B. Tech. Program (Mechanical Engineering)

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)

Shri Vile Parle Kelavani Mandal's

DWARKADAS J. SANGHVI COLLEGE OF ENGINEERING

(Empowered Autonomous) Affiliated to the University of Mumbai)

Department of Mechanical Engineering

Scheme for Final Year of B.Tech. Program in Mechanical Engineering: Semester VIII
(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 @	DJS23MCPE811	Design for X	3	-	-	3	2	60	-	-	-	60	15	15	10	40	-	**40**	100	3	**3**
	DJS23MCPE812	Air Handling Units																			
	DJS23MCPE813	Digital Manufacturing																			
	DJS23MCPE814	Lean Manufacturing																			
	DJS23MCPE815	Soft Computing and Optimization Techniques																			
	DJS23MCPE816	Startup Registration and Development																			
	DJS23MCPE817	Hydrogen Powered Vehicles																			
2	DJS23IPELX14	Internship (OJT) cum Project	-	36	-	18	2	-	-	-	200	200	-	-	-	-	400	**400**	600	18	**18**
3	DJS23MSC801	Machine Learning for Mechanical Engineers	1	-	-	1	-	-	-	-	-	-	15	15	10	40	-	**40**	40	1	1
		Total	**4**	**36**	**-**	**22**	**4**	**60**	**-**	**-**	**200**	**260**	**30**	**30**	**20**	**80**	**400**	**480**	**740**	**22**	

@ Any 1 Program Elective V (online) from the given list. 3: 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.	60	2
	* Computer-based assessment on the college premises.		
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: VIII**
Course: Design for X (DJS23MCPE811)		

Pre-requisites:

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

Objectives:

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

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

1. Explain the fundamental principles of DfX and its role in optimizing product design for various factors such as manufacturability, reliability, cost, and sustainability.
2. Apply Design for Manufacturability (DfM) principles to optimize material selection, process constraints, and design simplification for efficient manufacturing.
3. Analyze product designs to minimize assembly complexity, reduce part count, and optimize cost through effective DfA and DfC strategies.
4. Evaluate reliability and sustainability factors in product design using techniques such as Failure Modes and Effects Analysis (FMEA) and Life Cycle Assessment (LCA).
5. Integrate safety, maintainability, and serviceability considerations into product design to enhance usability, longevity, and compliance with industry standards.
6. Develop an optimized product design by integrating multiple DfX principles and using digital tools such as CAD, simulation, and AI-driven optimization.

Design for X (DJS23MCPE811)		
Unit	**Description**	**Duration**
1	**Introduction to Design for X** *Definition and Philosophy of DfX**:*** Understanding "X" as a variable representing key design considerations, Holistic and proactive approach to engineering design, Emphasis on life-cycle thinking. Importance of DfX in Product Development: Duration 8 Enhancing product quality, usability, and competitiveness, Reducing time-to-market and development cost, Supporting innovation while mitigating risks. Role of DfX in the Product Development Cycle: Integrating DfX early in the concept and design stages. Cross-functional collaboration (design, manufacturing, supply chain, sustainability, etc.). Aligning with customer requirements and business goals. *Overview of Key DfX Disciplines:* Design for Manufacturability (DfM), Design for Assembly (DfA), Design for Cost (DfC), Design for Reliability (DfR), Design for Sustainability (DfS) , Design for Safety (DfSa), Design for Maintainability & Serviceability (DfM&S) *Case studies on successful DfX applications:*	7

	Real-world examples of successful DfX applications from industries like automotive, aerospace, electronics, and consumer goods. Analysis of the impact of DfX on cost, quality, time, and environmental performance.	
2	**Design for Manufacturability (DfM)** *Principles of Manufacturability:* Designing products for ease, efficiency, and cost-effectiveness in manufacturing, Avoiding overly complex geometry and unnecessary features, *Material Selection and Process Constraints:* Matching materials to manufacturing processes and product requirements, Consideration of formability, machinability, weldability, etc. *Tolerance Analysis and Design Simplification:* Importance of tolerancing in manufacturability and quality, GD&T basics and statistical tolerance stacking, Simplifying part geometry to reduce processing steps. ***Design Guidelines for Key Manufacturing Processes:*** Casting: Uniform wall thickness, draft angles, and riser design. Machining: Tool access, fixturing, and reducing setup changes. Injection Molding: Parting lines, flow paths, undercuts, and sink marks. Sheet Metal: Bend radii, material usage, and nesting. Additive Manufacturing: Layer orientation, support structures, and topology optimization. Tools and Techniques: DFM/DFA software tools (DFMPro, DesignSpark, etc.), Case examples of design changes that improved manufacturability.	8
3	**Design for Assembly (DfA)** *Principles of Assembly Efficiency:* Minimizing assembly time, tools, and labor, Reducing orientation sensitivity. *Minimizing Part Count and Fasteners:* Use of multifunctional and self-locating parts, Snap-fits, interlocking components, and integrated designs. *Modular Design and Standardization:* Plug-and-play components, Reusability across product lines and platforms. *Automated Assembly Considerations:* Robotics and automation-friendly design, Avoiding small, fragile, or asymmetrical parts. **Design for Cost (DfC):** *Cost Modelling Techniques:* Parametric costing, activity-based costing. Material and Process Cost Trade-offs: Evaluating performance vs. cost. Design Simplifications for Cost Reduction: Standard components, simplified assemblies. *Life Cycle Cost Analysis:* CAPEX, OPEX, maintenance, and end-of-life.	9
4	**Design for Reliability (DfR)** *Failure Modes and Effects Analysis (FMEA):* Systematic identification and ranking of potential failure modes, Risk Priority Number (RPN) and mitigation strategies. *Reliability Prediction and Testing Methods:*	9

