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)

Third Year B. Tech

In

Mechanical Engineering

(Semester VI)

Revision 0 (Effective from A.Y. 2025-26)

Shri Vile Parle Kelavani Mandal's

DWARKADAS J. SANGHVI COLLEGE OF ENGINEERING

(Autonomous College Affiliated to the University of Mumbai)

NAAC Accredited with "A" Grade (CGPA: 3.18)

Department of Mechanical Engineering

Scheme for Third Year of B.Tech. Program in Mechanical Engineering: Semester VI (Autonomous-DJS23 NEP) (Academic Year 2025-2026)

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	DJS23MCPC601	Design of Machine Elements	3	--	--	3	2	60	--	--	--	60	15	15	10	40	--	40	100	3	
	DJS23MLPC601	Design of Machine Elements Laboratory	--	2	--	1	2	--	25	--	--	25	--	--	--	--	25	25	50	1	**4**
2	DJS23MCPC602	Finite Element Analysis	3	--	--	3	2	60	--	--	--	60	15	15	10	40	--	40	100	3	
	DJS23MLPC602	Finite Element Analysis Laboratory	--	2	--	1	2	--	--	--	25	25	--	--	--	--	25	25	50	1	**4**
3	DJS23MCPC603	Heat Transfer	3	--	--	3	2	60	--	--	--	60	15	15	10	40	--	40	100	3	
	DJS23MLPC603	Heat Transfer Laboratory	--	2	--	1	--	--	--	--	--	--	--	--	--	--	25	25	25	1	**4**
4	DJS23MCMD601	Control Systems	3	--	--	3	2	60	--	--	--	60	15	15	10	40	--	40	100	3	
	DJS23MLMD601	Control Systems Laboratory	--	2	--	1	--	--	--	--	--	--	--	--	--	--	25	25	25	1	**4**
5	DJS23MLSC601	CAD CAM Laboratory	--	2	--	1	2	--	--	--	25	25	--	--	--	--	25	25	50	1	**1**
6 @	DJS23MCPE621	Vibration Analysis and Smart Monitoring	3	--	--	3	2	60	--	--	--	60	15	15	10	40	--	40	100	3	
	DJS23MLPE621	Vibration Analysis and Smart Monitoring Laboratory	--	2	--	1	--	--	--	--	--	--	--	--	--	--	25	25	25	1	**4**
	DJS23MCPE622	Refrigeration and Air Conditioning	3	--	--	3	2	60	--	--	--	60	15	15	10	40	--	40	100	3	
	DJS23MLPE622	Refrigeration and Air Conditioning Laboratory	--	2	--	1	--	--	--	--	--	--	--	--	--	--	25	25	25	1	**4**
	DJS23MCPE623	Quality Engineering and Management	3	--	--	3	2	60	--	--	--	60	15	15	10	40	--	40	100	3	
	DJS23MLPE623	Quality Engineering and Management Laboratory	--	2	--	1	--	--	--	--	--	--	--	--	--	--	25	25	25	1	**4**
	DJS23MCPE624	Automotive Systems	3	--	--	3	2	60	--	--	--	60	15	15	10	40	--	40	100	3	
	DJS23MLPE624	Automotive Systems Laboratory	--	2	--	1	--	--	--	--	--	--	--	--	--	--	25	25	25	1	**4**
	DJS23MCPE625	Industrial Robotics	3	--	--	3	2	60	--	--	--	60	15	15	10	40	--	40	100	3	
	DJS23MLPE625	Industrial Robotics Laboratory	--	2	--	1	--	--	--	--	--	--	--	--	--	--	25	25	25	1	**4**
	DJS23MCPE626	Artificial Intelligence and Machine Learning	3	--	--	3	2	60	--	--	--	60	15	15	10	40	--	40	100	3	
	DJS23MLPE626	Artificial Intelligence and Machine Learning Laboratory	--	2	--	1	--	--	--	--	--	--	--	--	--	--	25	25	25	1	**4**
	DJS23MCPE627	Entrepreneurial Business Models	3	--	--	3	2	60	--	--	--	60	15	15	10	40	--	40	100	3	
	DJS23MLPE627	Entrepreneurial Business Models Laboratory	--	2	--	1	--	--	--	--	--	--	--	--	--	--	25	25	25	1	**4**
7	DJS23IPSCX04	Innovative Product Development IV	--	2	--	1	2	--	--	--	25	25	--	--	--	--	25	25	50	1	**1**
8	DJS23ICHSX09	Constitution of India	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Total	**16**	**14**	**0**	**22**	**18**	**300**	**25**	**0**	**75**	**400**	**75**	**75**	**50**	**200**	**175**	**375**	**775**	**22**	

@Any 1 Department Elective from the given list.

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

Department of Mechanical Engineering

Program: Mechanical Engineering	**T.Y. B.Tech**	**Semester: VI**
Course: Design of Machine Elements (DJS23MCPC601)		
Course: Design of Machine Elements Laboratory (DJS23MLPC601)		

Pre-requisite:

- Mechanics of Materials
- Engineering Materials

Objectives:

1. To study basic principles of the design of machine elements.
2. To familiarize with the use of design data books & various codes of practice.
3. To acquaint with functional and strength design principles of commonly used machine elements.
4. To make conversant with the preparation of working drawings based on designs.

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

1. Use design data books in designing various components and other considerations in the design of machine components.
2. Illustrate basic principles of machine design.
3. Demonstrate understanding of various design considerations, theories of failures, Standards/Codes.
4. Design machine elements for static as well as dynamic loading.
5. Design machine elements based on strength/ rigidity concepts.
6. Design of power transmitting shaft and flexible drives.

Design of Machine Elements (DJS23MCPC601)		
Unit	**Description**	**Duration**
1	**Introduction to Design of Machine elements:** Mechanical Engineering Design, Design methods, Aesthetic and Ergonomics consideration in design, Material properties and their uses in design, Manufacturing consideration in design, Design consideration of casting and forging, Basic Principle of Machine Design: Modes of failures, Factor of safety, Design stresses, Theories of failures, Standards, I.S. Codes, Preferred Series and Numbers.	7
2	**Design against Static Loads:** Cotter joint (Socket and spigot type), Knuckle joint, Bolted and welded joints under eccentric loading; Curved Beams: Assumptions made in the analysis of curved beams, Design of curved beams: Bending stresses in curved beams such as crane hook, C-frame, etc. Power Screw and its application along with the design of Frame- Screw Jack.	12
3	**Design against Fluctuating Loads:** Variable stresses - reversed, repeated, fluctuating stresses. Fatigue failure: static and fatigue stress concentration factors, Estimation of endurance limit, Design for finite and infinite life, Soderberg and Goodman design criteria, Fatigue design under combined stresses.	6
4	**Design of Shaft:** power transmitting and power distribution shafts (excluding crankshaft) under static and fatigue loading, Keys: Types of Keys and their selection. Couplings: Classification of coupling, Design of rigid flange couplings, Bush pin type flexible couplings. Design of Flexible curvature drive: Flat belt, V-belt, Rope, Selection of Roller Chain drive.	11

5	**Design of springs:** Design of helical compression and tension springs under Static and Variable loads, design of laminated springs.	6
	Total	**42**

Design of Machine Elements Laboratory (DJS23MLPC601)	
Exp.	**Suggested Lab Exercises**
The following assignments are to be solved in the lab sessions in the form of tutorials or any software-based exercises such as MS Excel, MATLAB etc. (Minimum six):	
1	Design of Curved Beams.
2	Design of Cotter Joint.
3	Design of Knuckle Joint.
4	Design of the screw jack along with the frame.
5	Design of bolted and welded joints.
6	Design under fluctuating loads (finite and infinite life).
7	Design of Shaft.
8	Design of Coupling.
9	Design of Helical Spring.
10	Design of a Laminated spring.
Prepare a layout of the following using any CAD software (Minimum two):	
11	Layout of Cotter Joint.
12	Layout of Knuckle Joint.
13	Layout of C-clamp.
14	Layout of the Screw jack.

Books Recommended:

Text Books:

- V. B. Bhandari, Design of Machine Elements, Tata McGraw-Hill Education, Third Edition, 2010.
- J.E.Shigley, Mechanical Engineering Design, McGraw Hill, Sixth Edition, 2001.
- Merhyle Franklin Spotts, Terry E. Shoup, Lee EmreyHornberger, Design of Machine Elements, Pearson/Prentice Hall, Eighth Edition, 2004.

Recommended Reading:

- Robert L. Norton, Machine Design- An Integrated Approach, Pearson Education Asia, Fifth Edition, 2013.
- M. F. Ashby, Materials Selection in Mechanical Design, Butterworth-Heinemann, Elsevier, 5th Edition, 2017.
- D N Reshetov, Machine Design, Mir Publishers.
- Black Adams, Machine Design, McGraw Hill, Third Edition.
- Hawrock, Jacobson, Fundamental of Machine Elements, McGraw Hill, Third Edition, 2014.
- V.M. Faires, Design of Machine Elements, The Macmillan Co., Fourth Edition.
- P. Orlov, Fundamentals of Machine Design, Mir Publishers.
- Design Data Book, PSG, 2012.
- Design Data Book, Mahadevan, CBS Publishers and Distributors Pvt Ltd, Fourth Edition, 2013.

Web References:

- Design of Machine Elements (https://nptel.ac.in/courses/112105124)

Department of Mechanical Engineering

Program: Mechanical Engineering	**T.Y. B.Tech**	**Semester: VI**
Course: Finite Element Analysis (DJS23MCPC602)		
Course: Finite Element Analysis Laboratory (DJS23MLPC602)		

Pre-requisites:

- Matrices, Differential Equations, and Numerical Integrations.
- Basics of Mechanics of solids, Thermodynamics, and Fluid mechanics.
- Solid Modelling software.

Objectives:

1. To acquaint learners with the principles of finite element analysis (FEA).
2. To acquaint learners with the applications of FEA for solving engineering problems.
3. To acquaint learners with FEA software for solving real-life engineering problems.

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

1. Summarize the finite element method and develop algorithms for the analysis of mechanical systems.
2. Evaluate differential equations using weak and Non-weak form methods.
3. Apply the basic finite element formulation techniques to solve one-dimensional engineering problems using bar, beam, and link elements.
4. Apply the basic finite element formulation techniques to solve two-dimensional engineering problems using triangular and quadrilateral elements.
5. Apply the finite element methods to find the natural frequency of dynamic systems.
6. Use modern FEA software/tools to find field variables.

