply project-management skills — scheduling work, procuring resources/components, budgeting, documenting technical and non-technical details, and working within defined deadlines as an effective team.

CO4: Develop and demonstrate the ability to test, validate, debug, and troubleshoot engineering systems (including software, hardware, and process components) and analyse the results.

CO5: Create technical reports and research papers in the prescribed format and effectively communicate and present the work to evaluators.

Scope and Nature of the Project Work

Final-year students have already undertaken project assignments in their pre-final year through Innovative Product Design / Mini Project work. In the final year, a group of a maximum of four students completes a comprehensive project based on the courses studied. The project work may be internally assigned or externally assigned by research institutes, industry, or similar organisations. Each group is assigned one faculty member as supervisor. The final-year project may be an extension of the Mini Project carried out in the pre-final year.

The main intention of the project work is to enable students to apply the knowledge and skills learnt across the programme to solve or implement a well-defined practical problem. The work may go beyond the scope of the curriculum or build upon courses studied, but the thrust should be on:

- Learning additional skills relevant to the chosen domain;
- Developing the ability to define, design, analyse, and implement a problem and carry it through to completion with proper planning;
- Learning behavioural science and professional ethics by working effectively in a group;
- Selecting a project area aligned with the student's intended higher education, employment, or self-employment goals;
- Choosing a topic that differs from, or meaningfully advances, the Mini Project topic;
- Using the opportunity to learn modern computational techniques, tools, and model development through an appropriate choice of project.

Continuous Assessment and Term Work

The department maintains a proper record of the progress of each project throughout the semester. At the end of the semester, the work is assessed for the award of Term Work (TW) marks by an approved internal faculty member appointed by the Head of the Institute, on the basis of:

- Scope and objectives of the project work;
- Extent and quality of the literature survey;
- Progress of the work (continuous assessment across reviews);
- Design, implementation, and analysis of the project work;
- Results, conclusions, and future scope;
- Report prepared in the prescribed University / institutional format.

Oral / Practical Examination: An approved external examiner together with an internal examiner appointed by the Head of the Institute assesses the project during the oral examination. The oral examination consists of a presentation by the group along with a demonstration of the work done. Each student is assessed individually for their contribution, understanding, and the knowledge gained.

Project Guide / Topic Allocation Policy

The project guide and topic-allocation policy is explained to students during the Orientation held in Semester VI. Each faculty member is allocated a minimum of one and a maximum of four project groups. As per the timeline in the academic calendar, the list of project topics and areas offered by each faculty member — three topics per faculty member — is displayed on the notice board. Allocation is carried out over successive rounds, and in each round students submit their preferences against the available topics and guides.

If a topic is preferred by only one group, that group is allocated to the corresponding guide and topic. If a topic is preferred by more than one group, the concerned faculty member reviews the applications and selects one group; the remaining groups carry forward to the next round. After each round, the list of groups and guides allotted so far is displayed, along with the topics and guides that remain available. Unallotted groups then submit fresh preferences from the available list. This process continues over successive rounds until every group has been allotted a guide, ensuring a uniform distribution of project groups among the faculty members.

Assessment Scheme

The Major Project carries a total of 100 marks — **Term Work (50)** assessed internally through continuous evaluation, and **Oral / Practical Examination (50)** assessed jointly by internal and external examiners. Each criterion is scored against three performance levels — Excellent, Satisfactory, and Below Expectation — as detailed below.

Rubric for Term Work (50 Marks)

Assessment Criteria (mapped CO)	Max	Excellent	Satisfactory	Below Exp.
Problem Definition, Objectives & Literature Survey (CO1)	**10**	8–10	5–7	0–4
Design, Methodology & Implementation Progress – Continuous Assessment (CO2)	**10**	8–10	5–7	0–4
Project Management & Teamwork (CO3)	**10**	8–10	5–7	0–4
Report / Thesis Writing – Written Communication (CO5)	**10**	8–10	5–7	0–4
Research Paper Writing / IPR – Patent or Copyright (CO5)	**10**	8–10	5–7	0–4
TOTAL	**50**			

Rubric for Oral / Practical / Presentation / Demonstration (50 Marks)

Assessment Criteria (mapped CO)	Max	Excellent	Satisfactory	Below Exp.
Concept & Problem Definition (CO1)	**5**	4–5	3	0–2
Design, Methodology & Implementation (CO2)	**15**	12–15	7–11	0–6
Project Management Skills (CO3)	**5**	4–5	3	0–2
Demonstration, Testing & Result Analysis (CO4)	**15**	12–15	7–11	0–6
Presentation & Oral Communication (CO5)	**10**	8–10	5–7	0–4
TOTAL	**50**			

Descriptive Assessment Rubric (Performance-Level Descriptors)

The following descriptors define each performance level and are applied consistently across all programmes. Examiners map a student's performance to the most appropriate level for each criterion before awarding the corresponding marks from the tables above.