	MTBF (Mean Time Between Failures), Weibull analysis, Accelerated life testing, environmental testing. *Fatigue, Wear, and Durability:* Stress-life and strain-life approaches, Material selection and design against degradation. *Redundancy and Fault-Tolerant Design:* Backup systems, graceful degradation, Criticality analysis and design for safe failure. **Design for Sustainability (DfS):** Environmental Impact (Energy consumption, emissions, waste), Life Cycle Assessment (LCA) (Cradle-to grave and cradle-to-cradle models), Sustainable Materials and Processes (Bio-based materials, green manufacturing), Circular Economy (Reuse, remanufacturing, recycling, and take-back systems).	
5	**Design for Safety (DfS)** Compliance with Safety Standards (ISO, OSHA, CE marking, etc.), Human Factors & Ergonomics (User interaction, comfort, and errors), Hazard Analysis Techniques (HAZOP, FTA (Fault Tree Analysis), ETA (Event Tree)), Fail-Safe and Foolproof Design (Interlocks, alarms, and error-proofing (Poka-yoke)). **Design for Maintainability & Serviceability (DfM&S):** Ease of Inspection and Diagnostics (Access to critical components, onboard diagnostics), Modularity and Repairability (Plug-and-play modules, standardized connectors), Spare Parts and Accessibility Considerations (Common fasteners, openable enclosures), Predictive Maintenance and IoT Integration (Real-time monitoring, analytics-driven alerts). **Integrated DfX Approach:** Cross-functional Optimization (Balancing manufacturability, cost, reliability, and sustainability), Trade-off and Decision-Making Techniques (Pareto analysis, QFD, TRIZ, multicriteria decision analysis). **Digital Tools and Software:** CAD/CAM/CAE integration for DfX analysis, PLM (Product Lifecycle Management) platforms, AI, and machine learning in design optimization. **Industry Trends and Future Directions:** Smart manufacturing, Industry 4.0, digital twins, DfX in circular economy and netzero goals, Role of generative design and design automation.	9
	Total	**42**

Books Recommended:

Reference Books:

- George Q. Huang, *Design for X: Concurrent Engineering Imperatives*, Springer London, 1996.
- Geoffrey Boothroyd, Peter Dewhurst, and Winston Knight, *Product Design for Manufacture and Assembly*, CRC Press, 2010.
- Gerhard Pahl and Wolfgang Beitz, *Engineering Design: A Systematic Approach*, Springer London, 2007.
- David M. Anderson, *Design for Manufacturability: How to Use Concurrent Engineering to Rapidly Develop Low-Cost, High-Quality Products for Lean Production*, CRC Press, 2014.
- Bryan R. Fischer, *Mechanical Tolerance Stackup and Analysis*, CRC Press, 2011.
- Peter Sandborn, *Cost Analysis of Electronic Systems*, World Scientific Publishing, 2013.
- E. E. Lewis, *Reliability Engineering*, Dover Publications, 1996.

- Patrick D. T. O'Connor and Andre Kleyner, *Practical Reliability Engineering*, Wiley, 2012.
- David T. Allen and David R. Shonnard, *Sustainable Engineering: Principles and Practice*, Pearson Education, 2011.
- Louis J. Gullo and Jack Dixon, *Design for Safety*, Wiley, 2018.
- Mark S. Sanders and Ernest J. McCormick, *Human Factors in Engineering and Design*, McGraw-Hill, 1993.
- B. S. Dhillon, *Maintainability, Maintenance, and Reliability for Engineers*, CRC Press, 2006.
- Andrew Kusiak, *Concurrent Engineering: Contemporary Issues and Modern Design Tools*, Wiley, 1993.

Web References:

- Dassault Systèmes (https://www.3ds.com/store/cad/design-for-x)
- ANSYS (https://www.ansys.com/en-in/blog/what-is-dfx)

Program: Mechanical Engineering	**Final Year B.Tech.**	**Semester: VIII**
Course: Air Handling Units (DJS23MCPE812)		

Pre-requisites:

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

Objectives:

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

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

1. Explain the Fundamentals and Functions of AHUs.
2. Analyze and Select AHU Components for Different Applications.
3. Perform AHU Design, Sizing, and Selection Based on Requirements.
4. Implement Control Strategies and Automation in AHUs.
5. Execute proper installation procedures, testing, troubleshooting, and preventive maintenance of AHUs.
6. Evaluate Energy Efficiency, Sustainability, and Future Trends in AHUs.