Finite Element Analysis (DJS23MCPC602)		
Unit	**Description**	**Duration**
1	**Introductory Concepts**: Historical Background, General FEA procedure, Applications of FEM in various fields, Advantages and disadvantages of FEA. **Definitions of Various Terms used in FEA**: Element, order of the element, internal and external node/s, degree of freedom, primary and secondary variables and boundary conditions. Mathematical modelling/governing differential equations in structural, thermal and fluid engineering fields.	**7**
2	**Non-Weak form Methods:** Collocation, Sub-domain, Petrov-Galerkin, Galerkin and Least square method. **Weak form method:** Rayleigh Ritz method for general elements and for the entire domain. Principle of minimum potential energy.	**7**
3	**One-Dimensional Finite Element Formulations:** One-dimensional second-order equations. Linear and higher order elements. Global, Local, and Natural coordinates. Derivation of shape functions, stiffness matrices and force vectors. **Assembly of Matrices**: solution of problems in one-dimensional structural analysis, heat transfer, and fluid flow (stepped and tapered bars, fluid network, and spring-cart systems). Analysis of plane trusses and beams.	**12**
4	**Two-Dimensional Finite Element Formulations:** Constant Strain Triangular (CST) and Linear Strain Triangular (LST) element, four-node rectangular element, four-node and eight-node quadrilateral element. Derivation	**10**

	of shape functions for triangular and quadrilateral elements. sub-parametric, isoparametric, super-parametric elements, Compatibility conditions, Patch test, Convergence criterion, and sources of errors in FEA. **Stress Analysis of Two-Dimensional Elements:** Equations of elasticity-Plane stress, plane strain, and axisymmetric problems. Jacobian matrix, stress analysis of CST element.	
5	**Finite Element Formulation of Dynamic System:** Applications of FEA to free longitudinal vibration problems. Lumped and consistent mass matrices. **Introduction to Non-linear FEA:** Geometric, material, and contact nonlinearity.	**6**
	Total	**42**

Finite Element Analysis Laboratory (DJS23MLPC602)	
Sr. No.	**Experiment Title**
1	Introduction to ANSYS software.
2	Analysis of a bar subjected to an axial load (Stepped/Tapered bar).
3	Analysis of a bar subjected to an axial load with thermal effects.
4	Analysis of a beam under various loads.
5	Steady state thermal analysis of a composite wall.
6	Analysis of Plane Truss.
7	Analysis of a plate with a circular hole at the centre using plane stress/plane strain conditions.
8	Modal analysis of a Mechanical component.
9	Analysis of the component using an axisymmetric element.

Learners shall use the commercial software (ANSYS/ABAQUS/NASTRAN/HYPERWORKS) or programs (Codes) to perform the above experiments. Learners shall also validate the experimental results with manual calculations (wherever applicable). Any other experiment based on the syllabus may be included, which would help the learner to understand the topic/concept. While performing the analysis of the above suggested experiments, the learners should understand the concepts of selection of element type, meshing and convergence of solution.

Course Project: A group of not more than four students shall do Finite Element Analysis (using commercial software or program codes) of any mechanical engineering component/system, which involves element selection, assigning material properties, meshing, assigning boundary conditions, analysis, and interpretation of results.

Books Recommended:

Textbooks:

- Seshu P., "Text book of Finite Element Analysis", Prentice-Hall of India Pvt. Ltd., New Delhi, 2012.
- S S Rao., "The Finite Element Method Engineering", Butter worth Heinemann, 2010. Pasquale Corbo, Fortunato Migliardini, and Ottorino Veneri, Hydrogen Fuel Cells for Road Vehicles, Springer London, 2011.

Reference Books:

- J N Reddy., "Finite Element Method", Tata McGraw Hill, 2019.

- R Dhanraj and K Prabhakaran Nair, "Finite Element Methods", Oxford University Press, 2015.
- Logan D L ., "A first course in Finite Element Method", Thomson Asia Pvt Ltd, 2002.
- Cook R D, Malkus D S, Plesha M E., "Concepts and Applications of Finite Element Analysis", John Wiley Sons, 2001.
- Chandrupatla and Belegundu , "Introduction to Finite Elements in Engineering", Prentice Hall, 2002.
- M. Asghar Bhatti., " Fundamental Finite Element Analysis and Application with Mathematica and MATLAB Computations", Wiley India Pvt. Ltd, 2005. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, and Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Practice, CRC Press, 2009.

Web References:

- NPTEL course on Basics of Finite Element Analysis-1
  https://nptel.ac.in/courses/112104193
- NPTEL course on Finite Element Method: Variational Methods to Computer Programming
  https://nptel.ac.in/courses/112103295

Program: Mechanical Engineering	**T.Y. B.Tech**	**Semester: VI**
Course: Heat Transfer (DJS23MCPC603)		
Course: Heat Transfer Laboratory (DJS23MLPC603)		

Pre-requisites:

- Engineering Mathematics
- Applied Thermodynamics
- Fluid Mechanics

Objectives:

1. To introduce the basic principles of heat transfer and steady state conduction.
2. To determine heat transfer from extended surfaces and unsteady state conduction.
3. To familiarize the principles of convection and the significance of dimensionless numbers.
4. To introduce different types of heat exchangers and their analysis.
5. To describe the principles of radiation heat transfer.

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

1. Explain the basic laws and modes of heat transfer and analyze one-dimensional steady-state conduction problems in simple geometries (walls, cylinders, spheres), including effects of thermal resistance and insulation.
2. Evaluate heat transfer performance of extended surfaces (fins) and apply analytical/graphical methods to solve transient heat conduction problems using Biot number, Fourier number, and Heisler charts.
3. Apply dimensional analysis and empirical correlations to estimate heat transfer coefficients for natural and forced convection in various flow configurations.
4. Analyze heat exchangers using LMTD and NTU methods, and explain heat transfer mechanisms during boiling and condensation processes.
5. Explain radiation laws, calculate radiative heat exchange between surfaces using view factors and electrical analogy, and apply concepts of radiation shields.

Heat Transfer (DJS23MCPC603)		
Unit	**Description**	**Duration**
1	**Introduction:** Thermodynamics and Heat Transfer, Applications of Heat Transfer, Basic Modes of Heat Transfer, Physical Mechanism of Heat Transfer, Fourier's Law of Heat Conduction, Newton's Law of Cooling, Stefan-Boltzmann Law. **One-Dimensional Steady State Conduction:** Thermal Conductivity, Variation of Thermal Conductivity in Solids, Liquids, and Gases, Thermal Diffusivity, General Heat Conduction Equation, Electrical Network Analogy, Boundary and Initial Conditions, Steady State Heat Conduction in Walls, Cylinders, and Spheres, Thermal Contact Resistance, Critical Thickness of Insulation.	**9**
2	**Heat transfer from Extended Surface:** Types of fins and their applications, Heat transfer from finned surface of uniform cross-sectional area, Effectiveness and Efficiency of fins, proper length of a fin. **Unsteady state Conduction:** Lumped Capacitance method, Biot number, Fourier number and their significance, Heisler charts.	**9**
3	**Convection:** Natural and Forced Convection, Hydrodynamic and Thermal Boundary Layers, Heat Transfer Coefficient, Principle of Dimensional Analysis, Buckingham's π Theorem, Application of Buckingham's π Theorem to Forced and Natural	**9**

	Convection, Physical Significance of Dimensionless Numbers, Nusselt Number, Grashof Number, Prandtl Number, Reynolds Number, and Stanton Number, Empirical Relations for Free and Forced Convection for Standard Cases.	
4	**Heat Exchangers:** Types of Heat Exchangers, Overall Heat Transfer Coefficient, Fouling Factor, Heat Exchanger Analysis using Log Mean Temperature Difference and Effectiveness-NTU method, Selection of heat exchangers, compact heat exchangers. **Boiling and Condensation:** Boiling heat transfer, Pool boiling, Boiling Regimes and Boiling Curve, Flow boiling, Condensation heat transfer, Film condensation, Dropwise Condensation.	**7**
5	**Radiation:** Emissive power, Emissivity, Irradiation, Radiosity, Absorptivity, Reflectivity and Transmissivity, Black body, Grey body, Opaque body, Kirchhoff's law, Planck's law, Wein's displacement law, Lambert cosine law, Intensity of Radiation, Solid Angle. Radiation heat exchange between two black and gray surfaces, View factor, View Factor relations, Application of Electrical Analogy to thermal radiation heat exchange between two parallel infinite plates, concentric infinitely long cylinders and two concentric spheres, Radiation shields.	**8**
	Total	**42**

Heat Transfer Laboratory (DJS23MLPC603)	
Sr. No.	**Experiment Title**
	Performance-Based Experiments
1	Determination of Thermal Conductivity of Solid and Liquid Materials
2	Measurement of Heat Transfer Coefficient in Natural Convection
3	Measurement of Heat Transfer Coefficient in Forced Convection
4	Study of Unsteady State Heat Transfer in a Cylinder, Rod, or Wall
5	Performance Analysis of Fins – Determination of Fin Efficiency and Effectiveness
6	Determination of Critical Heat Flux in Pool Boiling
7	Evaluation of Overall Heat Transfer Coefficient and Effectiveness of a Heat Exchanger
8	Verification of Stefan–Boltzmann Law using Stefan–Boltzmann Apparatus
9	Determination of Emissivity of a Grey Surface
	Numerical Analysis/ Simulation-based Experiments (Python/ MATLAB/ Simulink/ANSYS/Any other CFD Tool, etc.)
10	Numerical Modeling of a Heat Transfer Problem using Finite Difference Method (FDM)
11	Simulation of any conduction, convection problem.

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:

- C. P. Kothandaraman, Fundamentals of Heat and Mass Transfer, 4th Edition, New Age International Publishers, New Delhi, 2012.
- D. S. Kumar, Basics of Heat and Mass Transfer, S. K. Kataria & Sons, New Delhi, 2018.
- P. S. Ghoshdastidar, Heat Transfer, Oxford University Press, New Delhi, 2012.
- R. K. Rajput, A Textbook of Heat and Mass Transfer (SI Units), S. Chand, New Delhi, 2018.

Reference Books:

- Theodore L. Bergman, Adrienne S. Lavine, Frank P. Incropera, and David P. DeWitt, Fundamentals of Heat and Mass Transfer, 8th Edition, Wiley, Hoboken, 2018.
- Yunus Çengel and Afshin Ghajar, Heat and Mass Transfer: Fundamentals and Applications, McGraw Hill, New York, 2020.
- S. P. Sukhatme, Textbook of Heat Transfer, 4th Edition, Universities Press, Hyderabad, 2005.