Criteria	Excellent	Satisfactory	Below Expectation
Concept & Problem Definition	All major and minor objectives are identified and correctly prioritised. The problem statement is precise, relevant and well-scoped. All relevant information is gathered from valid sources and the proposed solution is well justified.	Major objectives identified but one or two minor ones missing or priorities not fully set. Problem statement mostly clear. Sufficient information from largely valid sources; solution mostly justified.	Several major objectives not identified. Problem statement vague or too broad. Insufficient information and/or invalid sources; proposed solution not justified.
Literature Survey	Comprehensive, current and well-organised survey of journals, standards, patents and existing products/systems. Research gap / novelty clearly identified and the chosen approach is well justified.	Adequate survey covering most key sources. Gap / novelty identified but only partially justified.	Sparse or outdated survey. Little or no identification of the gap; chosen approach not justified.
Design, Methodology & Implementation	Design is based on stated criteria, sound analysis and realistic constraints. Methodology is appropriate and well justified. Implementation	Design is reasonable and methodology mostly appropriate. Implementation is largely complete; deeper analysis of alternatives or	Only one solution considered or alternatives ignored. Weak methodology and incomplete implementation. Many

Criteria	Excellent	Satisfactory	Below Expectation
	is complete and robust and makes effective use of modern engineering / software tools.	constraints could improve the outcome.	constraints and criteria ignored.
Project Management & Teamwork	Responsibilities delegated fairly and every member contributes valuably. All members attend meetings and meet deliverable deadlines. Schedule, resources and budget are well managed.	Minor inequities in delegation; some members contribute more than others but all meet their responsibilities. Meetings mostly attended and deadlines mostly met.	Major inequities in delegation, with free-riders or dominating members. Meetings and deadlines frequently missed; poor planning of schedule and resources.
Demonstration, Testing & Result Analysis	Develops and follows logical testing / validation / experimental procedures. Selects appropriate tools, equipment, platforms or datasets and operates them confidently. Aware of errors / limitations, accounts for them, and interprets and relates the results to the objectives and underlying theory.	Procedures mostly followed with occasional oversight. Needs some guidance in selecting tools / equipment and is tentative in operating them. Aware of errors but accounts for them only minimally.	Does not follow a proper procedure. Cannot select appropriate tools / equipment or operates them incorrectly, needing frequent supervision. Makes no attempt to relate results to objectives.
Report / Thesis Writing (Written Communication)	Report is well organised and clearly written; the logic is easy to follow. Wording is precise; figures, tables and analyses enhance understanding. Grammatically correct, free of spelling errors, properly cited and free of plagiarism.	Report is mostly organised and clear; a few sections are harder to follow. Wording is good with minor exceptions; figures are consistent. Few grammatical / spelling errors that do not hinder the reader; some sources not fully cited.	Report lacks organisation and the logic is hard to follow. Figures absent or inconsistent. Grammatical and spelling errors hinder reading. Evidence of plagiarism or inadequate citation.
Research Paper Writing / IPR (Patent or Copyright)	A research / technical paper is drafted to publication standard in the required format, or a patent / copyright application is prepared and filed. Novelty and	A paper draft or IPR document is prepared and largely follows the required format. Novelty and contribution are stated but only partially developed, with minor	No paper / IPR document, or a weak draft that does not follow the required format. Novelty or contribution is unclear or unsupported, with

Criteria	Excellent	Satisfactory	Below Expectation
	contribution are clearly articulated, claims and results are well supported, and the work is original with proper citations and no plagiarism.	gaps in supporting evidence or formatting.	evidence of plagiarism or inadequate citation.
Presentation & Oral Communication	Slides are error-free and logically present the work and findings; they are readable and the graphics support the main ideas. Speakers are audible and fluent, do not rely on notes and answer questions accurately. Confident body language and eye contact convey strong engagement.	Slides are error-free and logical and mostly readable. Speakers are mostly fluent with minimal reliance on notes and answer most questions well. Slight discomfort or occasional distracting gestures.	Slides contain errors and lack logical flow; key aspects are absent and graphics confuse the audience. Speakers are inaudible or hesitant and rely heavily on notes, with difficulty answering questions. Body language conveys discomfort.

Program: Mechanical Engineering	**Final Year B.Tech.**	**Semester: VII**
Course: Disaster Management and Preparedness (DJS23ICHXS11)		

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.

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

1. Apply disaster management principles & guidelines.
2. Conduct risk assessments.
3. Develop community awareness & participation.
4. Utilize Science & Technology tools (GIS, GPS).
5. Prepare disaster management plans.

Disaster Management and Preparedness (DJS23ICHXS11)		
Unit	**Description**	**Duration**
1	**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.	**06**
2	**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.	**06**
3	**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.	**04**
4	**Recovery, Rehabilitation & Reconstruction:**	**04**

	• Post-disaster damage assessment. • Rehabilitation, Reconstruction, & Livelihood Restoration. • Sanitation, Hygiene, & Waste Management.	
5	**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	**08**
	Total	**28**

Books Recommended:

Reference Books and Reports:

- Disaster Management, by Harsh K. Gupta, Universities Press Publications (2003).
- Disaster Management: An Appraisal of Institutional Mechanisms in India, by O. S. Dagur, published by Centre for Land Warfare Studies, New Delhi, 2011.
- Introduction to International Disaster Management, by Damon Copolla, Butterworth Heinemann Elsevier Publications (2015).
- Disaster Management Handbook, by Jack Pinkowski, CRC Press, Taylor and Francis group (2008).
- Disaster management & rehabilitation, by Rajdeep Dasgupta, Mittal Publications, New Delhi (2007).
- Natural Hazards and Disaster Management, Vulnerability and Mitigation, by R B Singh, Rawat Publications (2006).
- Concepts and Techniques of GIS, by C. P. Lo Albert, K.W. Yonng, Prentice Hall (India) Publications (2006).
- Risk management of natural disasters, by Claudia G. Flores Gonzales, KIT Scientific Publishing (2010).
- Disaster Management – a disaster manager's handbook, by W. Nick Carter, Asian Development Bank (2008).
- Disaster Management in India, by R. K. Srivastava, Ministry of Home Affairs, GoI, New Delhi (2011)
- The Chernobyl Disaster: Legacy and Impact on the Future of Nuclear Energy, by Wil Mara, Marshall Cavendish Corporation, New York, 2011.
- 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.)