Air Handling Units ((DJS23MCPE812)		
Unit	**Description**	**Duration**
1	**Fundamentals of Air Handling Units (AHUs) and Airflow Principles** • Introduction to Air Handling Units (AHUs): Definition, Purpose, and Importance of AHUs; Role of AHUs in HVAC Systems and Building Management; Basic Structure and Working Principle • Principles of Airflow in AHUs: Concepts of Airflow, Static Pressure, and Velocity; Psychrometrics and Air Conditioning Processes; Ventilation: Fresh Air, Recirculated Air, and Exhaust Air; Air Distribution Systems: • Classification and Types of AHUs: Centralized vs. Decentralized AHUs; Packaged AHUs vs. Custom-Built AHUs; Indoor vs. Outdoor AHUs; Modular vs. Integrated AHUs • Industry Standards and Regulations: ASHRAE, ISO, and EN Standards for AHUs; Air Quality Standards and Energy Regulations	9
2	**AHU Components and Their Functions**	9

	• Components: AHU Casing: Materials, Insulation, and Construction; Fans and Blowers: Types, Selection Criteria, and Efficiency; Fan Laws and Performance Curves; Variable Frequency Drives (VFDs) and Energy Optimization • Air Filtration Systems: Types of Filters: Pre-Filters, Bag Filters, HEPA, Carbon Filters; Filtration Efficiency and Pressure Drop Considerations; Filter Replacement, Cleaning, and Maintenance Strategies • Air Treatment Components: Cooling and Heating Coils; Humidifiers and Dehumidifiers; Dampers and Louvers; Heat Recovery Systems (HRV, ERV) and Energy Efficiency	
3	**Design, Sizing, and Selection of AHUs** • AHU System Design Principles: Load Calculations for AHU Sizing, Airflow Rate and Capacity Calculations, Heat Load Considerations for Cooling and Heating Coils • AHU Selection Criteria: Application-Based AHU Selection (Commercial, Industrial, Healthcare, etc.), Sizing and Capacity Planning (CFM, ESP, Face Velocity), Fan Selection Based on System Resistance and Duct Design • Energy Efficiency and Performance Optimization: AHU Efficiency Metrics (COP, SEER, and EER), Variable Air Volume (VAV) vs. Constant Air Volume (CAV) Systems, Energy Recovery Strategies (Heat Exchangers, Enthalpy Wheels)	8
4	**AHU Control Systems and Automation** • Control Strategies: Temperature, Humidity, and Pressure Control; Airflow Regulation and Demand-Based Ventilation • Sensors and Actuators: Temperature and Humidity Sensors; CO_2 and Air Quality Sensors; Actuators for Dampers and Valves • Smart AHUs and IoT-Enabled Control: Role of Artificial Intelligence and Machine Learning in AHUs; Predictive Maintenance using IoT	8
5	**Installation, Commissioning, and Applications** • Installation and Site Considerations: AHU Placement (Indoor vs. Outdoor); Ductwork Connections and Air Distribution Considerations; Condensate Drainage and Water Management • Testing and Commissioning of AHUs: Pre-Commissioning Checklist and Procedures; Airflow Measurement and Balancing; Performance Testing and Functional Verification Instustry Applications and Future Trends • Application-Specific AHU configurations: Commericial Buildings; Industrial Applications; Healthcare and Cleanroom; Data Centers • Future Challenges and Market Trneds: Market Growth and Emerging Technologies; Challenges in Retrofitting old AHUs; Impact of Regulations on Future AHU Design.	8
	Total	**42**

Books Recommended:

Text Books:

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

- Ronald H. Howell, William J. Coad, Harry J. Sauer Jr., Ventilation, and Air Conditioning: ASHRAE (American Society of Heating, Refrigerating, and Air-Conditioning Engineers, 2017.
- Stanley E. Cummings, Airflow in Ducts and Fans, Elsevier, 2018.
- William Cory, Fans and Ventilation: A Practical Guide, 2007.
- R. A. Wallis, Centrifugal and Axial Flow Fans: Design and Applications, John Wiley & Sons.

Reference Books:

- Frank P. Bleier, Fan Handbook: Selection, Application, and Design, McGraw-Hill, 2009.
- Faye C. McQuiston, Jerald D. Parker, Jeffrey D. Spitler, Heating, Ventilating, and Air Conditioning: Analysis and Design, Wiley publication, 2005.

Web References:

- Refrigeration and Air-conditioning (https://onlinecourses.nptel.ac.in/noc19_me58)

Program: Mechanical Engineering	**Final Year B.Tech.**	**Semester: VIII**
Course: Digital Manufacturing (DJS23MCPE813)		

Pre-requisites:

1. Fundamentals of CAD/CAM.

Objectives:

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

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

1. Explain the various steps involved in digital manufacturing and smart factory concepts.
2. Explain the architecture of Industry 4.0 in the digital manufacturing planning process
3. Analyze the benefits of CAD/CAM/CAE in the digital manufacturing process.
4. Identify and evaluate cybersecurity issues in the digital manufacturing environment.