Web References:

- Heat Transfer (https://onlinecourses.nptel.ac.in/noc23_ch65/preview)
- Heat Transfer (https://onlinecourses.nptel.ac.in/noc25_me171/preview)

Department of Mechanical Engineering

Program: Mechanical Engineering	**Third Year B.Tech**	**Semester: VI**
Course: Control Systems (DJS23MCMD601)		
Course: Control Systems Laboratory (DJS23MLMD601)		

Pre-requisites:

- Engineering Mathematics: Laplace Transform and Differential Equations.
- Fundamentals of Electrical, Mechanical, and Mechatronic Systems.
- Basic concepts of Dynamics and Signal Representation.
- Exposure to MATLAB/Scilab or equivalent simulation tools.

Objectives:

1. To introduce mathematical modeling and representation of mechanical, electrical, and electromechanical systems.
2. To analyze control system behavior in time and frequency domains.
3. To study classical stability criteria and control design techniques.
4. To understand and apply PID controllers and compensators in engineering systems.
5. To introduce modern control theory and state-space representation.

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

1. Explain the principles, terminology, and types of control systems (open-loop, closed-loop) and their real-world significance.
2. Develop mathematical models and derive transfer functions for mechanical, electrical, and electromechanical systems.
3. Analyze system performance using time-domain and frequency-domain approaches, and evaluate stability using classical techniques.
4. Design suitable controllers and compensators (P, PI, PD, PID, lag-lead) to achieve desired system specifications.
5. Apply state-space representation and modern control concepts to model and simulate multi-variable systems.

Control Systems (DJS23MCMD601)		
Unit	**Description**	**Duration**
1	**Introduction and System Modeling** • Introduction to control systems: open-loop and closed-loop concepts. • Mathematical modeling of mechanical, electrical, thermal, and fluid systems. • Analogies: force-current and force-voltage. • Transfer functions, block diagram reduction, and signal flow graphs.	**9**
2	**Time Domain Analysis** • Standard test signals: step, ramp, impulse, and sinusoidal inputs. • Time response of first and second-order systems. • Time-domain specifications: rise time, settling time, overshoot, peak time. • Steady-state errors and error constants.	**8**
3	**Stability and Root Locus** • Stability criteria: Routh-Hurwitz method. • Root locus technique – rules, construction, and interpretation. • Determination of gain and phase margins. • Sensitivity analysis and stability improvement.	**10**

4	**Frequency Domain Analysis and Controllers** • Frequency response characteristics: Bode and Nyquist plots. • Gain and phase margins, bandwidth, resonant frequency. • Design of lag, lead, and lag-lead compensators. • Introduction to P, PI, PD, and PID controllers and tuning techniques.	**9**
5	**State Space and Modern Control Theory** • State-space representation and comparison with the transfer function model. • State equations, eigenvalues, and system stability. • Controllability and observability. • Modern control applications in robotics, mechatronics, and automation.	**6**
	Total	**42**

Control Systems Laboratory (DJS23MLMD601)	
Sr. No.	**Experiment Title**
	Study / Case Study-based Experiments
1	Study of control system components: servo motors, potentiometers, tachometers.
2	Comparison of open-loop and closed-loop systems.
3	Case study: Application of control systems in robotics, mechatronics, or process
	Simulation / Software-based Experiments
1	Simulation of first and second-order system responses using MATLAB/Scilab.
2	Root locus analysis of given transfer functions.
3	Frequency response analysis using Bode and Nyquist plots.
4	State-space modeling and stability analysis using MATLAB/Simulink.
5	Design and tuning of PID controllers for speed or temperature control systems.
	Performance / Hands-on Experiments
1	Experimental verification of time response for a second-order system.
2	PID control implementation on Arduino/PLC for DC motor speed control.
3	Stability testing of an electromechanical system using sensors and DAQ interface.

Any 8 Experiments to be performed based on the above list, and not limited to only the list. Any other relevant experiment/s can be added.

Books Recommended:

Textbooks:

- Katsuhiko Ogata, Modern Control Engineering, Pearson Education, 5th Edition, 2010.
- Norman S. Nise, Control Systems Engineering, Wiley India, 8th Edition, 2019.
- I.J. Nagrath & M. Gopal, Control Systems Engineering, New Age International, 5th Edition, 2018.

Reference Books:

- Richard C. Dorf & Robert H. Bishop, *Modern Control Systems*, Pearson, 13th Edition, 2017.
- Benjamin C. Kuo, *Automatic Control Systems*, Wiley, 9th Edition, 2014.
- Gene Franklin, J. Powell, A. Emami-Naeini, *Feedback Control of Dynamic Systems*, Pearson, 8th Edition, 2019.
- Brian Douglas, *Control System Concepts for Engineers*, Pearson, 2020.
- Ashish Tiwari, *Control Systems: Principles and Design*, McGraw-Hill, 2022.

Web References:

- Digital Twin – NPTEL Course: https://nptel.ac.in/courses/112107322
- *NPTEL – Control Engineering* (IIT Madras): https://nptel.ac.in/courses/108101174
- *NPTEL – Modern Control Theory* (IIT Kharagpur): https://nptel.ac.in/courses/108105130
- *MIT OpenCourseWare – Feedback Control Systems*: https://ocw.mit.edu
- *Coursera – Modern Robotics and Control*: https://www.coursera.org/learn/modern-robotics
- *MathWorks Tutorials – Control System Design*: https://www.mathworks.com/help/control

Program: Mechanical Engineering	**T.Y. B.Tech**	**Semester: VI**
Course: CAD CAM Laboratory (DJS23MLSC601)		

Pre-requisite:

- Knowledge of Engineering Graphics, Machine Drawing.
- Knowledge of drafting software such as AutoCAD, Autodesk Inventor, etc.
- Knowledge of Lathe, Milling, CNC Turning, CNC Milling Machines, and 3D Printers.

Objectives:

1. To introduce the concepts of computer-aided engineering for design & manufacture and familiarize them with the mathematical basis of computer graphics.
2. To impart knowledge on computer graphics, which are used routinely in diverse areas like science, engineering, medicine, etc.

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

1. Understand the software configuration of graphic packages.
2. Understand the use of Computer graphics in design.
3. Understand the Modeling of simple machine parts and assemblies from the part drawings using standard CAD packages.
4. Understand how to generate CNC turning and Milling codes for different operations using standard CAM packages and write manual part programming using ISO codes for turning and milling operations.

CAD CAM Laboratory (DJS23MLSC601)	
Exp.	**Suggested experiments**
1	Programming for transformations by using coding language (Translation, Rotation, Scaling & Magnification)
2	Part programming and part fabrication on CNC trainer (Turning / Milling)
3	Creating a script for generating a component or a sketch on software.
4	Simulation of the turning operation program on the software.
5	Simulation of the milling operation program on the software.
6	Program and Process Sheet Generation for turning operation by using CAM Software. (Two components)
7	Program and Process Generation for Milling operation by using CAM Software (Two components)
8	Development of a physical 3D mechanical component using any one of the additive manufacturing techniques 3 3D printer.
9	Development of a physical 3D mechanical component on the Automatic Turning Centre (Computerized)
10	Development of a physical 3D mechanical component on a vertical Machining Centre (Computerized).

Minimum 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 learnt.

Books Recommended:

Textbooks:

- Mikell P. Groover and Emory W. Zimmers; CAD/CAM: Computer-Aided Design and Manufacturing, Pearson Education, 2013.
- Ibrahim Zeid, R. Sivasubramanian; CAD/ CAM: Theory & Practice, Tata McGraw Hill Publications, 2009.
- P.N. Rao; CAD/CAM Principles and Applications, Tata McGraw-Hill Publications, 2017.

Reference Books:

- Donald Hearn and M. Pauline Baker; Computer Graphics, Pearson Education, 2006.
- William M. Neumann and Robert F. Sproul; Principles of Interactive Computer Graphics, McGraw-Hill Publishers, 1979.
- David L. Goetsch; Fundamentals of CIM technology, Delmar publication, 1988.
- David Bedworth; Computer Integrated Design and Manufacturing, McGraw-Hill Publishers, 1991.
- B.S. Pabla and M. Adithan; CNC Machines, New Age International Publishers, 2018.
- T.K. Kundra, P.N. Rao, and N.K. Tiwari, Numerical Control and Computer Aided Manufacturing, Tata McGraw-Hill Publishers, 1985.
- Krar S. and Gill A.; CNC Technology and Programming, McGraw-Hill Publishers, 1990.
- Paul G. Ranky; Computer Integrated Manufacturing - An Introduction with Case Studies, Prentice Hall International. 1986.
- Ian Gibson, David W Rosen, Brent Stucker, and Mahyar Khorasani. Additive Manufacturing Technologies, Springer, 2021.
- Juan Pou, Antonio Riveiro and J. Paulo Davim; Additive Manufacturing, Elsevier, 2021.
- M. Manjaiah, K. Raghavendra, N. Balashanmugam, J. Paulo Davim; Additive Manufacturing (A Tool for Industrial Revolution 4.0), Woodhead Publishing, 2021.

Program: Mechanical Engineering	**T.Y. B. Tech**	**Semester: VI**
Course: Vibration Analysis and Smart Monitoring (DJS23MCPE621)		
Course: Vibration Analysis and Smart Monitoring Laboratory (DJS23MLPE621)		

Pre-requisites:

- Engineering Mechanics
- Theory of Machines (Basic Vibrations)
- Introduction to Programming (Python/MATLAB)
- NPTEL Course Recommendations: "Introduction to Machine Learning", "Introduction to Internet of Things", "Introduction to Industry 4.0 and Industrial Internet of Things"

Objectives:

1. Understand and analyze multi-degree-of-freedom vibration systems using analytical and computational methods.
2. Apply signal processing techniques for vibration data analysis in both time and frequency domains.
3. Implement smart vibration sensors using ESP32 microcontrollers for real-time data acquisition and processing.
4. Design and develop IoT-based vibration monitoring systems with cloud integration and remote dashboards.
5. Apply machine learning techniques for intelligent fault detection and predictive maintenance in vibration systems.

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

1. Model and analyze multi-DOF vibration systems using matrix methods and Rayleigh/Holzer techniques.
2. Perform signal processing and feature extraction on vibration data using MATLAB/Python/Arduino programming.
3. Interface and calibrate MEMS sensors with ESP32 for vibration monitoring applications.
4. Develop and deploy IoT-based systems for real-time vibration data transmission and cloud storage.
5. Apply supervised and unsupervised machine learning algorithms for fault classification and anomaly detection in vibration systems.