Digital Manufacturing (DJS23MCPE813)		
Unit	**Description**	**Duration**
1	**Introduction to Digital Manufacturing** Evolution of conventional manufacturing to Digital Manufacturing (DM); concept and significance of digital transformation; drivers of digital transformation in manufacturing; three dimensions of digital manufacturing; Cyber-Physical Systems (CPS); Industrial Internet of Things (IIoT); digital thread and digital twin in manufacturing; need and components of digital infrastructure; challenges in implementing digital transformation; outcomes and benefits of digital transformation for industrial enterprises.	8
2	**Industry 4.0 and Digital Manufacturing Planning** Overview and progression of Industry 4.0; core components and enabling technologies; integration and connectivity of cyber-physical systems within manufacturing environments; current status and trends of Industry 4.0 adoption in India; six fundamental design principles of Industry 4.0; reference architectures and standard models for Industry 4.0; comparative analysis of digital manufacturing models and their adaptability; digital resource modelling and factory-level simulation techniques; digital manufacturing planning methodologies; integration of ERP systems with value chain management; and the role of validation and virtual commissioning in successful digital manufacturing implementation.	10
3	**CAD/CAM and CAE in Digital Manufacturing** Introduction to CAD/CAM systems; geometric modelling concepts and modelling kernels; computer-aided geometric modelling systems; component and assembly design methodologies; simulated motion analysis of machine components; fundamentals and procedures of finite element modelling and analysis (FEA); computer-aided engineering (CAE) implementation in product and process design; application of automation in digital manufacturing environments; principles of geometric dimensioning and tolerancing (GD&T); introduction to computer-aided	8

	fixture design.	
4	**Digital Twin and Industrial Internet of Things (IIoT)** **Digital Twin:** Introduction to digital twins and their working principles; applications of digital twins in manufacturing systems; scalability and complexity considerations in digital twin development; role of digital twins in the automotive industry; digital twins platform architecture and ecosystem; challenges, risks, and limitations associated with digital twin implementation. **IIOT:** Introduction to the Industrial Internet of Things (IIoT); role of sensor technologies in industrial applications; impact of IIoT on productivity, safety, and security; fundamentals of cloud computing for industrial data management; structure and components of the IIoT ecosystem; business value proposition of IIoT in manufacturing and industrial enterprises; challenges, risks, and limitations associated with IIoT deployment.	9
5	**Cybersecurity/ Big Data Security in Digital Manufacturing** Introduction to cybersecurity concepts in digital manufacturing, including threats, vulnerabilities, and attacks; network and system security measures such as wireless security, firewalls, intrusion detection and prevention systems; security of industrial control systems including SCADA, PLCs, and critical ICS components; data security strategies for protecting intellectual property, customer, and operational data using encryption, access control, and data loss prevention techniques; identification and mitigation of cybersecurity risks in digital manufacturing environments.	7
	Total	**42**

Books Recommended:

Textbooks:

- Sunil Mudumala, Leading Digital Transformation in Manufacturing Industry 4.0.
- J. Paulo Davim , Kaushik Kumar, Divya Zindani , J. Paulo Davim, Digital Manufacturing and Assembly Systems in Industry 4.0, Taylor and Francis, 2021.
- Mark J. Barrenechea, Tom Jenkins, Digital Manufacturing, Waterloo, 2018
- Y. Koren, "The Global Manufacturing Revolution", John Wiley & Sons, 2010.
- Chandrakant D. Patel, Chun-Hsien Chen, Digital Manufacturing, Elsevier, 2024.

Reference Books:

- Andries Feikema, Digital Transformation in Procurement, Koganpage, 2025.
- Lane Thames, Dirk Schaefer, Cybersecurity for Industry 4.0, Springer, 2017.
- R Sujatha, G Prakash, Noor Zaman Jhanjhi, Cyber Security Applications for Industry 4.0, Chapman & Hall, 2024.

Online Reference:

- The Future of Manufacturing Business: Role of Digital Technologies- https://onlinecourses.nptel.ac.in/noc21_mg83
- Industry 4.0: Managing The Digital Transformation- https://onlinecourses.nptel.ac.in/noc26_ge04/

Program: Mechanical Engineering	**Final Year B.Tech.**	**Semester: VIII**
Course: Lean Manufacturing (DJS23MCPE814)		

Objectives:

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

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

1. Apply observation skills using 4W1H labelling to identify unsafe conditions, hazards, and risks on shop floors.
2. Describe the evolution of manufacturing, key challenges, and core lean principles from Toyota Production System.
3. Explain factory essentials like business cycles, procurement, production, teamwork, and self-discipline in lean contexts.
4. Analyze lean operations, identify eight mudas, and create process flow diagrams for flow improvement.
5. Develop visual maps (VMapQ) and apply 5S, takt time, and flow attributes to optimize material, space, and information flow

Lean Manufacturing (DJS23MCPE814)		
Unit	**Description**	**Duration**
1	**Observation and Manufacturing Evolution:** **Observation Skills**: Safety and cleanliness in factory site visits, pre-training observation test, "Seeing vs Observing", 4W1H format (What, Where, When, Who, How), language of label writing, steps in label grouping, identifying unsafe conditions/acts, hazard-risk understanding. **Manufacturing History:** History of craftsmanship and its valuable lessons/practical needs, challenges of craft production, mass manufacturing and interchangeable parts/assembly line, Ford's challenges and fall, Toyota's rise, core Lean Principles (eliminate waste, continuous improvement, respect for people), Lean vs Mass Production. **Practical**: Factory site visit with 4W1H labeling exercise	**8**
2	**Factory Essentials and Lean Operations:** **Essential Factory Concepts:** Business cycle overview, concepts in procurement/production/delivery, organization of people (men), types of material handling, self-discipline, time management, teamwork, brainstorming techniques, conflict management in shop-floor teams. **Lean Operations:** Operations and functional silos (drawbacks, net negative impacts), Eight Muda (Overproduction, Waiting, Transport, Over-processing, Inventory, Motion, Defects, Unused Talent), eliminating muda through loops, Process Flow Diagram (PFD) creation, PFD case study analysis. **Practical:** Teamwork exercise on brainstorming production bottlenecks.	**8**
3	**Flow Management Fundamentals**	**9**

	Flow Concepts: Concept of Flow vs Process, Time and Motion Study fundamentals, Takt Time calculation and significance, origination of muda in non-flow processes, characteristics of flow in manufacturing vs business processes. **Flow Attributes:** Flow of material (one-piece flow principles), flow of information (pull systems intro), takt time application in line balancing, process vs flow comparison in mechanical manufacturing. **Practical:** Takt time calculation exercise using mechanical assembly line data.	
4	**Visual Mapping and 5S** **5S Methodology:** Complete 5S implementation steps (Sort, Set-in-order, Shine, Standardize, Sustain) with mechanical engineering examples. **VMapQ Family (Visual Mapping):** Introduction to VMapQ, benefits and stages of VMapQ creation, visualizing material flow, space allocation mapping, safety issues visualization. **VMapQ Creation Process:** Guidelines, Step 1-8 detailed process (current state mapping, proposed improvements), VMapQ Step 5-6 (waste identification), Step 7-8 (Kaizen proposals). **Practical:** Hands-on VMapQ creation for a mechanical workshop.	**9**
5	**Lean Implementation and Improvement** **Lean Deployment:** Integrating observation, flow, VMapQ tools for Kaizen events, MIJSC case studies from automotive/SME sectors, lean leadership, and employee involvement. **Implementation Challenges:** Barriers in Indian manufacturing SMEs, performance measurement (productivity, quality, delivery metrics), and shop-floor transformation roadmap. **Project Work:** Complete a lean improvement proposal using VMapQ methodology on a real manufacturing process (auto-components/sheet metal preferred). **Practical:** Group project presentation on VMapQ-based improvement proposal.	**8**
	Total	**42**

Books Recommended:

Textbooks:

- The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer by Jeffrey K. Liker (5th Edition, McGraw-Hill, 2021).
- Lean Thinking: Banish Waste and Create Wealth in Your Corporation by James P. Womack and Daniel T. Jones (Simon & Schuster, 2003).
- Lean Manufacturing: Fundamentals, Tools, Approaches, and Industry 4.0 Integration by S. Vinodh (CRC Press, 2022).

Reference Books:

- Learning to See: Value Stream Mapping to Add Value and Eliminate Muda by Mike Rother and John Shook (Lean Enterprise Institute, 1999).
- The Lean Six Sigma Pocket Toolbook: A Quick Reference Guide to Nearly 100 Tools by Michael L. George, John Maxey, David T. Rowlands, and Mark Price (McGraw-Hill, 2005).
- Kaizen Express: Fundamentals for Becoming a Lean Enterprise by Toshiko Narusawa and Masaaki Imai (Lean Enterprise Institute, 2007).

Web References:

- SWAYAM Foundations of Lean Manufacturing Course (IMB24_MG119): https://onlinecourses.swayam2.ac.in/imb24_mg119/preview - Free modules on observation, VMapQ, and flow matching syllabus.
- Mizuho India Japan Study Center (MIJSC) Lean Manufacturing Program: https://www.iimb.ac.in/mijsc/lean-manufacturing-transformation.php - Brochures, case studies, and VLCI-aligned resources for industry application

Program: Mechanical Engineering	**Final Year B.Tech.**	**Semester: VIII**
Course: Soft Computing and Optimization Techniques (DJS23MCPE815)		

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

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

1. Explain the principles of soft computing, intelligent systems, and optimization fundamentals, and interpret different types of optimization problems.
2. Apply fuzzy logic concepts and fuzzy inference systems to model and solve engineering problems involving uncertainty.
3. Analyze and implement evolutionary algorithms such as GA and related techniques for solving optimization problems.
4. Evaluate and compare swarm intelligence algorithms for solving complex, multi-modal optimization problems.
5. Apply multi-criteria decision-making (MCDM) techniques to select optimal solutions in engineering systems under deterministic and uncertain environments.