Vibration Analysis and Smart Monitoring (DJS23MCPE621)		
Unit	**Description**	**Duration**
1	**Multi-Degree-of-Freedom Vibration Systems:** Two-DOF undamped systems, Mode shapes and natural frequencies, Matrix formulation of equations of motion, Eigenvalue problems, Natural frequency determination using Rayleigh's Method, Holzer's Method for torsional and flexural vibrations.	**8**
2	**Signal Processing for Vibration Analysis:** Time-domain and frequency-domain analysis, FFT analysis and spectral methods, Statistical analysis of vibration signals, Power spectral density, Feature extraction techniques, Signal pre-processing and noise reduction	**8**
3	**Smart Vibration Sensors and ESP32 Implementation:** ESP32 microcontroller fundamentals, MEMS accelerometers (ADXL345, MPU6050) interfacing, Sensor calibration and data acquisition, Digital signal processing on microcontrollers, Circuit design for vibration monitoring	**8**

4	**IoT-Based Vibration Monitoring Systems:** Introduction to IoT fundamentals and protocols, Real-time data acquisition and transmission, Cloud connectivity and data storage, Remote monitoring dashboards, Wireless sensor networks for vibration monitoring, *IoT-Based Vibration Monitoring: Bearing Defect Frequencies Case Study*	**9**
5	**Machine Learning for Intelligent Vibration Analysis:** Introduction to AI/ML fundamentals and applications in engineering, Introduction to ML in vibration analysis, Supervised learning for fault classification (SVM, Decision Trees), Unsupervised learning for anomaly detection (K-means, PCA), Feature selection and model validation, Integration of ML with monitoring systems, *Machine Learning for Gear Meshing Frequency Analysis: A Case Study in Intelligent Vibration Diagnostics*	**9**
	Total =	**42**

Vibration Analysis and Smart Monitoring Laboratory (DJS23MLPE621)	
Sr. No.	**Experiment Description**
	Group 1: Fundamental Vibration Analysis (Experiments 1-4)
1	Matrix methods for multi-DOF vibration analysis using MATLAB/Python
2	Holzer's method for torsional and flexural vibration analysis using computational tools
3	Natural frequency experimental validation of multi-DOF systems
4	Signal processing and FFT analysis of vibration data using MATLAB/Python
	Group 2: Smart Sensor Implementation (Experiments 5-8)
5	ESP32 setup and MEMS accelerometer interfacing with breadboard design
6	ESP32 sensor programming: Data filtering, signal processing, and interrupt handling
7	Vibration sensor calibration and data validation using ESP32
8	ESP32-based vibration data acquisition with custom circuit design
	Group 3: IoT Integration and Connectivity (Experiments 9-12)
9	Real-time vibration data transmission using ESP32 and wireless protocols
10	IoT-based vibration monitoring with cloud connectivity (ThingSpeak/Firebase)
11	Remote vibration monitoring dashboard development
12	Multi-sensor vibration monitoring network implementation
	Group 4: Intelligent Analysis and Prediction (Experiments 13-16)
13	Feature extraction and statistical analysis of collected vibration data
14	Supervised learning for vibration-based fault classification using Python
15	Unsupervised anomaly detection in vibration patterns using ML algorithms
16	Integration of ML models with IoT monitoring systems for predictive maintenance

Term Work Requirements: At least 1 experiment from each group (minimum 5 experiments total)

Internal Test - Term Test 3 (Oral / Practical Exam): ESP32-based vibration monitoring system demonstration and viva voce on theory

Mini Project: Research-based project on Industry 4.0 vibration monitoring or IoT applications in predictive maintenance

ESE Exam: Students will be permitted to use PSG Design Data Book / Formula Sheet for ESE

Books Recommended:

Textbooks:

- S. S. Rao, Mechanical Vibrations, Pearson Education, 6th Edition, 2017.
- S. Graham Kelly, Fundamentals of Mechanical Vibration, Tata McGraw Hill, 2nd edition, 2000.

Reference Books:

- J. S. Rao and K. Gupta, Theory and Practice of Mechanical Vibrations, New Age International Publications, 2nd edition, 1999.
- William W. Seto, Schaum's Outline of Theory and Problems of Mechanical Vibration, McGraw Hill, 1964.
- G. K. Grover, Mechanical Vibrations, Nem Chand and Bros., Paper Back Edition, 2009.
- Daniel J. Inman, Engineering Vibration, Pearson, 4th Edition, 2014.
- Rao Singiresu S., Vibration of Continuous Systems, John Wiley and Sons, 2007.
- Kolban Neil, ESP32 Programming and IoT Development, Leanpub, 2017.
- Marco Schwartz, Internet of Things with ESP32, Packt Publishing, 2018.
- Vedat Ozan Oner, Practical IoT Projects with ESP32, Apress, 2020.

Web References:

- Introduction to Vibrations and Waves (https://nptel.ac.in/courses/122104019)
- Mechanical Vibrations (https://nptel.ac.in/courses/112103174)
- Internet of Things (https://nptel.ac.in/courses/106105166)

Program: Mechanical Engineering	**T.Y. B. Tech**	**Semester: VI**
Course: Refrigeration and Air Conditioning (DJS23MCPE622)		
Course: Refrigeration and Air Conditioning Laboratory (DJS23MLPE622)		

Pre-requisites:

- Thermodynamics
- Heat transfer

Objectives:

1. To gain an understanding of the principles of refrigeration and air-conditioning systems.
2. To analyse the performance of different refrigeration and air-conditioning systems.
3. To gain skills in designing, selecting, and sizing refrigeration and air-conditioning systems for various applications.
4. To develop lab skills related to the testing of refrigeration and air-conditioning systems.

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

1. Apply the principles of thermodynamics to air refrigeration systems
2. Analyse the performance of vapour compression refrigeration systems
3. Apply the principles of psychrometric properties and processes to air-conditioning systems.
4. Design air-conditioning systems using cooling load calculations and duct design principles.
5. Examine the role of sensors & control techniques used in modern HVAC systems.

Refrigeration and Air Conditioning (DJS23MCPE622)		
Unit	**Description**	**Duration**
1	**Introduction to Refrigeration:** First and Second Law applied to refrigerating machines, Carnot refrigerator & heat pump. Unit of refrigeration, Energy Efficiency Ratio (EER) and BEE star rating. Air refrigeration systems: Bell Coleman cycle, analysis and applications. Aircraft refrigeration systems: Simple, Bootstrap, Reduced ambient & Regenerative aircraft cooling system, Importance of Dry Air Rated Temperature.	**08**
2	**Vapour Compression Refrigeration Systems:** Analysis of simple vapour compression cycle, effect of liquid sub cooling & superheating, effect of evaporator and condenser pressures, methods of sub-cooling, Use of P-h charts, Actual VCR cycle, Analysis of 2 stage VCR systems & its applications. **Refrigerants:** Properties, ASHRAE numbering system, Secondary refrigerants, Low ODP and GWP refrigerants, International regulations and India's commitment towards sustainable refrigerants, sustainable cooling solutions, global climate protocols & Life cycle assessment for refrigerants. **Non-Conventional Systems:** Thermoelectric refrigeration, Thermo-acoustic refrigeration, Vortex tube refrigeration systems & Radiant heating and cooling systems.	**10**
3	**Psychrometry:** Need for air conditioning, Principle of psychrometry, Psychrometric properties, chart and processes, Bypass factor, Sensible heat factor, Adiabatic mixing of two air streams,	**07**

	Air washers, Requirements of comfort air conditioning, Summer and winter air conditioning.	
4	**Design of Air Conditioning Systems:** Different Heat sources, Cooling Load estimation, Ventilation and infiltration, Inside and Outside Design conditions, Room apparatus dew point and coil apparatus dew point temperature, RSHF, GSHF, ERSHF. Human Comfort, Effective temperature, Comfort chart, and Indoor Air Quality (IAQ). **Ducts:** Types of ducts, air flow in a duct, Equivalent diameter of a circular duct for rectangular ducts, Methods of duct design, Factors considered in air distribution systems, Air distribution systems for cooling and heating. Air Handling: Fan coil unit, Types of fans used in air conditioning applications, Fan laws, supply and return grills, Standards on ventilation and IAQ.	**10**
5	**Components:** Filters, Compressors, Condensers, Expansion devices, and Evaporators. Room/Split and Packaged Air Conditioners, VRF systems, VAV systems, Inverter Units. Cooling towers, types, tower approach, tower range, tower efficiency, tower losses, and tower maintenance. **Controls:** Digital controls, Control strategies, Electronic Controllers, LP/HP cut-off, Sensors: Temperature sensor, Humidity sensor, IAQ sensors, Green Buildings, Building Management Systems (BMS), smart sensors, and AI-based HVAC controls for predictive maintenance and energy optimization, IoT in the HVAC industry.	**07**
	Total	**42**

Refrigeration and Air Conditioning Laboratory (DJS23MLPE622)	
Sr. No.	**Experiment Title**
	Simulation / Study based experiments
1	Energy efficiency analysis and comparison of a conventional and inverter refrigerator
2	Simulation of Bell-Coleman cycle using any code
3	Study of refrigerant leak detection, recovery and charging techniques
4	Simulation of vapor compression cycle using any software (Coolpack, Refprop, DWSim)
5	Study of refrigerant properties and international regulations
6	Case study on IoT implementation in HVAC industry
	Performance based experiments
7	Performance Testing of a vapor compression refrigeration unit
8	Performance Testing of a domestic air-conditioning unit
9	Performance Testing of an Automotive Air-Conditioning Unit
10	Cooling Load Estimation for a building / room using ASHRAE / ISHRAE standards
11	Cooling Load Estimation for a building / room using E20 load sheet, HAP Codec
12	Visit report of a manufacturing unit of refrigerator/air-conditioner or a cold storage plant

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

Books Recommended:

Textbooks:

1. Refrigeration and air-conditioning, C P Arora, McGraw Hill Education, 4th Edition, 2021
2. Refrigeration and Air Conditioning, R.S. Khurmi & J.K. Gupta, S. Chand, 5th Edition, 2022
3. Refrigeration and air-conditioning – Domkundwar, Arora, Domkundwar, Dhanpat Rai, 8th Edition, 2018
4. Basic Refrigeration and air-conditioning- P.Ananthanarayana, McGraw Hill, 4th Edition, 2013

Reference Books:

- Principles of refrigeration – R J Dossat, Pearson Education, 4th Edition, 2014
- Air Conditioning System Design – Roger Legg, Butterworth-Heinemann, 2017
- ASHRAE Handbook of Fundamentals, 2021
- ISHRAE Refrigeration Handbook, 2015
- ISHRAE HVAC Data book, 2025

Program: Mechanical Engineering	**T.Y. B. Tech.**	**Semester: VI**
Course: Quality Engineering and Management (DJS23MCPE623)		
Course: Quality Engineering and Management Laboratory (DJS23MLPE623)		

Pre-requisites:

- Fundamentals of Mechanical Engineering.
- Fundamentals of Statistics.