Soft Computing and Optimization Techniques (DJS23MCPE815)		
Unit	**Description**	**Duration**
1	**Foundations of Soft Computing and Intelligent Systems** • Concept of Soft Computing: Definition, characteristics, hybridization, and advantages over hard computing • Uncertainty modeling: Approximate reasoning vs probabilistic reasoning • Intelligent systems architecture: Learning, adaptation, and generalization • Need and applications of soft computing in mechanical engineering • Optimization Fundamentals: Global and local optima, problem formulation • Introduction to optimization landscapes: multi-modal, convex, and non-convex functions, eigenvalue decomposition, singular value decomposition, high-dimensional • Classification of optimization problems in machine learning • Review and discussion of optimization methods: Linear Programming: Graphical method, Simplex method, Duality; Unconstrained Optimization:	**6**

	Gradient-based methods, Cauchy's steepest descent, Newton's method, Conjugate gradient method; Constrained Optimization: Direct methods, Penalty function methods, Steepest descent method (*Only review is expected as these methods are discussed in semester III and IV. The questions should not be asked in the theory exam.*)	
2	**Fuzzy Logic and Hybrid Systems** • Fuzzy Set Theory: Fuzzy sets, operations, membership functions • Fuzzy relations, propositions, implications, inference systems • Defuzzification techniques • Fuzzy Logic Controller (FLC): Design, rule base, inference mechanism	**6**
3	**Evolutionary Algorithms (EA)** • Introduction to EA, evolutionary computation concepts • Genetic Algorithm (GA); Genetic Programming (GP); Evolutionary Programming (EP); Evolution Strategies (ES) • Differential Evolution (DE); Cultural Algorithm (CA); Memetic Algorithms (MA); Co-evolutionary Algorithms • Artificial Immune System (AIS); Biogeography-Based Optimization (BBO)	**11**
4	**Swarm Intelligence Techniques** • Particle Swarm Optimization (PSO); Ant Colony Optimization (ACO); Artificial Bee Colony (ABC) Algorithm; Firefly Algorithm (FA); Cuckoo Search Algorithm (CSA) • Bat Algorithm; Grey Wolf Optimizer (GWO); Whale Optimization Algorithm (WOA); Dragonfly Algorithm (DA) • Grasshopper Optimization Algorithm (GOA); Salp Swarm Algorithm (SSA); Moth Flame Optimization (MFO); Ant Lion Optimizer (ALO) • Cat Swarm Optimization (CSO); Glowworm Swarm Optimization (GSO); Introduction to hybrid / emerging techniques: Hybrid GA–PSO; neuro-evolution techniques; fuzzy evolutionary algorithms; Quantum-inspired evolutionary algorithms; multi-objective evolutionary algorithms (MOEA – NSGA-II, SPEA2)	**11**
5	**Multi-Criteria Decision Making (MCDM)** • Introduction to decision-making in engineering systems • Need for MCDM in complex mechanical engineering problems • Types of decision-making environments: deterministic, uncertain, fuzzy • Basic concepts of MCDM: Alternatives, criteria, attributes; Decision matrix formulation; Criteria weighting and normalization techniques • Classification of MCDM methods • Analytical Hierarchy Process (AHP): • Technique for Order Preference by Similarity to Ideal Solution (TOPSIS): • VIKOR Method: • Entropy Method for criteria weight determination • Fuzzy MCDM approaches: Fuzzy AHP, Fuzzy TOPSIS • Handling uncertainty in decision-making	**8**
	Total	**42**

Books Recommended:

Textbooks:

- Mangey Ram, and Suraj B. Singh, Soft Computing: Techniques om Engineering Sciences, De Gruyter, 2020.
- S. Chakraverty, Deepti M. Sahoo, and Nisha R. Mahato, Concept of Soft Computing: Fuzzy and ANN Programming, Springer Nature Singapore, 2019.
- Ashish M. Gujarathi, B. V. Babu, Evolutionary Computation: Techniques and Applications, CRC Press 2016.
- Tettamanzi Andrea, Tomassini and Marco, Soft Computing Integrating Evolutionary, Neural and Fuzzy Systems, Springer, 2001.
- Singiresu S Rao, Engineering Optimization Theory and Practice, John Wiley & Sons, Inc, 2019
- Parag Kulkarni and Prachi Joshi, "Artificial Intelligence – Building Intelligent Systems", PHI learning Pvt. Ltd., 2015

Reference Books:

- Deisenroth, Faisal, Ong, Mathematics for Machine Learning, Cambridge University Press, 2020.
- X. Yao," Evolutionary Computation: Theory and Applications", World Scientific Publ. Co., Singapore, 1999.
- Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, "Digital Image Processing Using MATLAB", Third Edition Tata Mc Graw Hill Pvt. Ltd., 2011.
- Solanki, Kumar, Nayyar, Emerging Trends and Applications of Machine Learning, IGI Global, 2018.
- Mohri, Rostamizdeh, Talwalkar, Foundations of Machine Learning, MIT Press, 2018.
- Kumar, Zindani, Davim, Artificial Intelligence in Mechanical and Industrial Engineering, CRC Press, 2021.

Web References:

- Introduction to Soft Computing (https://onlinecourses.nptel.ac.in/noc26_cs44/preview)
- Soft Computing Techniques (https://onlinecourses.swayam2.ac.in/e-learning/preview/ntr26_ed73)
- Soft Computing Techniques (https://onlinecourses.nptel.ac.in/noc26_ma35/preview)
- Evolutionary Computation For Single And Multi-Objective Optimization (https://onlinecourses.nptel.ac.in/noc26_me17/preview)

Program: Mechanical Engineering	**Final Year B.Tech.**	**Semester: VIII**
Course: Startup Registration and Development (DJS23MCPE816)		

Pre-requisites:

1. Fundamentals of Business Development
2. Entrepreneurial Business Models

Objectives:

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

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

1. Select appropriate legal structures and complete the startup registration process with required compliances.
2. Utilize government schemes, incentives, and funding policies effectively for startup development.
3. Prepare key registration documents and implement intellectual property protection strategies.
4. Develop financial models and fundraising plans suitable for engineering-based startups.
5. Manage taxation, auditing, and regulatory requirements while planning for business growth.

Startup Registration and Development (DJS23MCPE816)		
Unit	**Description**	**Duration**
1	**Introduction to Startup Registration.** Definition, types, and importance of startups in the Indian economy. Comparison of different legal structures such as Proprietorship, LLP, Private Limited, and Public Limited companies. Step-by-step process of business registration, including necessary approvals and filings. Case studies on successful and challenging startup registrations with a focus on mechanical and engineering ventures.	**10**
2	**Government Policies and Incentives for Startups.** Overview of Startup India initiative, MSME schemes, and other relevant government policies. Tax benefits, grants, subsidies, and financial incentives available to startups. Public and private funding support mechanisms. Case studies of startups that successfully leveraged government incentives for early growth.	**08**
3	**Business Compliance and Documentation.** Preparation of important documents, including Memorandum of Association, Articles of Association, GST registration, and UDYAM certification. Obtaining necessary business licenses, permits, and compliance reports. Understanding business ethics, legal challenges, and documentation best practices for engineering startups.	**08**
4	**Intellectual Property Rights for Startups.** Importance of Patents, Trademarks, Copyrights, and Trade Secrets for protecting innovations in mechanical and engineering fields. Filing procedures, legal aspects,	**08**

	and maintenance of IPR. IP commercialization, licensing strategies, and case studies on successful IP protection by startups.	
5	**Fundraising, Taxation, Compliance, and Growth Strategies.** Seed funding, angel investors, venture capital, and crowdfunding options. Investor relations, pitching techniques, term sheets, and equity dilution concepts. GST, corporate tax, financial reporting, auditing, and legal risk management. Business growth pathways, including mergers, acquisitions, and IPOs, along with finalization of the startup business plan and course review.	**08**
	Total	**42**

Books Recommended:

- Purohit, Prachi. Startup India: The Complete Guide to Launching and Managing a Business. Notion Press, Chennai, 2021.
- Joshi, M.V. Entrepreneurship Development and Startup India. Himalaya Publishing House, Mumbai, 2020.
- Pathak, Akhileshwar. Legal Aspects of Business. McGraw Hill, New Delhi, 2018.
- Hegde, Dinesh S. Indian Startups and their Funding Journey. Springer, New Delhi, 2021.
- Sharma, Rajat. Business Laws for Entrepreneurs. Pearson, New Delhi, 2019.
- Blank, Steve, and Bob Dorf. The Startup Owner's Manual. K&S Ranch Publishing, Pescadero, 2012.
- Feld, Brad, and Jason Mendelson. Venture Deals: Be Smarter Than Your Lawyer and Venture Capitalist. Wiley, New Jersey, 2019.
- Desai, Vasant. Entrepreneurship Development in India. Himalaya Publishing House, Mumbai, 2019.

Program: Mechanical Engineering	**Final Year B.Tech.**	**Semester: VIII**
Course: Hydrogen Powered Vehicles (DJS23MCPE817)		

Pre-requisites:

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

Objectives:

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

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

1. Explain and classify hydrogen production methods, properties, and types, and assess their environmental impact in energy applications.
2. Describe and analyze different fuel cell technologies, their working principles, materials, and performance characteristics.
3. Evaluate hydrogen storage methods, infrastructure requirements, and apply safety standards in hydrogen systems.
4. Analyze and interpret the architecture, subsystem integration, and performance of hydrogen-powered vehicles.
5. Assess environmental impacts, economic feasibility, and future trends of hydrogen technology in sustainable transportation systems.