Objectives:

1. To proactively integrate quality into the entire product lifecycle by developing methodologies and processes that ensure products and services reliably meet and exceed customer expectations, leading to higher satisfaction, reduced costs, and faster, more dependable delivery.
2. To monitor a process over time to determine if it is stable and predictable, identify variations that indicate potential issues, and ultimately improve process performance and quality.
3. To assess the quality of a batch or lot of products by examining a representative sample, rather than inspecting every item.
4. To enhance customer satisfaction, improve product and service quality, reduce operational costs by minimizing errors and waste, and achieve long-term organizational success through continuous improvement and process efficiency.
5. To systematically identify, analyze, and solve quality problems to improve products and processes, reduce costs, enhance customer satisfaction, and establish a culture of data-driven continuous improvement.

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

1. Develop the methodologies and processes to enhance the quality of products and services.
2. Construct and interpret control charts to enhance the quality of products and services by controlling the processes and measuring the performance consistency in industries.
3. Develop the acceptance sampling procedures for incoming raw material.
4. Enhance operational efficiency, reduce waste, and decrease defects to improve the product and service quality, leading to increased customer satisfaction and loyalty.
5. Identify root causes of problems, make informed decisions, and implement continuous improvements, ultimately boosting competitiveness.

Quality Engineering and Management (DJS23MCPE623)		
Unit	**Description**	**Duration**
1	**Basic concepts in Quality Engineering** • Definitions, approaches, and relevance to organizational excellence. • Quality Dimensions for Products and Services • Introduction to Design for Quality • Inspection and Quality control • Quality planning and Quality Assurance • Quality costs and Quality loss function • Fundamental principles of Statistical Process Control (SPC) • Chance and assignable causes of process variation • Control chart patterns • Rules for application of control charts	**9**

	• Chance and assignable causes of process variation	
2	**Control Charts for Variables** • Control chart for mean and range • Moving Average charts • CUSUM charts • Trend control charts • Multivariate control charts. **Control Charts for Attributes** • Control charts for proportion non-conforming (p) • number of nonconforming items (np) • number of non-conformities (c) • number of non-conformities per unit (u) **Process Capability studies** • Various indices and approaches • Discussions on the capabilities of Process • setting specification limits.	**10**
3	**Product Quality Control** • Acceptance Sampling methods • Single, Multiple, and sequential sampling plans • Evaluation of Sampling Plans: AOQ, AOQL, ATI, ASN • Operating Characteristic Curves • Recent developments in inspection methods	**7**
4	**Basic concepts in Quality Management** • Total Quality Management: An Overview • The 8 Primary Principles of Total Quality Management • Deming's 14 Points on Quality Management • Crosby's 14 steps of quality management to achieve zero defects • Introduction to ISO 14001 and ISO 45001	**9**
5	**Quality Management Tools** • 5 Whys • Ishikawa Diagram • Measurement System Analysis (MSA) • Pareto chart • Quality Function Deployment (QFD) • Failure Mode and Effects Analysis (FMEA) • Fault Tree Analysis (FTA) • Total Productive Maintenance (TPM)	**7**
	Total	**42**

Quality Engineering and Management Laboratory (DJS23MLPE623)	
Sr. No.	**Experiment Title**
	Study-Type/ Case-Study-based Experiments (Theoretical and Conceptual Learning)
1	A case study on Design for Quality

2	A case study on Robust Design.
3	A case study on ISO 14001 or ISO 45001
4	A case study on any one Quality Management Tool
	Numerical Analysis/ Simulation-based Experiments (Python/ MATLAB/ Simulink, etc.)
5	Construction and usage of Control charts for Variables
6	Construction and usage of Control charts for Attributes
7	A study on Acceptance Sampling.

All 7 experiments from the above-suggested list and any other experiment based on the syllabus will be included, which would help the learner to apply the concept.

Books Recommended:

Textbooks:

- D. C. Montgomery, Introduction to Statistical Quality Control, John Wiley & Sons, 2019
- K. Krishnaiah, Applied Design of Experiments and Taguchi Methods, Prentice Hall of India, 2012
- N. Logothetis, Managing for Total Quality, Prentice Hall of India,1997
- D. R. Kiran, Total Quality Management, Butterworth-Heinemannm,2016
- Poornima M. Charantimath, Total Quality Management, Dorling Kindersley (India), 2011

Reference Books:

- Rajesh Kumar R, Quality Engineering and Management, Jyothis Publishers, 2023
- Scott A. Laman, The ASQ Certified Quality Engineer Handbook, ASQ Quality Press, 2022
- Madhav Phadke, Quality Engineering Using Robust Design, Phadke Associates, Incorporated,2021
- Jong S. Lim, Quality Management in Engineering: A Scientific and Systematic Approach, CRC Press, 2019
- Chao-Ton Su, Quality Engineering: off-Line Methods and Applications, CRC Press, 2016
- K.S. Krishnamoorthi, V. Ram Krishnamoorthi , A First Course in Quality Engineering: Integrating Statistical and Management Methods of Quality, Taylor & Francis, 2011
- Sung H. Park, Jiju Antony, Robust Design for Quality Engineering and Six Sigma, World Scientific, 2008
- Jeff Tian, Software Quality Engineering: Testing, Quality Assurance, and Quantifiable Improvement, Wiley, 2005

Web References:

- Quality Design and Control (https://onlinecourses.nptel.ac.in/noc21_mg24)
- Inspection and Quality Control in Manufacturing (https://onlinecourses.nptel.ac.in/noc21_me16)
- Quality Control and Improvement with MINITAB (https://onlinecourses.nptel.ac.in/noc22_mg40)
- Design And Analysis of Experiments (https://www.youtube.com/playlist?list=PLPjSqITyvDeWS9Lxp4jreGJ7eNsxHxJA8)
- Total Quality Management I https://nptel.ac.in/courses/110104080
- Total Quality Management – II https://onlinecourses.nptel.ac.in/noc21_mg72/preview

Program: Mechanical Engineering	**T.Y. B. Tech**	**Semester: VI**
Course: Automotive Systems (DJS23MCPE624)		
Course: Automotive Systems Laboratory (DJS23MLPE624)		

Pre-requisite: --

- Manufacturing processes, mechanics of materials
- Fluid mechanics
- Basic electronics

Objectives:

1. To impart an understanding of important mechanical systems of an automobile.
2. To impart an understanding of the electrical and electronic systems of an automobile.
3. To familiarize with the latest technological developments in automotive technology.

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

1. Describe the types and working of the clutch and transmission system.
2. Illustrate the working of steering and braking systems.
3. Describe the role of vehicle suspension systems and the vehicle body.
4. Describe the different automotive electrical and electronic systems.
5. Acquaint with recent developments in automobiles.

Automotive Systems (DJS23MCPE624)		
Unit	**Description**	**Duration**
1	**Introduction:** Classification of automobiles, Importance of various sub-systems of an automobile, development of an automobile, and aspects of automotive engineering. **Clutch:** Performance characteristics of a prime mover, requirements & types of clutches, single plate, multi-plate, wet clutch, centrifugal clutch. Clutch materials. Clutch operating mechanisms - Mechanical, Electric, Hydraulic, and Vacuum. Troubleshooting and remedies. Clutch-by-wire. **Transmission:** Requirements of the gearbox. Sliding mesh, Constant mesh, and Synchromesh Gearbox. Gear selector mechanisms. Overdrives, under-gearing, over-gearing, tractive effort, and hydrodynamic torque converter, Epicyclic gear train, and automatic transmissions. Troubleshooting and remedies. Automated Manual Transmission (AMT), Continuously Variable Transmission (CVT), Dual Clutch Transmission (DCT).	**09**
2	**Driveline sub-systems:** Propeller shafts and universal joints: Types and construction, Different types of universal joints and constant velocity joints. Classification of axles, Loads on axles, Semi, Three-quarter, and Full floating axles. Troubleshooting and remedies. Types of Final drives: spiral, bevel, Hypoid, and worm drives. Necessity of differential, Working of a differential, Conventional and limited-slip differential, Troubleshooting and remedies. **Steering System:** Steering requirements, Steering linkages, and steering gears. Steering geometry parameters, Analysis of steering geometry, Over-steer and Under-steer characteristics, Reversibility of steering gears. Troubleshooting and remedies. **Braking System:**	**09**

	Requirements of brakes, Classification of brakes, Brake Actuation Methods: Mechanical, Hydraulic, Pneumatic, Electro, and vacuum brakes. Types of Disc brakes and Drum Brakes, Brake troubleshooting, and Anti-lock braking system (ABS).	
3	**Suspension System:** Objects of suspension, Basic requirements, Sprung and unsprung mass, Types of Independent, semi-independent, and rigid axle suspension. Air suspension and its features. Pitching, rolling, and bouncing. Shock absorbers and their types, Troubleshooting and remedies. Electronically controlled active suspension system. **Wheels and Tyres:** Requirements of wheels and tyres. Types of wheels, tyres, and carcass materials. Tyre and wheel manufacturing processes. Troubleshooting and remedies. Airless tyres & run flat tyres.	**08**
4	**Vehicle Structure:** Importance of the vehicle body and its types. Loads on the vehicle body, materials for body construction. Layouts of passenger cars, buses, and truck bodies. Chassis types and structure types: Open, semi-integral, and integral structures. Frames: Types of frames and their functions, Loads on frames, Load distribution of structure. Importance of crumple zone in vehicles, Crash safety ratings in India.	**08**
5	**Automotive electronics and recent developments:** **Storage Systems:** Lead-Acid Battery; construction, working, ratings, types of charging methods, Alkaline battery, ZEBRA, and Sodium Sulphur battery. Lithium-ion battery, battery pack for electric vehicles, Battery management system. Solid-state battery. Alternative fuel storage systems for CNG and Hydrogen vehicles. **Vehicle Sensors:** Vehicle speed sensor, Mass air flow sensor, temperature sensor, MAP sensor, Lambda sensor, TP sensor, Steering angle sensor, Acceleration sensor, Yaw rate sensor, Airbag sensor, Radar, LiDAR sensor. **Recent developments:** Active and Passive Safety systems in an automobile. Cruise Control, Adaptive Cruise Control, Predictive Cruise Control, Electronic Stability Program, Electronic Brake Distribution System, Traction Control System, Integrated Starter-Alternator, Hill Assist, Launch Control, Connected Cars with V2V Communication & Pre-Collision Technology.	**08**
	Total	**42**