Hydrogen-Powered Vehicles (DJS23MCPE817)		
Unit	**Description**	**Duration**
1	**Hydrogen Fundamentals and Production** • Hydrogen as an energy carrier: Properties, advantages, and limitations • Global hydrogen economy: Opportunities, challenges, and applications in transportation • Physical and chemical characteristics relevant to transportation. • Hydrogen production methods: Steam reforming, electrolysis, biomass gasification, thermochemical methods • Types of hydrogen: Grey, blue, green – environmental impact comparison • Water splitting using renewable energy sources	**8**
2	**Hydrogen Fuel Cells – Principles and Materials** • Working principles of fuel cells: PEMFC, SOFC, DMFC • Performance characteristics, advantages, limitations, and comparative analysis • Thermodynamic principles and efficiency of fuel cells	**8**

	• Materials in fuel cells: Catalysts, membranes, bipolar plates, gas diffusion layers, electrodes • Material selection criteria and degradation mechanisms • Challenges: Durability, cost, and efficiency improvement strategies	
3	**Hydrogen Storage, Infrastructure, and Safety** • Hydrogen storage methods: Compressed, liquid, metal hydrides, chemical and solid-state storage • Hydrogen transportation and refueling infrastructure • Design and operation of hydrogen refueling stations • Safety considerations: Handling, storage, and transportation risks • Codes, standards, and regulations for hydrogen systems • Cost and feasibility analysis of hydrogen logistics • Emerging technologies in hydrogen storage and distribution	**8**
4	**Design and Architecture of Hydrogen-Powered Vehicles** • Vehicle architecture: Fuel cell stack, hydrogen tank, electric drivetrain, auxiliary systems • Fuel cell integration into vehicle platforms and hybrid systems • Power management systems and hybrid configurations • Thermal management of fuel cells • Integration with digital technologies: IoT and AI for monitoring and optimization • Comparison: Hydrogen-powered vehicles vs BEVs and ICE vehicles • Regulations and standards for hydrogen-powered vehicles • Case studies: Toyota Mirai, Hyundai Nexo, Honda Clarity Fuel Cell	**10**
5	**Environmental Impact, Economics, and Future Trends** • Life Cycle Assessment (LCA) of hydrogen-powered vehicles • Environmental and economic benefits of hydrogen technology • Policies and global initiatives (EU Hydrogen Strategy, Japan Hydrogen Roadmap) • Economic viability and market potential of hydrogen vehicles • Barriers to large-scale adoption and mitigation strategies • Hydrogen in renewable energy integration and energy storage • Applications in heavy-duty transport (buses, trucks, trains, ships, aircraft) • Emerging trends: Autonomous hydrogen vehicles and advanced fuel cell technologies • Case reference: Hindenburg Disaster and modern safety advancements • Contribution to Sustainable Development Goals: SDG 7 (Clean Energy), SDG 13 (Climate Action)	**8**
	Total	**42**

Books Recommended:

Textbooks:

- Pasquale Corbo, Fortunato Migliardini, Ottorino Veneri, Hydrogen Fuel Cells for Road Vehicles, Springer London, 2011.
- Marco Alverà, The Hydrogen Revolution: A Blueprint for the Future of Clean Energy, Hodder & Stoughton, 2021.

- Paulo Emilio Miranda, Science and Engineering of Hydrogen-Based Energy Technologies: Hydrogen Production and Practical Applications in Energy Generation, Elsevier Science, 2018.
- Catherine Azzaro-Pantel, Hydrogen Supply Chain: Design, Deployment and Operation, Elsevier Science, 2018.
- Shigenori Mitsushima, Viktor Hacker, Fuel Cells and Hydrogen: From Fundamentals to Applied Research, Elsevier, 2018.
- Adolfo Iulianelli, Angelo Basile, Advances in Hydrogen Production, Storage and Distribution, Woodhead Publishing, 2014.

Reference Books:

- Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Practice, CRC Press, 2009.
- Mehmet Sankir, Nurdan Demirci Sankir, Hydrogen Electrical Vehicles, Wiley, 2023.
- Akari Hayashi, Hai-Wen Li, Junichiro Yamabe, Kazunari Sasaki, Stephen M. Lyth, Teppei Ogura, Hydrogen Energy Engineering: A Japanese Perspective, Springer Japan.
- Selim Koca, Transition to Hydrogen Fuel Cell Vehicles, Nova Science Publishers, 2010.
- Ronald K. Jurgen, Fuel Cell Hybrid EVs, SAE International, 2010.
- Amgad Elgowainy, Electric, Hybrid, and Fuel Cell Vehicles, Springer New York, 2021.
- Joseph M. Norbeck, Thomas Durbin, James Heffel, Michelle Montano, Hydrogen Fuel for Surface Transportation, SAE International, 1996.
- James John MacKenzie, The Keys to the Car: Electric and Hydrogen Vehicles for the 21st Century, World Resources Institute, 1994.

Web References:

- Hydrogen Energy: Production, Storage, Transportation and Safety (https://nptel.ac.in/courses/103101215)
- Cryogenic Hydrogen Technology (https://nptel.ac.in/courses/112105422)
- Fuel Cell Technology (https://nptel.ac.in/courses/103102015)