Automotive Systems Laboratory (DJS23MLPE624)	
Exp.	**Suggested experiments**
1	Identify and illustrate various components in a clutch assembly.
2	Simulation of powertrain systems on Lotus Engineering Software
3	Simulation of powertrain systems on MATLAB Simulink software.
4	Simulation and analysis of transmission system gear ratio using MATLAB Simulink software
5	Simulation and analysis of the braking system using MATLAB Simulink software
6	Modeling and FEA analysis of vehicle frame designs on ANSYS / Solidworks

7	Modeling and FEA analysis of vehicle frame materials on ANSYS / Solidworks
8	Characterization and visualization of the output of various sensors, such as TPS, MAP, and ECT sensors.
9	Simulation of a cruise control system using MATLAB Simulink software
10	Case study presentation and report on upcoming vehicle technologies
11	Field visit to an automotive manufacturing plant / service station

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

Books Recommended:

Textbooks:

1. Automobile Engineering, Dr. Kirpal Singh, Standard publishers, Vol I & II, 14th Edition, 2018
2. Automobile Engineering, Devendra Vashist & Mukhtar Ahmad, Dreamtech Press, Publications, 2022
3. Automobile Engineering, R. K. Rajput, 2nd Edition, Laxmi Publications, 2012

Reference Books:

1. Encyclopedia of Automotive Engineering, David Crolla, Wiley Publication, 2015
2. Automotive Electrical and Electronic Systems, Tom Denton, Routledge, 5th Edition, 2017
3. Automotive Engineering Fundamentals, Jeffrey Ball, Richard Stone, SAE International, 2004
4. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, Mehrdad, Yimin, Sebastian, Ali, CRC Press, 3rd Edition, 2019

Program: Mechanical Engineering	**T.Y. B.Tech**	**Semester: VI**
Course: Industrial Robotics (DJS23MCPE625)		
Course: Industrial Robotics Laboratory (DJS23MLPE625)		

Pre-requisites:

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

Objectives:

1. To study the various types of industrial robots, their anatomy, safety protocols, and work environments, with attention to emerging designs and cost considerations.
2. To understand modelling, analysis, and integration of robotic kinematics, dynamics, and work cell architectures, including collaborative and multi-robot systems.
3. To evaluate drive systems, actuator technologies, sensor integration, and machine vision, focusing on reliability, efficiency, and recent advancements.
4. To design, simulate, and program robotic systems using contemporary platforms, and implement control strategies suitable for industrial automation tasks.
5. To explore advancements in robotics applications, artificial intelligence, and expert systems, emphasizing trends in industrial, service, and field robotics.

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

1. Identify and evaluate industrial robot anatomy, configurations, safety practices, and economic factors for deploying robots in manufacturing and allied industries.
2. Model and analyze robotic manipulators for kinematics and dynamics; design robust work cells for both standalone and collaborative robotic applications.
3. Select and integrate appropriate drive systems, actuators, and sensors; apply machine vision principles for process automation and quality assurance.
4. Design, program, and simulate industrial robots, implementing control architectures for real-world path planning and automation workflows.
5. Critically analyze current and future trends in robotics, covering AI integration, expert systems, and innovative application areas in heavy industry and emerging sectors

Industrial Robotics (DJS23MCPE625)		
Unit	**Description**	**Duration**
1	**Introduction & Fundamentals** • Definition and scope, history, and evolution of robots • Robot anatomy: links, joints, coordinate systems, degrees of freedom, work volume • Classification of robots and robot configurations (Cartesian, Cylindrical, SCARA, Articulated, etc.) • Social issues, safety, and ethics in robotics • Overview of industrial and non-industrial applications	**7**
2	**Robot Kinematics, Dynamics, and Intelligence** • Homogeneous Transformations	**9**

	• Kinematic modelling: forward and inverse kinematics, Denavit-Hartenberg parameters • Basics of robot dynamics, motion interpolation, and trajectory analysis • Robot Intelligence & Task Planning Introduction, • State space search, Problem reduction, use of predictive Logic, • Problem solving, Robot learning and Robot task planning.	
3	**Drives, Actuators, Sensors & Machine Vision** • Types of drives: electrical, hydraulic, pneumatic • Actuators: DC/AC servo, stepper motors, transmission systems • Feedback devices: position, velocity, force sensors • Robot control systems: open vs. closed-loop, path/trajectory control • Internal and external sensors: tactile, proximity, vision, force/torque, range sensors • Machine vision: image acquisition, pre-processing, segmentation, feature extraction • Applications of machine vision in robotics	**9**
4	**Robot Programming & Work Cell Design** • Programming methods: teach pendant, lead-through, offline programming • Robot languages; introduction to programming platforms (e.g., VAL, AML, Python, C/C++) • Task-level programming and simulation environments • Module 6: Robot Work Cell Design and Integration (4 hours) • Robot work cell layouts, robot cycle time analysis, safety in robotic work cells • Multiple robots and machine interference, collaborative robotics • Human-robot interaction basics	**9**
5	**Advanced Applications, AI & Trends** • Robot applications in manufacturing: material handling, assembly, welding, painting, inspection • Field robots: agriculture, mining, underwater, civil, military, and space • Latest trends: mobile robots, UAVs, service robots, Industry 4.0 integration • Industrial applications: material handling, welding, inspection, modern field robots • Artificial intelligence in robotics: expert systems, robot learning, knowledge representation, Industry 4.0, mobile & collaborative robots, future directions	**8**
	Total	**42**

Industrial Robotics Laboratory (DJS23MLPE625)	
Sr. No.	**Experiment Title**
	Study-Type/ Case-Study-based Experiments (Theoretical and Conceptual Learning)
1	**Industrial Robot Selection and Application Analysis**-Analyze the selection criteria, deployment factors, and program structure for a robot used in a real-world industry (automotive, packaging, or medical). Include safety, cost, and technical factors.

2	**Robot Work Cell Layout and Cycle Time Study**-Review a typical work cell setup using multiple robots and machines. Calculate cycle time, analyze bottlenecks, and propose layout or task sequencing improvements for productivity.
3	**Sensor Integration and End Effector Case Study**-Evaluate a manufacturing cell where complex sensing and tailored end effectors are used. Discuss challenges and strategies in selecting and integrating multiple sensor types for real applications
4	**Comparison of Robot Programming Methods**-Examine case studies of different programming approaches (teach pendant, offline, simulation-based) for industrial robots, outlining pros and cons, use cases, and programming safety.
5	**Industry 4.0 and Collaborative Robotics Evaluation**-Conduct a guided review of robotics adoption for smart factories, focusing on collaborative robots and human-robot interaction, referencing recent industry case studies
	Simulation-based Experiments (Python/ MATLAB/ Simulink, etc.)
6	**Forward and Inverse Kinematics Simulation for 2- and 4-Axis Arms**-Simulate both forward and inverse kinematics of articulated and SCARA robots using Python or MATLAB. Analyze arm configurations and reach within spatial constraints.
7	**Workspace Envelope Visualization using Python/MATLAB**-Develop a program that graphically simulates workspace envelopes of different robot architectures (Cartesian, polar, cylindrical, articulated). Evaluate their suitability for industrial tasks.
8	**Robot Trajectory Planning and Path Optimization**-Use MATLAB Simulink to design and simulate trajectory planning—linear, parabolic, and cubic polynomial path generation for pick-and-place operations with obstacle avoidance.
9	**Simulation of Machine Vision-Based Inspection**-Build a Python/MATLAB program that uses image processing (thresholding, segmentation, feature extraction) to simulate a robotic vision inspection task in manufacturing.
10	**Robot Cell Coordination and Collision Avoidance Simulation**-Use Simulink or Python to model robot cell control, including interlocks and collision detection algorithms for multiple robots working in a shared space.
	Case Study based Experiments (Mini-Projects)
11	Develop a semi-virtual model of an industrial robot cell that automates material handling, assembly, and inspection.
12	Integrate kinematic modeling, trajectory planning, and sensor-based decision logic using Python/MATLAB/Simulink.
13	Evaluate cell layout, cycle time, safety protocols, and scalability with collaborative robotic arms.
14	Document design choices, software implementation, and test scenarios in alignment with current Industry 4.0 trends.

A minimum of 5 experiments from the above-suggested list or any other experiment based on the syllabus will be included, along with one mini-project assigned to students in a group of 4, which would help the learner to apply the concept.

Books Recommended:

Textbooks:

- Isak Karabegović (Ed.), Industrial Robots: Design, Applications and Technology, Nova Science Publishers, 2020.
- Antoni Grau and Zhuping Wang, Industrial Robotics: New Paradigms, BoD – Books on Demand, 2020.
- Ganesh S. Hegde, A Textbook of Industrial Robotics, Laxmi Publications, 2023.
- T. C. Manjunath, "Fundamentals of Robotics Vol-I", Nandu Publishers, 5th Edn., Mumbai, 2014.
- Elaine Rich & Kevin Knight, "Artificial Intelligence", McGraw-Hill, Singapore, 3rd Edn., 2017.
- T. C. Manjunath, "Fast Track to Robotics", Nandu Publishers, 5th Edn., Mumbai, Maharashtra, India, 2017.
- K. S. Fu, R.C. Gonzalez, C.S.G. Lee, "Robotics: Control, Sensing, Vision & Intelligence", McGraw-Hill, USA, 5th Edition, 2010.
- Robin R. Murphy, "Introduction to AI and Robotics", MIT Press, Second Edition, 648 pp., Oct. 2019.

Reference Books:

- Divya Mishra and Shanu Sharma (Eds.), Revolutionizing Industrial Automation Through the Convergence of Artificial Intelligence and the Internet of Things, IGI Global, 2022.
- Lejla Banjanović-Mehmedović, Industrial Robotics, DOAB Open Access, 2021.
- Yingjie Qian, Jianjun Yuan, Liming Gao, and Zhaojiang Yu, AI Developments for Industrial Robotics and Intelligent Drones, IGI Global, 2023.
- Divya Mishra and Shanu Sharma (Eds.), AI and Blockchain Applications in Industrial Robotics, IGI Global, 2023.
- John Billingsley, Control Basics for Mechatronics, Emerald Group Publishing, 2024.
- S. R. Deb, Sankha Deb, Robotics Technology and Flexible Automation, McGraw-Hill, 2nd Edition, 2021
- Yoram Koren, Robotics for Engineers, McGraw-Hill Book Co., 1st Edition, 1985
- Larry Heath, Fundamentals of Robotics: Theory and Applications, Reston Publishing Co., 1984
- Harry Asada and Jean-Jacques Slotine, Robot Analysis and Control, John Wiley & Sons, 1st Edition, 1986
- Alan Pugh, Robot Technology, Peter Peregrinus Ltd./IEE Control Engineering Series, 1983
- Shimon Y. Nof (Ed.), Handbook of Industrial Robotics, John Wiley & Sons, 2nd Edition, 1999
- Roland Siegwart, Illah Reza Nourbakhsh, and Davide Scaramuzza, Introduction to Autonomous Mobile Robots, MIT Press, 2nd Edition, 2011
- Robert J. Schilling, Fundamentals of Robotics: Analysis and Control, Prentice Hall, 1990
- P. A. Janaki Raman, Robotics and Image Processing: An Introduction, Tata McGraw Hill Publishing Company Ltd., 1st Edition, 1995

Web References:

- Industrial Robotics: Theories for Implementation, IIT-ISM Dhanbad (https://onlinecourses.nptel.ac.in/noc25_me161/preview)
- Robotics Basics and Selected Advanced Concepts (IISc Bangalore) (https://nptel.ac.in/courses/112108298)
- Advanced Robotics Applications (IIT Kanpur)(https://nptel.ac.in/courses/112104620)

Program: Mechanical Engineering	**T.Y. B.Tech**	**Semester: VI**
Course: Artificial Intelligence and Machine Learning (DJS23MCPE626)		
Course: Artificial Intelligence and Machine Learning Laboratory (DJS23MLPE626)		

Pre-requisites:

- Linear Algebra, Probability, Statistics, Logical Reasoning.
- Fundamentals of Mechanical Engineering.

Objectives:

1. To acquaint students with the fundamentals of artificial intelligence and machine learning.
2. To learn feature extraction and selection techniques for processing a data set.
3. To impart the basic algorithms used in classification and regression problems.
4. To outline the steps involved in the development of a machine learning model.
5. To familiarize with concepts of reinforced and deep learning.
6. To analyze a machine learning model in mechanical engineering problems.

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

1. Demonstrate the fundamentals of artificial intelligence and machine learning in the context of mechanical engineering.
2. Apply feature extraction and selection techniques for the mechanical engineering dataset.
3. Apply machine learning algorithms for classification and regression problems.
4. Develop a machine learning model using various steps.
5. Use the reinforced and deep learning model in mechanical engineering problems.

Artificial Intelligence and Machine Learning (DJS23MCPE626)		
Unit	**Description**	**Duration**
1	**Introduction to AI-ML** History of AI, Comparison of AI with data science, Need for AI in mechanical engineering, Introduction to ML. Basics: Reasoning, problem solving, knowledge representation, planning, learning, perception, motion, and manipulation. Approaches to AI: Cybernetics and brain simulation, symbolic, sub-symbolic, and statistical. Approaches to ML: Supervised learning, unsupervised learning, reinforcement learning.	**8**
2	**Feature Extraction and Selection** **Feature extraction:** Statistical features, PCA. **Feature selection:** Ranking, decision tree - entropy reduction and information gain, exhaustive, best first, greedy forward & backward, applications of feature extraction and selection algorithms in mechanical engineering.	**9**
3	**Classification and Regression Models** **Classification Models:** Random forest, logistic regression, decision tree, SVM, KNN, K-means, Naive Bayes. **Regression Models -** Linear and non-linear regression, neural network regression, overfitting, and underfitting. Applications of classification and regression models in Mechanical Engineering. Explainable AI (XAI) in safety-critical systems.	**9**

4	**Development of ML Model** **Understanding and preparing data:** Data types, data collection methods, data preprocessing techniques: Missing data handling, noise filtering, outlier detection, normalization, standardization. **Problem identification:** Classification, clustering, regression, ranking. **Steps in ML modeling:** Data collection, data pre-processing, model selection, model training (training, testing, K-fold cross-validation), model evaluation (Understanding and interpretation of confusion matrix, accuracy, precision, recall, true positive, false positive, etc.), hyperparameter tuning, predictions. **Ethics and bias in AI:** Ethical considerations in ML applications, bias in datasets and algorithms, implications in safety-critical systems such as quality control and industrial automation. Basics of model deployment.	**8**
5	**Reinforced and Deep Learning** What is reinforcement learning? terms used, key features, working process, approaches: value-based, policy-based, and model-based; Elements: policy, reward signal, value function, model of the environment; The Bellman equation, Types: positive and negative, RL algorithms, Q-learning, comparison between RL and supervised learning. Transfer learning. Characteristics of deep learning, ANN, CNN, etc.	**8**
	Total	**42**

Note: *Numerical should be related to mechanical and allied engineering domains. Some of the domain areas are: Thermal/ Heat Transfer/ HVAC/ Fluid Mechanics/ Fluid Power, Solid Mechanics/ Design, Machining/ Manufacturing, Automation and Robotics, Maintenance/ reliability/ condition monitoring, Quality Control, Materials and metallurgy, Energy Conservation and Management, Industrial Engineering, Estimation, and Management, Automotive Technology.*

Artificial Intelligence and Machine Learning Laboratory (DJS23MLPE626)	
Sr. No.	**Experiment Title**
Group A: Any five experiments from the following list for a data set using a suitable software package/ programming language	
1	To study supervised/unsupervised/Reinforcement learning approach.
2	To acquire, visualize, and analyze the data set (from time-domain/ frequency-domain/ etc.).
3	To extract features from the given data set and establish training data.
4	To select relevant features using a suitable technique.
5	To use PCA for dimensionality reduction.
6	To classify features/to develop a classification model and evaluate its performance (any one classifier).
7	To develop a regression model and evaluate its performance (any one algorithm).
8	Markov process for modelling manufacturing processes.
9	Reinforced Learning for optimizing engineering designs / Robot Guidance and Navigation.
10	GA for optimization of multi-dimensional function/path planning in robotics.
11	NN for parameter and model identification/tuning of Control Algorithms.

Group B (Mandatory)
One mini project (in a group of 2 students) based on the above contents and using a mechanical engineering application dataset.

Books Recommended:

Textbooks:

- Deisenroth, Faisal, Ong, Mathematics for Machine Learning, Cambridge University Press, 2020.
- B. Joshi, Machine Learning and Artificial Intelligence, Springer, 2020.
- Parag Kulkarni and Prachi Joshi, "Artificial Intelligence – Building Intelligent Systems," PHI learning Pvt. Ltd., ISBN – 978-81-203-5046-5, 2015
- Stuart Russell and Peter Norvig, "Artificial Intelligence: A Modern Approach," Third edition, Pearson, 2003.
- Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, O'Reilly Media, ISBN:9781098122478, 109812247X, 2022.
- Ian Goodfellow, Yoshua Bengio, and Aaron Courville, Deep Learning, MIT Press, ISBN:9780262035613, 0262035618, 2016.
- Nathan George, Practical Data Science with Python: Learn Tools and Techniques from Hands-on Examples to Extract Insights from Data, Packt Publishing, ISBN:9781801076654, 1801076650, 2021.

Reference Books:

- 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.
- Zsolt Nagy - Artificial Intelligence and Machine Learning Fundamentals-Apress (2018)

Web References:

- An Introduction to AI (https://archive.nptel.ac.in/content/syllabus_pdf/106102220.pdf)
- Fundamentals of Artificial Intelligence (https://nptel.ac.in/courses/112103280)
- Machine Learning (https://nptel.ac.in/courses/106/106/106106202/)
- Introduction to Machine Learning (https://nptel.ac.in/courses/106106139)
- Deep Learning (https://padhai.onefourthlabs.in/courses/dl-feb-2019)

Program: Mechanical Engineering	**T.Y. B.Tech**	**Semester: VI**
Course: Entrepreneurial Business Models (DJS23MCPE627)		
Course: Entrepreneurial Business Models Laboratory (DJS23MLPE627)		

Pre-requisite: Nil

Objectives:

1. To enable learners to understand business model frameworks:
2. To enable learners to analyse value creation strategies:
3. To enable learners to assess revenue and cost structures:
4. To enable learners to evaluate customer segmentation and market fit:
5. To enable learners to integrate innovation into business models:
6. To enable learners to apply business model frameworks effectively:

Outcomes: Upon successful completion of the course, learners will be able to:

1. Illustrate the components of a business model.
2. Analyse market needs and develop value propositions.
3. Evaluate cost and revenue structures for financial sustainability.
4. Assess customer segmentation strategies for market alignment.
5. Apply innovation-driven strategies to enhance business models.
6. Construct adaptive and scalable business models for various industries.

Entrepreneurial Business Models (DJS23MCPE627)		
Unit	**Description**	**Duration**
1	**Introduction to Business Models** Definition and Importance Components of a Business Model Case Studies on Successful Business Models	**8**
2	**Value Creation and Market Positioning** Identifying Customer Needs Competitive Advantage and Differentiation Market Research and Business Fit	**8**
3	**Revenue and Cost Considerations** Revenue Models and Pricing Strategies Cost Structure and Financial Sustainability Key Financial Metrics	**6**
4	**Customer Segmentation and Market Alignment** Identifying Target Segments Business Model Adaptation for Different Markets Consumer Behavior and Decision MakingCollaborative Business Models	**7**
5	**Innovation and Disruptive Business Models** Leveraging Technology in Business Models Business Model Evolution in Emerging Industries Digital Transformation Strategies	**7**
6	**Developing and Validating Business Models**	**6**

	Business Model Testing and Refinement Risk Assessment and Contingency Planning Final Business Model Development and Evaluation	
		42

Entrepreneurial Business Models Laboratory (DJS23MLPE627)		
Sr. No.	**Exercise**	**Detailed Description**
1	**Business Model Analysis**	Study and evaluate business models of successful companies using real-world case studies. Identify key components such as value proposition, revenue streams, and customer segments.
2	**Customer Value Proposition Mapping**	Develop customer value propositions for a selected business idea. Define key benefits offered to customers and create differentiation strategies.
3	**Business Model Canvas Development**	Construct a Business Model Canvas for a proposed startup, detailing key partners, activities, customer relationships, cost structure, and revenue models.
4	**Revenue and Cost Structure Analysis**	Identify and analyze various revenue streams and cost drivers for a given business idea. Assess financial sustainability and explore monetization strategies.
5	**Market Opportunity Identification**	Conduct primary and secondary market research to validate business ideas. Identify customer needs, potential market size, and growth opportunities.
6	**Competitive Analysis and Positioning**	Assess competition in a given industry. Identify direct and indirect competitors, analyze market positioning, and develop differentiation strategies.
7	**Business Model Testing and Validation**	Apply structured testing frameworks (e.g., Lean Startup methodology) to refine business assumptions. Conduct customer interviews and prototype testing.
8	**Scalability and Sustainability Assessment**	Evaluate the long-term scalability and sustainability of a business model. Assess factors such as resource allocation, market expansion potential, and financial growth.
9	**Innovative Business Model Design**	Design a business model for an emerging industry or disruptive technology. Develop creative approaches to solving market problems.
10	**Final Business Model Presentation**	Prepare and present a refined business model to a panel. Justify business assumptions, financial projections, and growth strategies. Receive feedback for improvement.

Books Recommended:

- Baisya, Rajat K. Indian Entrepreneurship: Analysis of Business Practices. SAGE Publications, New Delhi, 2021.
- Blank, Steve, and Bob Dorf. The Startup Owner's Manual. K&S Ranch Publishing, Pescadero, 2012.
- Desai, Vasant. Entrepreneurship Development in India. Himalaya Publishing House, Mumbai, 2019.

- Joshi, M.V. Entrepreneurship Development and Startup India. Himalaya Publishing House, Mumbai, 2020.
- Kumar, S. Ramesh. Business Development: A Comprehensive Approach. McGraw Hill, New Delhi, 2018.
- Osterwalder, Alexander. Value Proposition Design. Wiley, New Jersey, 2014.
- Osterwalder, Alexander, and Yves Pigneur. Business Model Generation. Wiley, New Jersey, 2010.
- Prasad, Rohit. Start-up Sutra: What the Angels Won't Tell You About Business and Life. Hachette India, New Delhi, 2013.
- Purohit, Prachi. Startup India: The Complete Guide to Launching and Managing a Business. Notion Press, Chennai, 2021.
- Ries, Eric. The Lean Startup. Crown Business, New York, 2011.
- Thiel, Peter. Zero to One. Crown Business, New York, 2014.
- van der Pijl, Patrick. Business Model Shifts. Wiley, New Jersey, 2020.

Objectives:

1. To acquaint the students with the process of identifying the need (considering a societal requirement) and ensuring that a solution is found out to address the same by designing and developing an innovative product.
2. To familiarize the students with the process of designing and developing a product while they work as part of a team.
3. To acquaint the students with the process of applying basic engineering fundamentals, so as to attempt at the design and development of a successful value-added product.
4. To inculcate the basic concepts of entrepreneurship and the process of self-learning and research required to conceptualize and create a successful product.

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

1. Identify the requirement for a product based on societal/research needs.
2. Apply knowledge and skills required to solve a societal need by conceptualizing a product, especially while working in a team.
3. Use standard norms of engineering concepts/practices in the design and development of an innovative product.
4. Draw proper inferences through theoretical/ experimental/simulations and analyze the impact of the proposed design and development of the product.
5. Develop product/project management skills, interpersonal skills, self-learning, and effective communication, eventually preparing them to be successful entrepreneurs.

Guidelines for the proposed product design and development:

- Students shall form a team of 3 to 4 students (max allowed: 5-6 in extraordinary cases, subject to the approval of the department review committee and the Head of the department).
- Students should carry out a survey and identify the need, which shall be converted into conceptualization of a product, in consultation with the faculty supervisor/head of department/internal committee of faculty members.
- Students should recognize the essential requirements for product development and choose the most suitable design in consultation with the faculty supervisor.
- Students shall transform the most appropriate design solution into a functional model, incorporating components from their specific domain and related interdisciplinary fields.
- Throughout the two-semester duration of the activity, faculty supervisors will provide guidance to students, with a primary emphasis on self-directed learning.
- Each team is required to maintain an activity log-book, where they can document their weekly progress. The guide or supervisor should review the recorded notes and comments and provide approval on a weekly basis.
- Students should validate the design solution with appropriate justifications and compile a report in a standard format for submission to the department. Additionally, students are encouraged to make efforts to publish a technical paper, either in the institute journal 'Techno Focus: Journal for Budding Engineers' or in a suitable publication approved by the department's research committee or the Head of the department.
- The focus should be on self-learning, capability to design and innovate new products as well as on developing the ability to address societal problems. Advancement of entrepreneurial capabilities and quality

development of the students through the year long course should ensure that the design and development of a product of appropriate level and quality is carried out, spread over two semesters, i.e. during the semesters III and IV.

Guidelines for Assessment of the work:

- The review/ progress monitoring committee shall be constituted by the Head of the Department. The progress of design and development of the product is to be evaluated on a continuous basis, holding a minimum of two reviews in each semester.
- In the continuous assessment, focus shall also be on each individual student's contribution to the team activity, their understanding and involvement, as well as responses to the questions being raised at all points in time.
- Distribution of marks individually for both reviews as well as for the first review during the subsequent semester shall be as given below:
    - Marks awarded by the supervisor based on log-book: 20
    - Marks awarded by the review committee: 20
    - Quality of the write-up: 10

In the last review of the semester VI, the term work marks will be awarded as follows.

A. Marks awarded by the supervisor (Considering technical paper writing) : 15

B. Marks awarded by the review committee: 10

The review/progress monitoring committee may consider the following points during the assessment.

- In semester V, the entire design proposal shall be ready, including components/system selection as well as the cost analysis. Two reviews will be conducted based on the presentation given by the student's team.
    - First shall be for the finalization of the product selected.
    - Second shall be on the finalization of the proposed design of the product.
- In semester VI, the expected work shall be procurement of components/systems, building of the working prototype, testing, and validation of the results based on work completed in semester V.
    - First review is based on the readiness of building the working prototype.
    - Second review shall be based on a presentation as well as the demonstration of the working model, during the last month of semester VI. This review will also look at the readiness of the proposed technical paper presentation of the team.

The overall work done by the team shall be assessed based on the following criteria;

- Quality of survey/ need identification of the product.
- Clarity of Problem definition (design and development) based on need.
- Innovativeness in the proposed design.
- Feasibility of the proposed design and selection of the best solution.
- Cost effectiveness of the product.
- Societal impact of the product.
- Functioning of the working model as per stated requirements.
- Effective use of standard engineering norms.
- Contribution of each individual as a member or the team leader.
- Clarity on the write-up and the technical paper prepared.

The semester reviews (V and VI) may be based on relevant points listed above, as applicable.

Guidelines for Assessment of Semester Reviews:

- The write-up should be prepared as per the guidelines given by the department.
- The evaluation of the product's design and development will involve a presentation and demonstration of the working model by the student team. This assessment will be conducted before a panel of Internal and External Examiners, preferably with more than five years of experience in industry or research organizations. The Head of the Institution approves the selection of these examiners. The presence of an external examiner is desirable only for the second presentation during semester VI. Additionally, students are required to present an outline of the technical paper they have prepared during the final review in semester VI.

Program: Common to all Programs	**T.Y. B.Tech**	**Semester: VI**
Course: Constitution of India (DJS23ICHSX09)		

Course Objectives:

1. To provide basic information about the Indian Constitution.
2. To identify individual roles and ethical responsibilities towards society.
3. To understand human rights and their implications.

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

1. Have general knowledge and legal literacy, and thereby take up competitive examinations.
2. Understand state and central policies, fundamental duties.
3. Understand the Electoral Process, special provisions.
4. Understand powers and functions of Municipalities, Panchayats, and Co-operative Societies.
5. Understand Engineering ethics and the responsibilities of Engineers.
6. Understand Engineering Integrity & Reliability.

Constitution of India (DJS23ICHSX09)		
Unit	**Syllabus Content**	**Duration**
1	**Introduction to the Constitution of India** The Making of the Constitution and Salient Features of the Constitution. Preamble to the Indian Constitution. Fundamental Rights & its limitations.	**02**
2	**Directive Principles of State Policy:** Relevance of Directive Principles, State Policy, Fundamental Duties. Union Executives – President, Prime Minister, Parliament, Supreme Court of India.	**02**
3	**State Executives:** Governor, Chief Minister, State Legislature, and High Court of the State. Electoral Process in India, Amendment Procedures, 42nd, 44th, 74th, 76th, 86th & 91st Amendments.	**03**
4	**Special Provisions:** For SC & ST, Special Provision for Women, Children & Backward Classes, Emergency Provisions.	**03**
5	**Human Rights:** Meaning and Definitions, Legislation Specific Themes in Human Rights, Working of National Human Rights Commission in India, Powers and functions of Municipalities, Panchayats and Co-Operative Societies.	**02**
6	**Scope & Aims of Engineering Ethics**: Responsibility of Engineers and Impediments to Responsibility. Risks, Safety, and Liability of Engineers. Honesty, Integrity & Reliability in Engineering.	**02**
	Total hours	**14**

Books Recommended:

Textbooks:

1. Durga Das Basu, *"Introduction to the Constitution on India",* (Students Edition) Prentice Hall

EEE, 19th / 20th Edition, 2001.

2. Charles E. Haries, Michael S. Pritchard and Michael J. Robins, *"Engineering Ethics",* Thompson Asia, 2003.

***Reference Books**:*

1. M. V. Pylee, *"An Introduction to Constitution of India",* Vikas Publishing, 3rd Edition, 2003.
2. M. Govindarajan, S. Natarajan, V. S. Senthilkumar, *"Engineering Ethics",* Prentice Hall of India Pvt. Ltd. New Delhi, 2013.
3. Brij Kishore Sharma, *"Introduction to the Constitution of India",* PHI Learning Pvt. Ltd., New Delhi, 7th Edition 2015.
4. Latest Publications of *Indian Institute of Human Rights*, New Delhi

Website Resources:

1. www.nptel.ac.in
2. www.hnlu.ac.in
3. www.nspe.org
4. www.preservearticles.com